FINAL

S U M M A R Y R E P O R T

ZEBRA MUSSEL ERADICATION PROJECT

LAKE OFFUTT
OFFUTT AIR FORCE BASE, NEBRASKA

NOVEMBER 2009

Prepared for
55 CES/CEV
Offutt Air Force Base, Nebraska

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List of Acronyms

AF	Air Force
AFB	Air Force Base
AFI	Air Force Instructions
CEQ	The Council of Environmental Quality
CFR	Code of Federal Regulations
EA	Environmental Assessment
°F	Degrees Fahrenheit
FONSI	Finding of No Significant Impact
GIS	Geographical Information System
GPS	Global Positioning System
MCL	maximum contaminant level
msl	mean sea level
NDA	Nebraska Department of Agriculture
NDEQ	Nebraska Department of Environmental Quality
NEPA	National Environmental Policy Act of 1969
NGPC	Nebraska Game and Parks Commission
NHU	Natural Habitats Unlimited
NISIC	National Invasive Species Information Center
NOAA	National Oceanic and Atmospheric Administration
NPPD	Nebraska Public Power District
OPPD	Omaha Public Power District
ppm	parts per million
PVC	Polyvinyl Chloride
URS	URS Group, Inc.
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VDGIF	Virginia Department of Game and Inland Fisheries.

EXECUTIVE SUMMARY

Zebra mussels are an invasive species from Eurasia that were introduced in Lake St. Clair, in the Great Lakes region in 1988. The ability of zebra mussels to attach to hard surfaces, their ability to live for extended periods out of water, and the small size of their larvae (veligers) allow them to be transported unknowingly on recreational boats, trailers, and bait buckets, and has contributed to their rapid range expansion. Within four years after being introduced in Lake St. Clair, zebra mussels had become established in all of the Great Lakes as well as the Arkansas, Cumberland, Hudson, Illinois, Mississippi, Ohio, and Tennessee River systems.

It is believed that zebra mussels gained access to Lake Offutt when a boat or boat trailer that had been used on a water body infested with zebra mussels was transported and unloaded into Lake Offutt. The Nebraska Game and Parks Commission (NGPC) confirmed the presence of zebra mussels in Lake Offutt in April 2006. This was the first confirmed reproducing population of zebra mussels in the state of Nebraska. The Zebra Mussel Working Group was formed to discuss treatment options and preventative measures and included representatives from government agencies and private stakeholders. Offutt Air Force Base (AFB), in cooperation with the Zebra Mussel Working Group, determined that treating the lake with copper sulfate would be the most feasible treatment method with the greatest potential for successful eradication.

Offutt AFB contracted URS Group, Inc. (URS) to treat Lake Offutt in an attempt to eradicate zebra mussels (*Dreissena polymorpha*). An United States Environmental Protection Agency (USEPA) Special Local Need Label was acquired in order to treat the lake with a sufficient concentration of copper sulfate to eradicate zebra mussels (1 part per million [ppm] lake-wide copper concentration). Copper Sulfate was applied in two treatments to Lake Offutt over 30-hour periods on 17 and 18 September 2008 and again on 7 and 8 April 2009. Post application monitoring was performed in four categories: 1) water quality, 2) adult zebra mussels sampling, 3) larval zebra mussels sampling, and 4) fish mortality. Thus far no zebra mussels have been detected in Lake Offutt since the first treatment was applied.

1.1 HISTORY OF ZEBRA MUSSEL INTRODUCTIONS

Zebra mussels (*Dreissena polymorpha*) are named for the striped pattern of their shells, though their color patterns vary, sometimes having dark or light colored shells and no stripes. These small bivalve mollusks (clams) are native to the Black, Caspian, and Azov Seas in Eurasia. Dispersal of the species occurs by the passive drifting of larvae (veligers) and attachment of adults to hard surfaces including boats. Their dispersal capability and high reproduction rate allows them to gain access and rapidly colonize new waters. Under cool, humid conditions, zebra mussels can stay alive for several days out of water, and veligers can survive for long periods in standing water in boats/trailers as they are transported to other water bodies (United States Geological Survey (USGS) 2009). Due to these survival characteristics, overland dispersal by recreational boats has proven to be a significant pathway for the continued range expansion of zebra mussels in the United States.

Zebra mussels dispersal and colonization capabilities were first observed in Europe as canal systems were being constructed during the late 18th and early 19th centuries. By 1824, zebra mussels were introduced and spread to most major drainages in Western Europe and Great Britain. Zebra mussels reached North America in 1988; via a commercial cargo ship traveling from the Black Sea to Lake St. Clair in the Great Lakes Region released larval mussels during ballast water exchange. By 1990, zebra mussels had been found in all the Great Lakes and within a year, zebra mussels had become established outside of the Great Lakes in the Illinois and Hudson Rivers. By 1992, only 4 years after they were first discovered in Lake St. Clair, zebra mussels had become established in the Arkansas, Cumberland, Hudson, Illinois, Mississippi, Ohio, and Tennessee rivers. By 1994, zebra mussels had spread to 20 states throughout these river watersheds (USGS 2009). More recently, zebra mussels have been discovered in seven Kansas reservoirs since 2003 and nine reservoirs in Colorado since 2007 (Fowler 2009).

1.2 EFFECTS OF ZEBRA MUSSELS ON AQUATIC ECOSYSTEMS

Zebra mussels are classified as an invasive species by the National Invasive Species Information Center (NISIC) and can cause severe economic and ecologic damages in areas where they invade and establish new territory (NISIC 2008, USGS 2000). Their high reproductive yield and ability to readily attach to available substrates are key factors for their invasion capability. Unlike native freshwater bivalves, the adult zebra mussels have byssal threads which allow them to attach to nearly any stable substrate including rock, macrophytes, artificial surfaces (cement, steel, rope, aluminum cans), and even the shells of native mussels. Once colonized on a new substrate they also attach to each other, forming large and very dense colonies. The colonies can cause long term disruptions to natural food web structures by filtering phytoplankton and other suspended material from the water column (Strayer 2009). In Lake Erie, diatom abundance declined by 82 to 91 percent and water clarity increased by 100 percent after the zebra mussel invasion (Holland 1993). In smaller lakes, zebra mussels caused a complete trophic shift from pelagic-dominated to benthic-dominated systems (Scheffer et al. 1993). Other reports indicate that zebra mussels can reduce the growth rate of larval fish and cause declines in overall fish

health due to these food web interactions (Raikow 2004, National Oceanic and Atmospheric Administration [NOAA] 2008).

In addition to their undesirable effects on aquatic ecosystems, zebra mussels can cause serious economic impacts. Zebra mussels are notorious for their bio-fouling capabilities on industrial facilities having surface water intakes. Zebra mussel densities have been reported as high as 65,000 per square foot at one power plant in Michigan (USGS 2009). Their invasion and reproduction capabilities make zebra mussels very difficult and expensive to control. Congressional researchers estimated that the United States power industry spent $3.1 billon from 1993 to 1999 to control zebra mussels (United States Fish and Wildlife Service [USFWS] 2005). Recently, a single water works facility in Virginia estimated that to control zebra mussels they would need an initial startup fund of $2 to $4 million for chemical feed facilities and $500,000 to $850,000 annually for chemicals and system maintenance (Virginia Department of Game and Inland Fisheries [VDGIF] 2009). Zebra mussels also have adverse economic effects on recreation, fisheries, shipping, and other industries.

1.3 MANAGEMENT/CONTROL OF ZEBRA MUSSELS

Several control strategies have been used to combat zebra mussel invasions. Removal methods have included chemical, manual, dewatering/desiccation, thermal, electrical current, and biological controls. Often, total eradication is not feasible so populations are repeatedly reduced to lessen long term impacts, which results in ongoing economic impact to the facility. However, if a body of water is isolated and not too large, total eradication may be possible in select situations. In 2006, total eradication was attempted at Millbrook Quarry Lake in Virginia. This lake was small (12 acres), deep (93 feet), and hydrologically isolated from other water bodies. VDGIF employed an application of potassium chloride solution to eradicate the zebra mussels. Post eradication observations and sampling have not documented any live zebra mussels and VDGIF has concluded that the zebra mussel has been successfully eliminated from the quarry (VDGIF 2009).

1.4 STUDY AREA

Lake Offutt (also known as “Base Lake”) is located at Offutt Air Force Base (AFB) near Bellevue, Nebraska (Figure 1-1). The lake is approximately 115 acres in size but varies seasonally/annually from approximately 110 to 123 acres. Generally the lake has an average depth of approximately 15 feet, with some areas over 30 feet deep. Variations in the elevation of the Missouri River, located approximately 3,000 feet east of Lake Offutt, and local precipitation events affect the water level of the lake. The lake was formed as a result of dredging to supply sand and gravel for construction on Offutt AFB. Since its formation, riprap (broken concrete) has been placed along the bank of the lake to stabilize the shoreline. The soil composition and slope of the banks coupled with high usage makes vegetative cover difficult to establish and maintain. Aquatic macrophytes are presently limited to areas along the lake inlet (Figure 1-2). Willows and cottonwoods have become established in the fluctuation zone of the lake where steep banks and exposed riprap are not present.

Drainage from the southeastern portion of Offutt AFB (south of the flight line) collects in a series of drainages and flows into Lake Offutt via the East Gate Drain. Most collected runoff in this drainage area accumulates in a detention pond located near the south end of the runway (Figure 1-2). Water collected in this detention pond is able to infiltrate, evaporate, or discharge to the East Gate Drain and into Lake Offutt. The discharge of the East Gate Drain accounts for most of the surface flow that enters the lake.

Prior to 2006, the lake was connected to the Bellevue Drain via the lake outlet; two 48-inch overflow culverts (Figure 1-3). During periods of high lake levels the lake discharged water to the drain, and during periods of high flow in Bellevue Drain, water flowed from the drain into Lake Offutt. The Bellevue Drain flows east to the Missouri River, approximately one mile downstream of the Lake Offutt overflow culverts (Figure 1-1). The lake outlet was sealed in 2006 after zebra mussels were discovered.

Lake Offutt is a popular recreational spot for military families and retirees. Recreational activities include softball, boating, camping, fishing, horse riding, and hiking. Amenities at the lake include the boathouse, campsites, indoor and outdoor pavilions, barbecue sites, softball field, playgrounds, horse stables, and a paintball/archery range (Figure 1-3).

The primary goal of fish management at Lake Offutt is to maintain/enhance game fish populations. Prominent game fish species found in Lake Offutt during a fish survey conducted in 2006 included largemouth bass, smallmouth bass, walleye, saugeye, bluegill, white and black crappie, channel catfish, flathead catfish, and black bullhead. Non-game fish species sampled included gizzard shad, river carpsucker, bigmouth buffalo, smallmouth buffalo, freshwater drum, shortnose gar and longnose gar (Natural Habitats Unlimited [NHU] 2006). Several non-native invasive fish species are present in Lake Offutt including bighead carp, common carp, grass carp, and white perch.

1.5 HISTORY OF ZEBRA MUSSEL INFESTATION AT LAKE OFFUTT

The Nebraska Game and Parks Commission (NGPC) confirmed the presence of zebra mussels in Lake Offutt in April 2006. The NGPC and Offutt AFB met in October 2006 to determine an approach to controlling the zebra mussel population. The NGPC and Offutt AFB determined that a Zebra Mussel Working Group should be established to bring interested stakeholders together to identify potential solutions to the issue and to have a focused approach in implementation of solutions. The Zebra Mussel Working Group was established in March 2007 and was comprised of local and regional stakeholders from federal, state, and local government agencies and utility companies. The following agencies/companies were represented on the Zebra Mussel Working Group.

- Offutt AFB
- United States Fish and Wildlife Service (USFWS)
- United States Environmental Protection Agency (USEPA)
- United States Army Corps of Engineers

- Nebraska Game and Parks Commission (NGPC)
- Nebraska Department of Environmental Quality (NDEQ)
- Nebraska Department of Agriculture (NDA)
- Nebraska Department of Natural Resources
- Kansas Department of Wildlife and Parks
- Missouri Department of Conservation
- Iowa Department of Natural Resources
- Virginia Department of Game and Fish (VDGIF)
- Lower Platte South Natural Resource District
- Papio-Missouri Natural Resource District
- Nemaha Natural Resource District
- Nebraska Public Power District (NPPD)
- Omaha Public Power District (OPPD)
- Kansas City Board of Public Utilities
- MidAmerican Energy
- City of Bellevue
- Kansas City Power and Light

The Zebra Mussel Working Group met five times in 2007 to discuss concerns and establish goals. The major concern identified by the Zebra Mussel Working Group was the threat of zebra mussels becoming established in the Missouri River and other connected water bodies. The invasion of zebra mussels into the Missouri River would be both ecologically and economically costly. There are numerous natural resources in the river and associated ecosystems that would be negatively impacted. Numerous cities, electric power companies, and other industries that utilize water from the river would be burdened with extra costs associated with zebra mussel control. The continued presence of zebra mussels in Lake Offutt would be a continual source of zebra mussels to colonize in the Missouri River and would have a direct negative effect on the recreational use of the lake. Based on these concerns, the Zebra Mussel Working Group established both short-term and long-term goals. Two short-term measures were identified and implemented to prevent the immediate spread of zebra mussels:

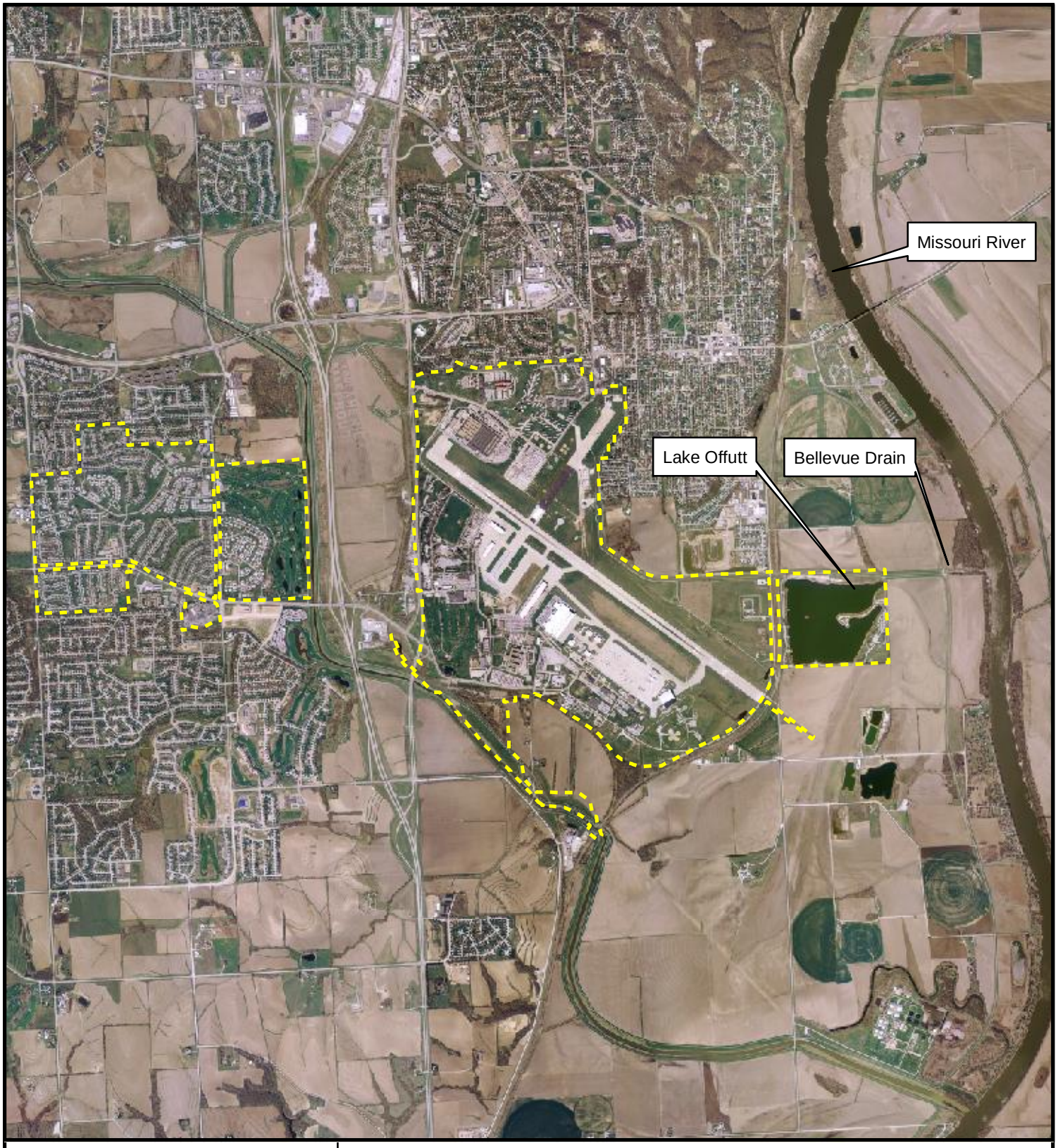
- Plugging the 48-inch outlet between Lake Offutt and Bellevue Drain
- Prohibiting private boat usage on the lake

One long-term goal was established:

- Total eradication of zebra mussels at Lake Offutt

The primary motivation for total eradication was to reduce the potential for zebra mussels spreading to other water bodies, particularly the Missouri River, and to maintain the recreational value and function of the lake. The Zebra Mussel Work Group considered several control methods including confinement, physical removal, thermal removal, biological removal, and chemical removal. It was determined that chemical application would be the most practical method for eradication of zebra mussels.

The zebra mussel population in Lake Offutt was monitored throughout 2006 and 2007 and it was evident that the population expanded substantially during that time period. By the fall of 2007, almost all available substrate areas were entirely covered with zebra mussels, frequently in multiple layers. Although no actual counts were made, it was evident that in areas with suitable substrate, their density was several thousand individuals per square foot of substrate. In addition, the change in color and increased clarity of the water indicated that zebra mussels were dramatically affecting nutrient resources in the lake. Therefore, Offutt AFB concluded that the recreational usage (fishing, boating, wading, etc.) would be severely curtailed if the zebra mussels were not removed from the lake. Based on all of the information, Offutt AFB, in concert with the Zebra Mussel Working Group, initiated plans to implement the long-term goal of eradicating zebra mussels from Lake Offutt.



URS

Figure 1-1
Offutt AFB Location Map

Designed By: SP	Zebra Mussel Eradication Offutt AFB, Nebraska
Drawn By: SP	
Checked By: BO	
Submitted By: BO	Projection: NAD83 HARN State Plane, Nebraska, Feet

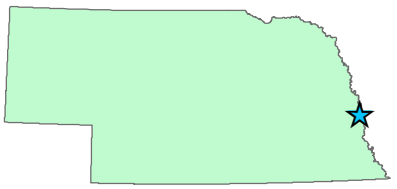
Legend

Offutt AFB Boundary

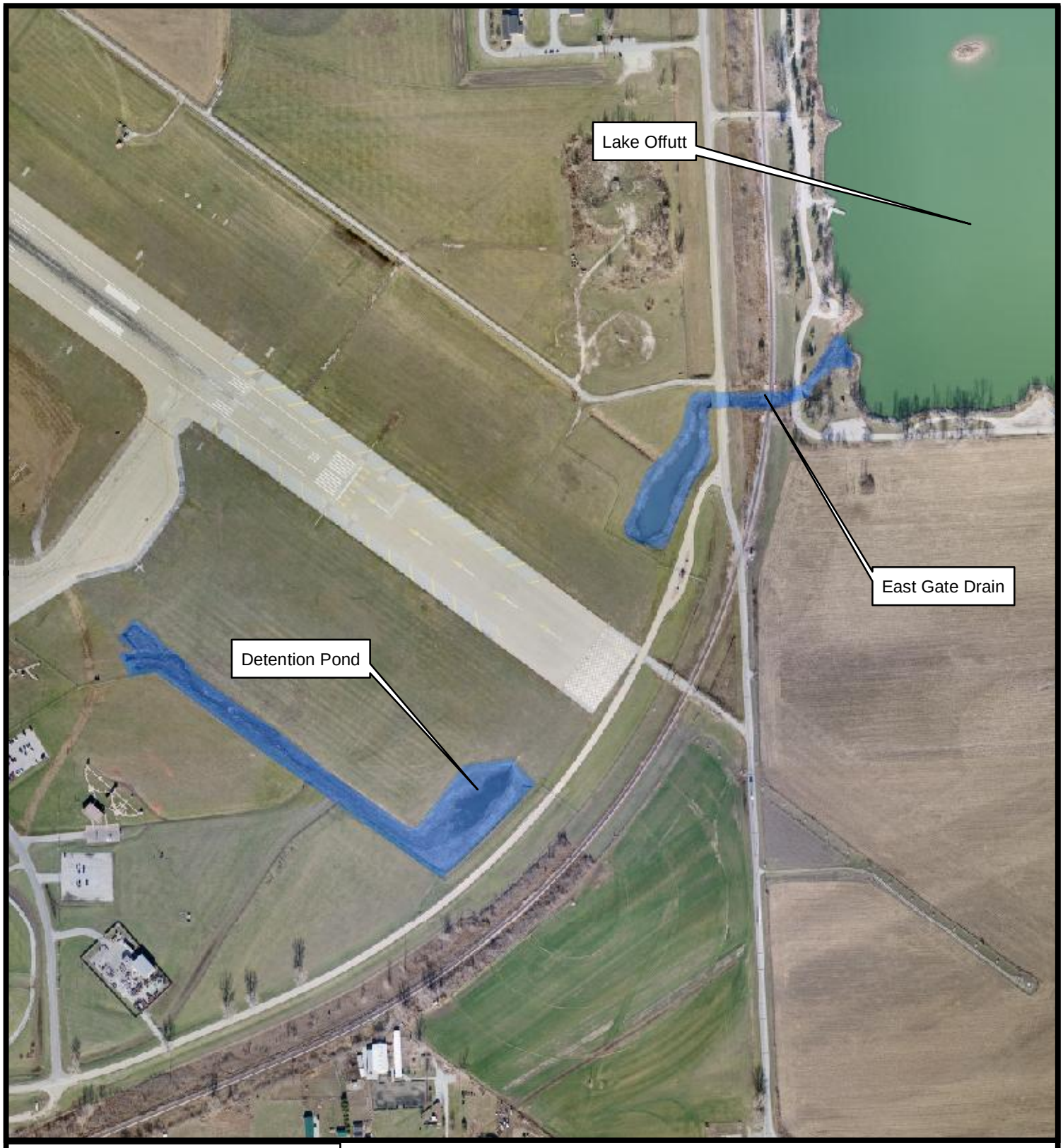
N

0 0.5 1 1.5 Miles

Locator Map



Nebraska



URS

Figure 1-2
Lake Offutt Inlet and Ponded Areas

Designed By: SP	Zebra Mussel Eradication Offutt AFB, Nebraska
Drawn By: SP	
Checked By: BO	
Submitted By: BO	Projection: NAD83 HARN State Plane, Nebraska, Feet

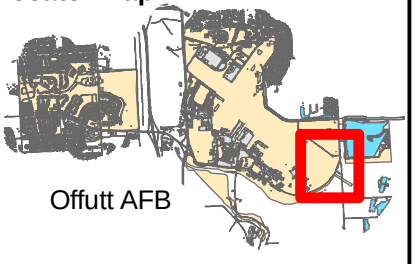
Legend

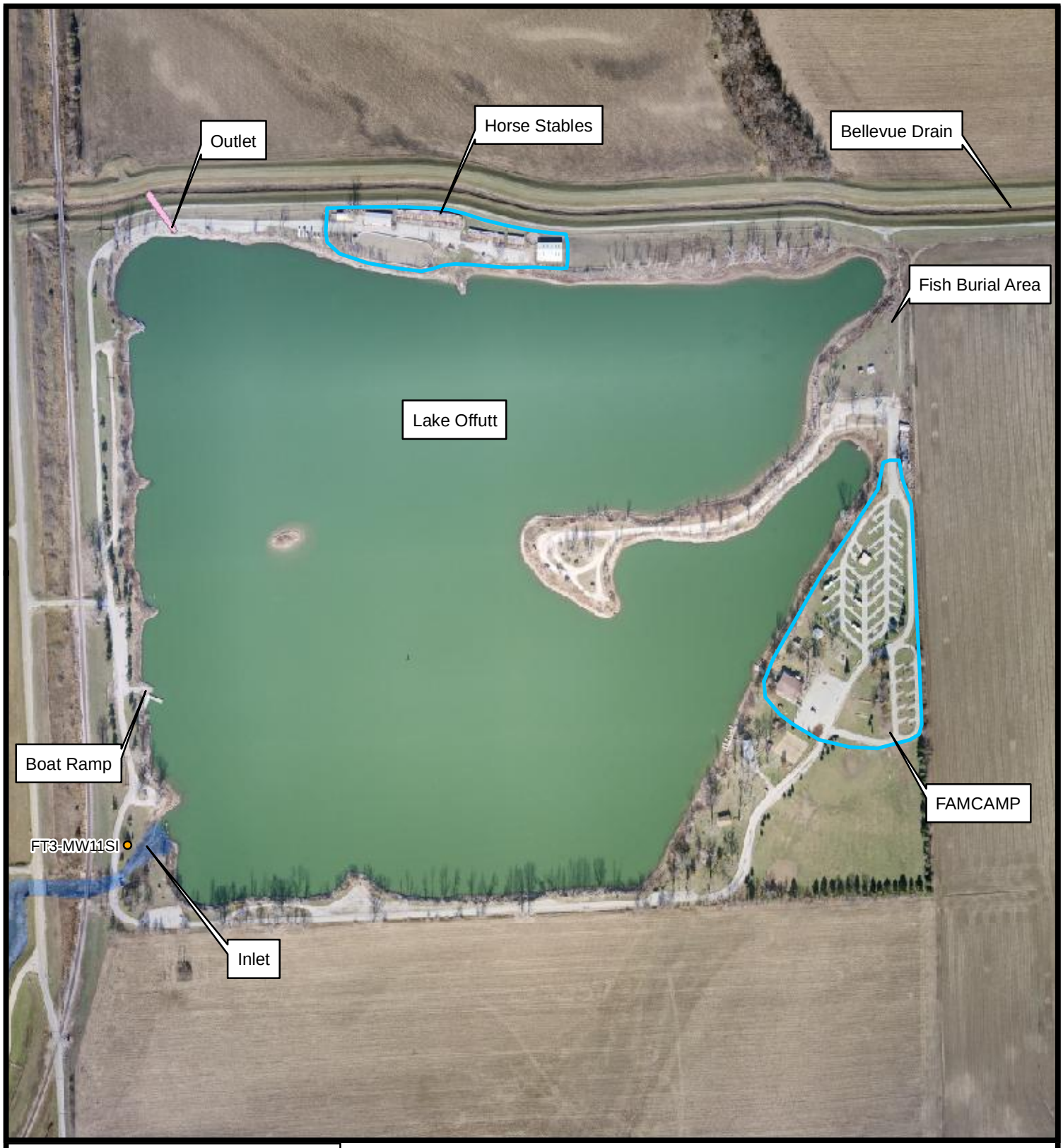
Upgradient Drainage Areas

N

0 500 1,000 Feet

Locator Map





URS

Figure 1-3
Lake Offutt Features

Designed By: SP	Zebra Mussel Eradication Offutt AFB, Nebraska
Drawn By: SP	
Checked By: BO	
Submitted By: BO	Projection: NAD83 HARN State Plane, Nebraska, Feet

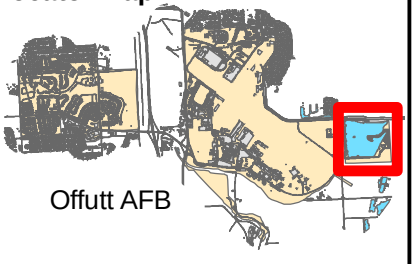
Legend

- Lake Features
- Monitoring Well
- East Gate Drain
- Outlet Area

N

0 500 1,000 Feet

Locator Map



2.1 PRE-APPLICATION ACTIVITIES

The methods and procedures that were used during the project are provided in this section (Section 2). Results of the surveys, monitoring, and eradication using the described methods are provided in Section 3.

2.1.1 Selection of Chemical

Two potential chemicals (potassium chloride and copper sulfate) emerged as viable options for further evaluation by the Zebra Mussel Work Group, and are discussed in more detail in the following subsections.

Potassium Chloride

The use of potassium chloride was proven effective in the Millbrook Quarry, a very deep 12 acre lake in Virginia (VDGIF 2009). Approximately 174,000 gallons of potassium chloride solution was applied to the quarry lake over a 3 week period in 2006 to achieve a target concentration of 100 parts per million (ppm) potassium. Post-application monitoring indicated that the treatment was successful and the zebra mussels were successfully eradicated from the quarry. The application of potassium chloride to Lake Offutt was evaluated, but was determined to be cost prohibitive due to the recent price increases in potassium and the quantity of potassium chloride that would be required to bring the average concentration of elemental potassium to 100 ppm (approximately 340 tons). In addition, the logistics of transporting, storing, and applying 340 tons of potassium chloride made this treatment option unfeasible.

Copper Sulfate

Copper is toxic to most aquatic species because it binds to gill membranes, which causes tissue damage and interferes with osmoregulation and gas exchange (USEPA 2008). Copper sulfate has been used as a treatment for Island Apple Snails, an invasive mollusk in Florida (Haller 2007) and has been used to effectively reduce snail populations in catfish ponds (Mischke et al. 2009). Copper sulfate is also toxic to all life stages of zebra mussels (Kennedy et al. 2006). Various copper products have been regularly used in industrial settings as an effective anti-fouling coating due to its toxicity to zebra mussels (Claudi and Mackie 1994). Further input on copper sulfate application was solicited from William T. Haller, Acting Director of Aquatic and Invasive Plants at the University of Florida. He prepared a technical report for Offutt AFB describing the potential use of copper sulfate to eradicate zebra mussels at Lake Offutt (Haller 2007). This report identified the recommended concentration of elemental copper (1 ppm) that would result in mortality of the population of zebra mussels. Based on this report and project requirements, Offutt AFB and the Zebra Mussel Working Group determined that treating the lake with copper sulfate pentahydrate crystals would be the most feasible treatment method with the greatest potential for success. Copper sulfate pentahydrate crystals (USEPA registration number 56576-1) were chosen because the chemical product was already registered with USEPA and the NDA. In addition, it is listed as a molluscicide on the product label.

2.1.2 Special Local Need Label

In order to legally apply this product for eradication of zebra mussels, a USEPA Section 24 (c) Special Local Need Label was required. Offutt AFB worked with the NDA to acquire the Special Local Need Label from the USEPA for the use of copper sulfate crystals to eradicate zebra mussels from Lake Offutt (Appendix A). The Special Local Need Labeling for the use of copper sulfate at Offutt AFB included the following stipulations:

- The label only applied to Lake Offutt.
- The label was only valid for two applications, and expired on 31 May 2009.
- The average lake concentrations of elemental copper could not exceed 1 ppm based on the total lake volume.
- The lake area must be monitored for dead fish during daylight hours. All dead fish must be collected and disposed of by burial or landfill.
- Swimming in the lake, consumption of fish from the lake, and the use of the lake as direct or indirect source of drinking water were prohibited during and after lake treatment until the water concentration of copper was at or below 1.3 ppm.
- Warning signs must be posted at the lake.

Once it was known that the desired label would be issued by the USEPA, Offutt AFB contracted with URS Group, Inc. (URS) for the purchase and application of the copper sulfate, pre- and post-treatment monitoring, compliance with the National Environmental Policy Act of 1969 (NEPA), and preparation of interim and final reports.

2.1.3 Purchase and Delivery of Chemical

Chem One Ltd. of Houston, Texas acquired the special use label from the USEPA that allowed copper sulfate to be used as molluscicide (Appendix A). URS then procured 50,000 pounds of copper sulfate with a portion to be delivered to Lake Offutt in September 2008 and the remainder delivered in April 2009.

2.1.4 Lake Volume Determination

The quantity of copper sulfate needed to eradicate the zebra mussels was dependent upon the volume of water in Lake Offutt. The NGPC used global positioning system (GPS) and sonar to collect bathymetric (depth) readings throughout the lake. The collected information was used to create a contour map of the lake (Figure 2-1) (NGPC 2006). The NGPC used the area and depth of the various contours to calculate the lake's volume at various water elevations (Table 2-1). Information in this table was used to determine the volume of water to be treated during each application of copper sulfate.

2.1.5 Veliger Sampling

The NPPD collected veliger samplings from Lake Offutt, Carter Lake, and the Missouri River to determine if zebra mussels were present in the Missouri River or lakes associated with the Missouri River. These samples were collected on 31 July and 13 September 2007 and were sent to Dr. Gerald Mackie of the University of Guelph in Guelph, Ontario, Canada for identification and enumeration. Samples collected from Carter Lake and the Missouri River contained no veligers, whereas two of the three samples collected from Lake Offutt contained numerous zebra mussel veligers.

To determine if zebra mussels had gained access to the East Gate Drain upstream from the Lake Offutt, personnel from Offutt AFB, URS, and OPPD collected veligers samples from ponded areas within the East Gate Drain (Figure 1-2) on 8 August 2008. A total of three samples were collected and none of the collected samples contained zebra mussel veligers.

2.1.6 National Environmental Policy Act

The Council of Environmental Quality (CEQ) regulations on implementing NEPA [40 Code of Federal Regulations (CFR) Parts 1500 through 1508] and the Air Force regulations for NEPA compliance (32 CFR Part 989 and Air Force Instructions (AFI) 32-7062), direct the Air Force (AF) to fully understand and take into consideration during decision-making, the environmental consequences of the proposed federal action. Therefore, to comply with NEPA and these other associated regulations, Offutt AFB prepared an Environmental Assessment (EA) that identified the proposed action and the expected environmental consequences of the action.

The EA was completed in 2008 and evaluated potential environmental impacts related to the application of copper sulfate (Proposed Action) and the No Action Alternative, defined as maintaining the status quo with no actions being funded or completed to remove the zebra mussels from the Lake Offutt. The EA provided the public and decision-makers with the information required to understand and evaluate these potential impacts. The EA determined that potential consequences of copper sulfate treatments would result in no significant adverse effects on resources within and in the vicinity of Lake Offutt (URS 2008c).

Offutt AFB published a public notice in a local newspaper informing the public of the proposed project and allowing the public 14 days to comment on the Draft EA. Relevant comments received during this comment period were attached to the Final EA. Because no significant adverse effects would result from the implementation of the proposed action, preparation of an Environmental Impact Statement was not required and a Finding of No Significant Impact (FONSI) was appropriate. A FONSI was prepared and signed on 19 September 2008.

2.1.7 Public Outreach Activities

In addition to the public notice about the Draft EA for the zebra mussel eradication, Offutt AFB distributed fact sheets regarding the proposed treatment throughout Offutt AFB and to interested people, including horse owners that boarded horses at the Lake Offutt horse stables. A notice was also published in the Offutt AFB newspaper and on the Offutt AFB website. The fact sheets

included information about zebra mussels, the planned copper sulfate treatment activities, and lake use restrictions during and following the treatment.

2.1.8 Zebra Mussel Distribution SCUBA Survey

To provide information on the distribution of adult zebra mussels within Lake Offutt, URS employed SCUBA divers to visually survey the bottom of the lake and record the distribution of zebra mussel colonies. Information collected was used to determine the appropriate pattern for the application of the copper sulfate crystals. The SCUBA survey was conducted on 31 July 2008 and consisted of multiple 200-foot transects from a center point established at several locations at various depths (Figure 2-2). In addition, free dives were also made around a submerged tree and near the boat dock.

Generally, the divers observed zebra mussels on any available hard substrate including concrete, boat docks, inundated and submerged trees and brush, and debris such as aluminum cans, golf balls, and eyeglasses. However, no zebra mussels were observed within areas that contained only silt and/or sand, which generally describes the substrate of the deeper portions of the lake. The adult zebra mussels distribution was mostly limited to the shallow shoreline areas of the lake, which contained substrate that could be colonized by the zebra mussels.

2.1.9 Pre-Treatment Data Collection

The lake water elevation and basic water quality parameters were measured prior to both applications. The information was used to determine the amount of copper sulfate needed, if thermal stratification was present in the lake, and to document pre-treatment alkalinity and copper concentrations. Throughout the project, all field work was performed in general accordance with the work plan (URS 2008a) and the site safety and health plan (URS 2008b). All field activities and analyses results were recorded in the field log book.

2.1.9.1 Lake Elevation Surveys

Pretreatment lake elevation surveys were conducted on 15 September 2008 and 17 March 2009, using a surveyor's level. A nearby groundwater monitoring well (FT3-MW11SI) was used as a benchmark for the survey (Figure 1-3). The well casing has a known elevation of 966.78 feet above mean sea level (msl). The elevation difference between the lake water and the casing elevation was used to determine the lake elevation prior to each application. With the elevation of the lake known, Table 2-1 was used to determine the amount of water to be treated.

2.1.9.2 Water Quality Surveys

Prior to the each application of the copper sulfate, URS collected water quality information at seven locations on the Lake Offutt (Figure 2-3). Samples were collected on 30 July 2008 and 2 April 2009. The coordinates for each location were recorded using a Trimble Juno® GPS. Subsequent samples (post-treatment) were collected from the same approximate location on the lake. Parameters measured included temperature, pH, alkalinity, and copper concentration. The following equipment was used to obtain the water quality information:

- Temperature and pH — Oakton® pH/Con/10 meter
- Alkalinity — Hach® alkalinity test strips or a Hach ® digital titration kit
- Copper — Hach® Pocket Colorimeter II test kit

Temperature and pH measurements were collected throughout the water column to establish a vertical profile and determine if a thermocline was present in the lake. This was accomplished by lowering the submersible probe into the water and taking readings at 3-foot depth intervals. Alkalinity and copper concentration were collected at three points throughout the water column (surface, middle, and bottom depths) to determine an average concentration throughout the lake. The water depth was measured at each sampling point with a Hummingbird® fish finder. Copper and alkalinity samples were collected by lowering a Whale® submersible electric pump and polyethylene tubing to the desired water depth. The water was then collected in vials and immediately analyzed for alkalinity and copper concentrations.

2.2 TREATMENT PROCEDURES

Copper sulfate was applied to the Lake Offutt during two separate treatments on 17 and 18 September 2008 and again on 7 and 8 April 2009. All work was completed in accordance with the work plan (URS 2008a). URS adhered to all stipulations of the Special Local Need Label (Appendix A). All field activities were logged daily in a field log book.

2.2.1 Lake Use Restrictions

Prior to treatment with copper sulfate, signs were posted to indicate the closure of Lake Offutt to all activities including fishing and boating. The signs were posted at the entrance to the lake, at the gate to the horse stables, the boat ramp, in the area of Cast-a-Ways Boathouse, and at several parking areas used by fishermen. During the 2008 application, the signs were left up for seven days, at which time the measured copper concentrations were well below the 1.3 ppm label requirement. During the second application, signs were up for 3 days and again the copper concentrations at all measured locations were well below 1.3 ppm before the signs were removed.

2.2.2 Chemical Application

Copper sulfate pentahydrate was applied to the Lake Offutt in two treatments on 17 and 18 September 2008 and again on 7 and 8 April 2009. Each application was completed within a 30-hour period, which was well within the stipulation of the Special Local Need Label (Appendix A). As discussed in Section 2.1.9, the lake's elevation was measured prior to each application and used to determine the volume (acre feet) of water in the lake that needed to be treated (Table 2-1). Based on the number of acre feet of water in the lake, the amount of copper sulfate needed to achieve a 1 ppm concentration of copper (10.8 pounds of copper pentahydrate per acre foot of water) was determined. During the 2008 application, there was approximately 2,500 acre feet of water in the lake and 27,000 pounds of copper sulfate were needed to achieve the desired copper concentration. In April 2009, the lake level was lower and 2,130 acre feet of water was in the lake and 23,000 pounds were required to achieve the desired concentration. The copper sulfate

product consisted of medium sized (5 to 8 millimeter diameter) copper sulfate pentahydrate crystals.

Farmers National Company (FNC) was sub-contracted to apply the copper sulfate to the lake. Prior to each application, FNC conducted a pre-application visual survey of the lake to note obstructions and planned application paths. The copper sulfate was applied via boat mounted vortex spreaders that uniformly dispersed the chemical in an approximately 25 to 30 foot swath. Copper sulfate was spread evenly at a rate between 1,000 to 1,500 pounds per hour. Multiple applications paths were made across the lake to ensure even coverage of copper sulfate. A GPS unit was used to assist in navigation of the lake and to ensure full coverage was achieved. Line transect data for each treatment were recorded during application, analyzed in Geographical Information System (GIS), and mapped with 25 foot buffers to depict the coverage of copper sulfate spreaders. The application paths are shown in Figures 2-4 and 2-5.

During both applications, the copper sulfate was spread thoroughly in areas with a dense distribution of adult zebra mussels, based on the recommendations from Haller (2007) and the results of the pre-application diver survey. Copper sulfate was also distributed throughout the lake, but the application paths differed between the 2008 and 2009 treatments based on field conditions. In 2008, more copper sulfate was spread throughout the lake (as opposed to concentrated on shorelines) because the water temperature exceeded 54 degrees Fahrenheit (°F), the minimum required temperature for zebra mussel reproduction and presence of veligers (Claudi and Mackie 1994). During the April 2009 application, copper sulfate was applied throughout the lake but was more concentrated on the perimeter since the presence of veligers was unlikely due to the water temperature being below 50 °F.

Hand application of copper sulfate was completed in drainage ways and other areas that could not be reached with the boat due to obstructions (docks, trees, rocks, etc.) The volume of water in these areas was calculated based on the approximate surface area and average depth by referring to aerial photographs and confirming with field measurements. Hand application was used to apply 110 pounds of copper sulfate to acres with ponded water located up gradient of Lake Offutt to achieve the desired 1 ppm copper concentration.

To prevent the spread of zebra mussels, all equipment that came in contact with lake water was decontaminated using an approved method prior to being used at other water bodies. This primarily applied to the boats used to spread the chemical, the trailers that were used to transport the boats, and any analytical equipment that was removed from the study area. Decontamination methods included a steam cleaner and "dry docking" for a minimum of 14 days.

2.3 POST-TREATMENT MONITORING

Post-application monitoring was performed in four categories, 1) water quality monitoring, 2) adult zebra mussel monitoring, 3) veliger (larval) zebra mussel monitoring, and 4) fish mortality. These monitoring categories are described in the following sections.

2.3.1 Water Quality Monitoring

Post-treatment water quality monitoring for temperature, pH, alkalinity, and copper occurred at seven locations using the same methods as the pre-treatment water quality analysis (see Section 2.2.1). The samples were collected in the same approximate location as the pre-treatment samples (Figure 2-2). Post-treatment temperature and pH were measured in May 2009. Residual copper concentration and alkalinity monitoring occurred at the same sample locations (Figure 1-3) and with the same methods as the pre-treatment analysis (Section 2.1.9). Copper and alkalinity measurements were collected 24 hours after treatment in both years. Additional measurements were collected at 30 days after treatment in 2008. In 2009, additional measurements were collected at four, seven, and 30 days after treatment.

2.3.2 Adult Zebra Mussel Monitoring

Adult zebra mussel mortality monitoring was used to determine the effectiveness of the copper sulfate treatment. Live zebra mussel colonies were deployed on 15 September 2008, two days prior to the first copper sulfate treatment. Six colonies of approximately 40 live zebra mussel individuals attached to rock substrate were collected from the shore and placed in minnow buckets at six locations throughout the lake. The minnow buckets were attached to buoys and the colonies were monitored for mortality at one day (19 September 2008), three days (21 September 2008), and eight days (26 September 2008) after the 2008 application. Mortality was based on the estimated proportion of shells that had opened at the time of observation. Due to potential re-infestation, no live zebra mussel colony mortality monitoring occurred in 2009.

Re-colonization of zebra mussels was monitored by employing coupon sampling, a procedure that utilizes an artificial substrate or "coupon" to provide habitat for zebra mussels to attach. In 2008, it was determined that a combination of concrete blocks, wood, and polyvinyl chloride (PVC) piping would be used for each coupon sampler and seven coupons were installed immediately after the treatment of the copper sulfate (Figure 2.2). In 2008, the coupon samplers were checked only once (approximately 30 days following the copper sulfate applications) because available boats on the lake were removed for winter prior to 60 days post-treatment. All recovered coupons were thoroughly inspected and returned to the water.

Due to theft/loss of buoys in 2008, the 2009 coupon sampling system was modified so that samplers could be recovered without using surface buoys. GPS coordinates were recorded for each of the seven coupons set in 2009. The samplers were recovered by using GPS to locate the coupon locations and a grapnel hook was used to retrieve the rope lines. The coupon substrate was also modified in 2009 to include a multi-plate sampler made of plywood and PVC pipe (see photo Appendix B). This design provided increased surface area for colonization. In 2009, the coupons samplers were checked approximately 60, 90, and 120 days after treatment. All recovered coupons were thoroughly inspected and returned to the water. All recovered coupons were removed on 10 August, 2009.

2.3.3 Veliger Monitoring

Zebra mussel veliger sampling was performed using a modification of the quantitative veliger sampling procedure in Claudi and Mackie (1994). Plankton samples were collected with a 80 micrometer mesh funnel shaped plankton net with a 8 inch opening. The net was pulled for a minimum of 150 feet in a horizontal tow, with the net being pulled from the bottom of the lake to the surface. After the net was retrieved the inside was rinsed with water and collected in vials and mixed with isopropyl alcohol to achieve a 70 percent preservative solution. Veliger samples were analyzed for veliger presence by Dr. Gerald Mackie, University of Guelph, Ontario, Canada. During each sampling event, three samples were taken from different locations within the lake. Figure 2-6 shows the location of the veliger tows in both 2008 and 2009. In 2008, veliger samples were collected approximately 30 days after copper sulfate application (winter conditions prevented additional sampling). In 2009, the samples were collected approximately 60, 90, and 120 days after treatment. The approximate distance of each plankton net tow and sample location was determined, either by visual estimate or GPS points, and recorded. Approximate volume of filtered water was calculated according to the following formula:

$$\text{Volume} = \pi r^2 \times h$$

where r = radius of the plankton net opening, h = distance the net is pulled and $\pi = 3.14160$.

2.3.4 Fish Mortality Monitoring

Monitoring for non-target fish mortality began immediately following the 2008 and 2009 copper sulfate treatments, as specified by the Special Local Need Label. A major concern of Offutt AFB was that dead fish would attract scavenging birds, which pose a safety hazard to the nearby flight line. Field crews wearing waders patrolled the entire shoreline and manually removed all observed dead fish. Fish were also collected by boat using handheld nets as needed. All fish were gathered in plastic tubs and identified. The weight and/or counts of fish species were estimated and recorded in the field log book or on fish tally sheets. All collected fish were buried at the end of each collection day in pits adjacent to the Lake Offutt (Figure 1-3) in accordance with the Special Local Need Label. The pits were located and excavated to meet all of the recommendations from the NDEQ environmental guidance document for disposal of animal carcasses (NDEQ 2007). Fish mortality monitoring continued as needed until no dead fish were observed for 48 consecutive hours. Dead fish removal continued for approximately 40 days following both the 2008 and 2009 copper sulfate applications.

TABLE 2-1
ELEVATION AND VOLUME
LAKE OFFUTT
OFFUTT AFB

Elevation (msl)	Surface Area (acres)	Water Volume (acre feet)
957.8	122.7	2611.4
956.8	121.5	2489.3
955.8	120.2	2368.4
954.8	119.0	2248.8
953.8	117.7	2130.4
952.8	116.5	2013.3
951.8	115.1	1897.5
950.8	113.7	1783.1
949.8	112.3	1670.1

Source: NGPC 2006

Notes:
msl = mean sea level
ppm = parts per million

URS

Figure 2-1
Lake Offutt Bathymetric Contours

Designed By: SP	Zebra Mussel Eradication Offutt AFB, Nebraska
Drawn By: SP	
Checked By: BO	
Submitted By: BO	Projection: NAD83 HARN State Plane, Nebraska, Feet

Legend

5 Foot Contours

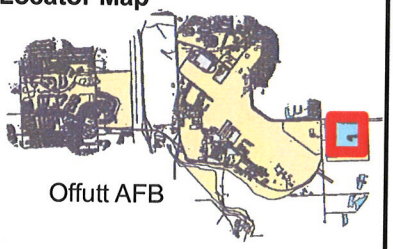
Roads

N

Source: Nebraska Game And Parks Commision Fisheries Division (2006)

0 75 150 300 450 600 Feet

Locator Map



Offutt AFB

URS

Figure 2-2
SCUBA Diving Locations

Designed By: JW	Zebra Mussel Eradication Offutt AFB, Nebraska
Drawn By: JW	
Checked By: BO	
Submitted By: BO	Projection: NAD83 HARN State Plane, Nebraska, Feet

Legend

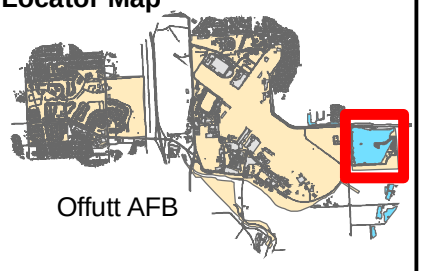
SCUBA Free Dive Area

SCUBA Transects

0 500 1,000 Feet

N

Locator Map



URS

Figure 2-3
Water Quality Analysis Locations

Designed By: SP	Zebra Mussel Eradication Offutt AFB, Nebraska
Drawn By: SP	
Checked By: BO	
Submitted By: BO	Projection: NAD83 HARN State Plane, Nebraska, Feet

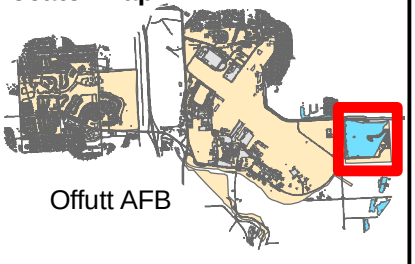
Legend

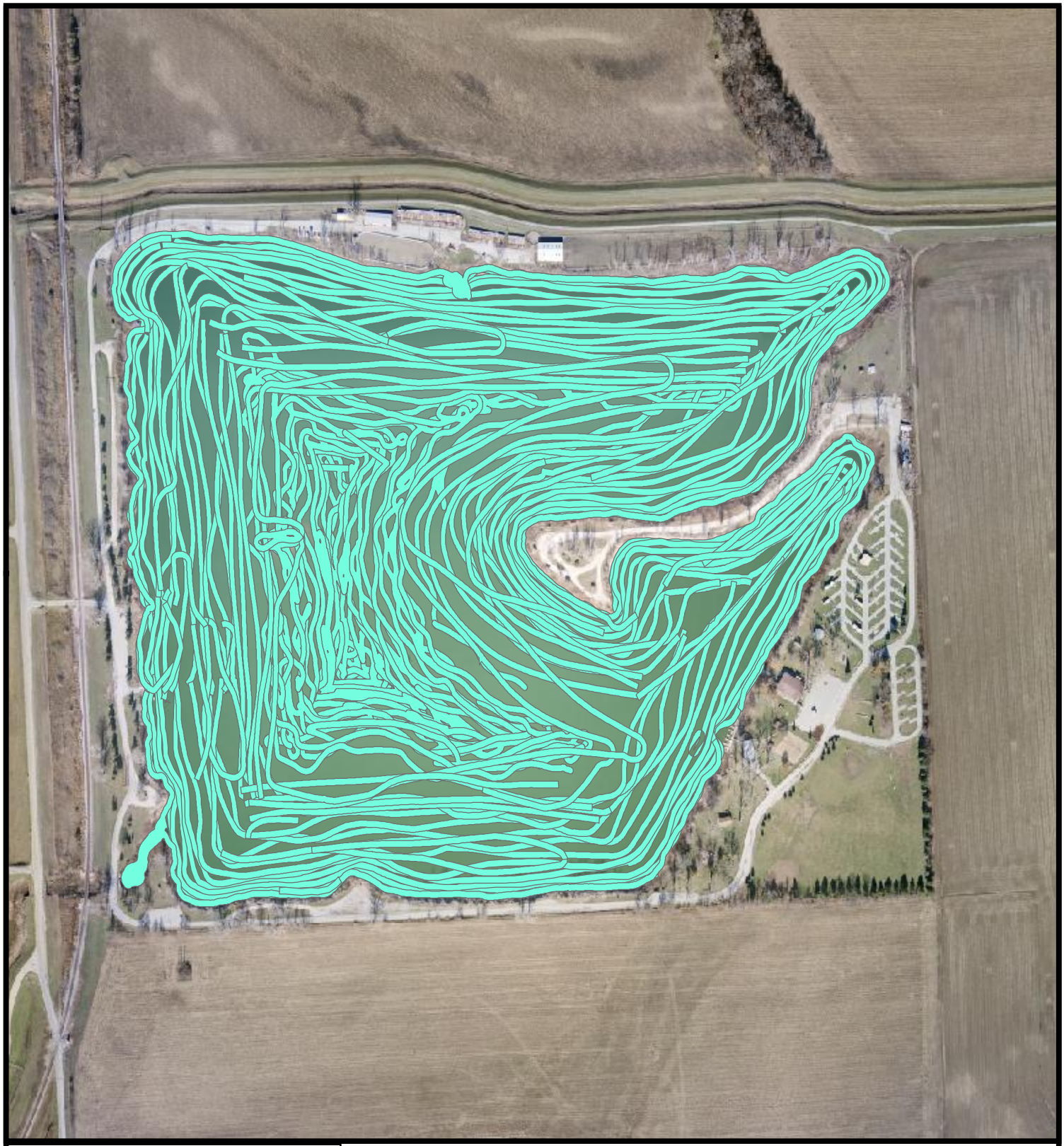
- water quality point 2008
- water quality point 2009
- coupon samplers

0 500 1,000 Feet

N

Locator Map





URS

Figure 2-4
2008 Copper Sulfate Application Paths

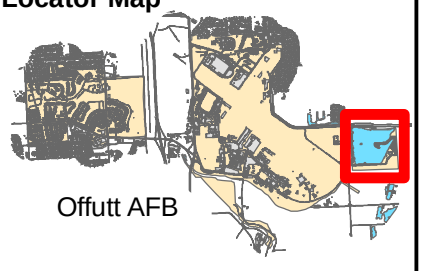
Designed By: SP	Zebra Mussel Eradication Offutt AFB, Nebraska
Drawn By: SP	
Checked By: BO	
Submitted By: BO	Projection: NAD83 HARN State Plane, Nebraska, Feet

Legend

2008 Copper Sulfate Application Paths (25 ft)

0 500 1,000 Feet

Locator Map



URS

Figure 2-5
2009 Copper Sulfate Application Paths

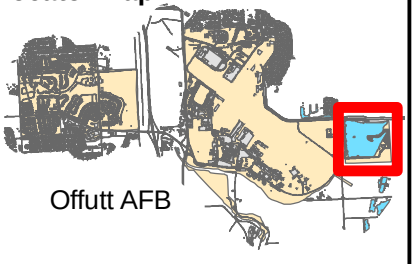
Designed By: SP	Zebra Mussel Eradication Offutt AFB, Nebraska
Drawn By: SP	
Checked By: BO	
Submitted By: BO	Projection: NAD83 HARN State Plane, Nebraska, Feet

Legend

2009 Copper Sulfate Application Paths (25 ft)

0 500 1,000 Feet

Locator Map



URS

Figure 2-6
Veliger Tow Locations

Designed By: SP	Zebra Mussel Eradication Offutt AFB, Nebraska
Drawn By: SP	
Checked By: BO	
Submitted By: BO	Projection: NAD83 HARN State Plane, Nebraska, Feet

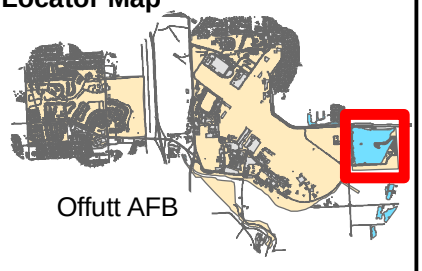
Legend

- Plankton Net Tow Paths
- October 2008
- June 2009
- July 2009
- August 2009

0 500 1,000 Feet

N

Locator Map



3.1 GENERAL FIELD OBSERVATIONS AND CONDITIONS

Due to above average precipitation during the summer of 2008 and the plugging of the outlets to the Bellevue Drain, the water elevation in Lake Offutt was above average, which increased the surface area of the lake. The higher water levels resulted in much of the riparian vegetation around the lake being inundated, which provided additional substrate for colonization by zebra mussels. Prior to the 2008 treatment, Lake Offutt had increased clarity not usually observed in sandpit lakes in the region. The increased clarity was likely the result of a reduced quantity of phytoplankton due to the large number of zebra mussels. Within a month after the 2008 treatment, the lake underwent a noticeable shift to a more eutrophic condition (cloudy, green water), which indicated an increase in phytoplankton in the lake.

The elevation of the lake was approximately 3.5 feet lower during the 2009 treatment than the 2008 treatment, resulting in a large quantity of zebra mussel shells that were previously submerged along the shoreline being readily visible. Additionally, millions of empty zebra mussel shells washed up on the shoreline. These observations indicate that copper sulfate was effective in killing zebra mussels.

3.1.1 Water Temperature and pH

Table 3-1 lists the pre-treatment and post-treatment temperature measurements in both 2008 and 2009. A temperature profile of the lake was completed on 30 July 2008, in conjunction with the pre-treatment SCUBA survey. At this time, the mean temperature of the lake was 82 °F, and stratification was noted with temperature decreasing considerably at depths greater than 18 feet. At the time of the 2008 treatment (15 September 2008), another temperature profile was completed and the mean temperature had decreased to 70° F and temperature stratification was not evident with less than 2° F difference from top to bottom.

The 2009 treatment was completed in April when the water temperature was much cooler than the 2008 treatment. The mean lake temperature on 2 April 2009 was measured at 46° F with no noticeable stratification. The mean lake temperature on 6 May 2009, 30 days after the lake treatment, was measured at 61° F with a slight stratification present at approximately 15 feet below the water surface.

During the sampling events in 2008 and 2009, pH measurements ranged from 8.2 to 8.6 and were slightly higher in 2009 than in 2008 (Table 3-1). These pH values are consistent with the pH of most surface waters found in eastern Nebraska. The general pattern shows that pH decreased with depth.

3.1.2 Alkalinity

Table 3-2 lists the values for alkalinity measurements. The average alkalinity concentration in the lake ranged from 90.5 to 127.0 ppm.

3.1.3 Copper

Copper concentrations for the pre-treatment and post-treatment water quality monitoring are shown in Table 3-3 and Figure 3-1. Average copper concentrations never exceeded the USEPA maximum contaminant level (MCL) of 1.3 ppm for drinking water during or following either the 2008 or 2009 treatments. The lake-wide average copper concentration increased following the copper sulfate application and generally became more uniform and decreased over time. In 2008, the 24-hour post-treatment copper concentrations varied from 0.00 to 0.73 ppm, with a mean concentration of 0.25 ppm, and the 30-day concentrations varied 0.04 to 0.20 with a mean concentration of 0.10 ppm.

In 2009, the 24-hour post-treatment copper concentrations varied from 0.15 to 0.56 ppm with a mean concentration of 0.32 ppm, the 96-hour concentrations varied between 0.13 and 0.68 ppm with an average concentration of 0.33 ppm, the 7-day concentrations ranged from 0.06 to 0.41 ppm with an average concentration of 0.28 ppm, and the 30-day concentrations ranged from 0.15 to 0.39 ppm with an average concentration of 0.28 ppm. Several copper concentrations were not measured on 4 April 2009, due to a limited supply of reagent packets for the Hach® Colorimeter.

3.2 ADULT ZEBRA MUSSEL MONITORING RESULTS

The sample containers (minnow buckets) in which adult zebra mussels had been placed following the 2008 application of copper sulfate were checked at 24, 72, and 168 hours to determine the mortality of adult zebra mussels. At 24 hours, approximately 50 percent of the zebra mussels were dead (individuals with open shells). Mortality was determined to be 95 percent at 72 hours and at 168 hours all of the adult zebra mussels were dead. However, it should be noted that between the 72 hour and 168 hour observations, two of the samplers had been removed by unknown parties.

Only three of the coupon samplers (Points 2, 5, and 6) were recovered 30 days after the 2008 treatment; however, no indication of colonization was observed on the three coupons. It is assumed the remaining coupon samplers were removed by fisherman or other lake users.

Only four of the 2009 samplers (Points 2, 4, 6, and 7) were recovered during the 60-day coupon monitoring on 9 June 2009. Three of the 2008 samplers (Points 2, 5, and 7) were also recovered at this time. No zebra mussels were observed on any of these seven coupons. Similarly, no zebra mussels were observed on the four recovered coupon samplers on 8 July 2009 (two from 2009 [Points 2 and 7], two from 2008 [Points 2 and 7]) or the three samplers recovered on 10 August 2009 (two from 2009 [Points 2 and 4], one from 2008 [Point 7]).

In addition to monitoring the coupon samplers, multiple rocks and other substrate were inspected along the shoreline during the fish collection activities and after the last coupon sampling event on 10 August 2009. No live zebra mussels were ever observed.

3.3 VELIGER SAMPLING RESULTS

Table 3-4 shows the results for the veliger sampling conducted during 2008 and 2009. Between 415 and 2,157 gallons of water were sampled during the plankton net tows. Although the samples contained numerous plankton species (including various copepods, cladocerans, and rotifers), no zebra mussel larvae were present in any of the samples. This is substantially different from samples NPPD collected from Lake Offutt on 31 July 2007 that contained up to 168 veligers in a sample.

3.4 FISH MORTALITY RESULTS

Copper sulfate was applied to Lake Offutt at a concentration of 1 ppm elemental copper. Although copper sulfate is an approved chemical that can be applied in the aquatic environment for the control of aquatic weeds and snails, many previous applications were either at lower application rates or were used as spot treatment for control of nuisance aquatic weeds. Some fish mortality was expected since copper is known to be toxic to certain fish at lower concentrations under various conditions. However, it was not known which species would be affected or to what extent due to differing sensitivity or exposures to the chemical.

Fish mortality occurred following both the 2008 and 2009 copper sulfate treatments, and extended over a prolonged period in both events. Table 3-5 lists the 21 fish species killed following the copper sulfate treatments. Table 3-6 provides the estimated weight of dead fish collected as well as the time period of mortality. As stated previously, the Special Local Need Label issued by the USEPA required that all dead fish be picked up and disposed until no dead fish were found during a 48-hour period. Dead fish were picked up for approximately 5 weeks following both the 2008 and 2009 treatments and buried in an area adjacent to the lake. Both the species composition and the poundage of fished killed varied between the two treatments.

In 2008, dead fish were evident starting on 18 September 2008 (during the second day of the copper sulfate application). Dead fish removal started immediately following the completion of the application of the copper sulfate and continued for approximately 5 weeks. During this period, approximately 38,500 pounds of dead fish were collected (Table 3-6). This quantity of fish killed equates to approximately 320 pounds of fish per acre. The vast majority (approximately 72 percent by weight) of dead fish recovered in 2008 were buffalo (bigmouth and smallmouth). Other species that were killed in sizable numbers included common carp, grass carp, bighead carp, white perch, freshwater drum, and gizzard shad. Smaller quantities of game fish species (largemouth bass, smallmouth bass, paddlefish, black bullhead, flathead catfish, channel catfish, crappie, and walleye/saugeye) were also killed in 2008. As will be discussed in the following paragraphs, approximately 97 percent of the fish killed (by weight) were non-game fish and less than 0.2 percent was prized game fish (bass, catfish, walleye/saugeye, and crappie).

In 2009, distressed fish were observed on 8 April 2009, during the second day of the copper sulfate application. Collection of dead fish started on 9 April 2009 and continued until 15 May 2009. Approximately 3,000 pounds of dead fish were collected and buried. The 2009 treatment resulted in an approximately 26 pounds per acre of fish being killed of which almost 86 percent were non-game species. The majority of the fish collected were buffalo (bigmouth and

smallmouth) and common carp. Other species that were collected in fairly significant numbers were freshwater drum, bighead carp, and crappie. The majority of crappie that was collected died within the first two weeks after treatment. In 2009 prized game fish (largemouth bass, smallmouth bass, channel catfish, flathead catfish walleye/saugeye, and crappie) comprised approximately 10 percent of the poundage killed.

In summary, it was apparent that some species of fish were much more susceptible to copper sulfate than other species and the period of mortality is shown on Table 3-5. Based on the fish collected, the most susceptible species included gizzard shad, common carp, bigmouth buffalo, smallmouth buffalo, bighead carp, walleye/saugeye, and freshwater drum. In 2009, an estimated 3,000 pounds of fish were killed and, similar to the 2008 event, the majority of species affected were the non-game species (mostly buffalo and common carp). However, the overall mortality rate was drastically lower in 2009. The biomass killed following the 2008 treatment (approximately 320 pounds of fish per acre) may have had major influence on the quantity of fish remaining in the lake in 2009. Another disparity between the years is that a larger number of crappie were killed in 2009 (approximately 600 individuals). Only one new species (bluegill) was collected in 2009. Two species (paddlefish and black bullhead), were collected in 2008, but not in 2009. In 2009 there were fewer gizzard shad, white perch, walleye/saugeye, and freshwater drum. In 2009 the precise periods of mortality by species was not as pronounced as it was in 2008. In summary, the two copper sulfate treatments resulted in approximately 41,500 pounds of dead fish being removed from the lake, of which over 40,000 pounds (97 %) were non-game and invasive fish species and approximately 325 pounds (less than 1 %) were prized game fish species.

TABLE 3-1
TEMPERATURE AND pH DATA
LAKE OFFUTT
OFFUTT AFB

	7/30/2008			9/15/2008			4/2/2009			5/6/2009		
Location	Depth	Temp	pH	Depth	Temp	pH	Depth	Temp	pH	Depth	Temp	pH
Point #1	0	83.1	8.2	0	69.3	8.0	0	46.9	8.2	0	63.1	8.8
	3	82.6	8.3	3	69.3	8.2	3	46.6	8.2	3	63.1	8.7
	6	81.9	8.2	6	69.1	8.1	6	46.0	8.3	6	62.8	8.7
	9	81.7	8.2	9	69.1	7.9	9	45.9	8.2	9	62.2	8.7
	12	81.5	8.0	12	69.1	7.8	12	45.9	8.2	12	58.1	8.5
	15	81.3	8.0									
Point #2	0	84.4	8.3	0	69.3	8.2	0	47.1	8.7	0	62.6	8.8
	3	82.8	8.5	3	69.3	8.3	3	47.1	8.6	3	62.2	8.8
	6	81.9	8.5	6	69.3	8.2	6	46.9	8.5	6	61.9	8.7
	9	81.5	8.4	9	69.3	8.2	9	46.9	8.4	9	61.2	8.7
	12	81.3	8.3	12	69.3	8.2	12	46.9	8.4	12	59.9	8.8
	15	81.1	8.1	15	69.3	8.2	15	46.9	8.4	15	57.9	8.6
	18	80.4	7.8	18	69.3	8.1	18	46.9	8.4	18	56.1	8.6
	21	78.4	7.6	19	69.1	7.9						
Point #3	0	84.4	9.1	0	69.4	8.2	0	46.6	8.7	0	62.8	8.7
	3	82.9	9.1	3	69.4	8.2	3	46.6	8.6	3	62.2	8.9
	6	82.4	9.1	6	69.4	8.1	6	46.4	8.6	6	61.5	8.7
	9	82.2	8.9	9	69.4	8.0	9	46.4	8.5	9	61.5	8.8
	12	82.0	8.7	12	69.3	8.1	12	46.4	8.4	12	60.6	8.7
	15	81.7	8.3	15	69.3	8.0	15	46.2	8.4	13	58.6	8.4
	18	80.8	8.0	18	69.3	8.0	18	46.2	8.4			
	21	78.1	7.8	21	69.3	8.0	19	46.2	8.4			
	23	74.3	7.8									
Point #4	0	85.5	8.9	0	70.2	8.0	0	46.8	8.2	0	62.6	8.6
	3	83.8	9.0	3	70.2	8.0	2	46.8	8.3	2	62.6	8.6
	6	82.8	9.0	6	70.0	8.0	4	46.8	8.2			
	9	82.4	8.9	9	69.8	7.9						
	12	82.0	8.7	12	69.8	7.9						
	15	81.7	8.4	15	69.6	8.0						
	18	80.8	8.1	18	69.4	7.9						
	21	78.8	7.9	21	69.4	7.9						
	23	75.4	7.7	24	69.4	7.9						

TABLE 3-1
TEMPERATURE AND pH DATA
LAKE OFFUTT
OFFUTT AFB

	7/30/2008			9/15/2008			4/2/2009			5/6/2009		
Location	Depth	Temp	pH	Depth	Temp	pH	Depth	Temp	pH	Depth	Temp	pH
Point #5	0	84.6	8.2	0	70.7	7.8	0	46.4	8.6	0	62.4	8.5
	3	82.6	8.3	3	70.2	7.9	3	46.4	8.5	3	62.4	8.5
	6	81.7	8.2	6	69.8	7.8	6	46.4	8.4	6	62.4	8.5
	9	81.5	8.1	9	69.8	7.8	9	46.4	8.4	9	61.9	8.5
	12	81.3	8.0	12	69.8	7.7	12	46.4	8.5	12	61.7	8.6
	18	81.1	7.8	15	69.6	7.8	15	46.4	8.4	15	57.2	8.5
	20	80.6	7.7	18	69.6	7.8	18	46.2	8.4	17	55.9	8.0
				21	69.4	7.8	21	46.2	8.4			
				23	69.4	7.7						
Point #6	0	87.1	8.4	0	70.2	8.3	0	46.8	9.4	0	63.0	8.6
	3	83.3	8.3	3	70.2	8.1	3	46.4	9.1	3	62.8	8.6
	6	82.0	8.1	6	70.2	8.0	6	46.2	8.8	6	62.8	8.6
	9	81.7	8.0	9	69.8	8.0	9	46.2	8.6	9	62.6	8.6
	12	81.3	7.9	12	69.8	7.9	12	46.2	8.6	12	60.8	8.6
	15	81.0	7.7	15	69.6	7.9	16	46.2	8.5	14	57.2	8.4
	17	80.2	7.2	18	69.3	7.9						
				19	69.3	7.8						
Point #7	0	84.6	8.3	0	70.2	7.9	0	46.6	9.5	0	63.7	8.7
	3	82.6	8.3	3	70.2	8.0	3	46.6	9.1	3	63.5	8.7
	6	81.9	8.0	6	69.8	8.0	6	46.6	8.9	6	63.3	8.6
	9	81.5	7.9	9	69.8	7.9	9	46.2	8.7	9	62.6	8.6
	12	81.5	7.9	12	69.6	7.9	12	45.9	8.6	12	60.8	8.5
	15	81.3	7.8	15	69.3	7.9	13	45.7	8.6	14	57.2	8.4
	18	80.4	7.5	16	69.3	7.6						
	21	79.0	7.3									
	23	75.0	7.0									
Average		81.5	8.2		69.6	8.0		46.5	8.5		61.2	8.6

Notes:
Depth = Feet Below Surface
Temp = Degrees Fahrenheit

TABLE 3-2
ALKALINITY MEASURED
LAKE OFFUTT
OFFUT AFB

Location	Depth	7/30/2008	10/15/2008	4/2/2009	4/9/2009	4/11/2009	4/14/2009	5/6/2009
Point #1	top	195	80	80	220	80	130	120
	middle	181	80	120	240	80	100	100
	bottom	104	70	120	200	100	100	120
Point #2	top	80	120	120	120	100	60	100
	middle	120	80	100	200	100	100	140
	bottom	160	80	100	120	90	90	140
Point #3	top	89	40	80	100	80	100	120
	middle	113	90	100	160	120	120	100
	bottom	105	110	100	100	80	100	100
Point #4	top	107	120	120	100	120	120	100
	middle	140	100	N/A	N/A	N/A	N/A	N/A
	bottom	120	110	120	120	60	N/A	100
Point #5	top	40	130	120	80	80	90	100
	middle	80	120	120	160	100	N/A	120
	bottom	90	100	120	80	80	100	120
Point #6	top	180	40	N/A	80	100	N/A	120
	middle	80	100	N/A	100	120	N/A	140
	bottom	60	80	N/A	80	80	N/A	120
Point #7	top	60	70	120	80	60	110	140
	middle	85	170	120	100	100	N/A	140
	bottom	120	120	120	100	80	120	120
Lake Average		110.0	95.7	110.6	127.0	90.5	102.9	118.0

Notes:
All concentrations are in parts per million
Depth = position in water column

TABLE 3-3
COPPER CONCENTRATION MEASURED
LAKE OFFUTT
OFFUTT AFB

Point	Depth	7/30/2008	9/19/2008	10/15/2008	4/2/2009	4/9/2009	4/11/2009	4/14/2009	5/6/2009
Point#1	top	0.45	0.32	0.20	0.03	0.34	0.44	0.33	0.31
	middle	0.10	0.31	0.14	0.08	0.38	0.26	0.27	0.23
	bottom	0.74	0.31	0.20	0.06	0.37	0.26	0.29	0.15
Point #2	top	0.10	0.38	0.09	0.02	0.30	0.38	0.34	0.17
	middle	0.00	0.13	0.10	0.05	0.21	0.27	0.30	0.22
	bottom	0.04	0.00	0.14	0.05	0.28	0.30	0.30	0.30
Point #3	top	0.06	0.38	0.04	0.02	0.32	0.44	0.41	0.26
	middle	0.06	0.35	0.05	0.07	0.15	0.24	0.19	0.21
	bottom	0.17	0.73	0.04	0.10	0.16	0.20	0.06	0.27
Point #4	top	0.06	0.00	0.04	0.02	0.56	0.30	0.28	0.39
	middle	0.00	0.25	0.04	N/A	N/A	N/A	N/A	N/A
	bottom	0.35	0.41	0.04	0.00	0.32	0.37	N/A	0.36
Point #5	top	0.00	0.41	0.15	0.01	0.45	0.34	0.30	0.33
	middle	0.00	0.00	0.07	0.08	0.34	0.41	N/A	0.28
	bottom	0.00	0.11	0.11	0.03	0.47	0.13	0.25	0.36
Point #6	top	0.06	0.32	0.14	0.11	0.28	0.68	N/A	0.29
	middle	0.23	0.30	0.11	0.01	0.31	0.43	N/A	0.30
	bottom	0.06	0.22	0.15	0.06	0.26	0.29	N/A	0.31
Point #7	top	0.00	0.35	0.11	0.11	0.27	0.29	0.33	0.28
	middle	0.00	0.00	0.11	0.00	0.35	0.17	N/A	0.19
	bottom	0.42	0.00	0.12	0.01	0.30	0.37	0.24	0.30
Lake Average		0.14	0.25	0.10	0.05	0.32	0.33	0.28	0.28

Notes:
Application of copper sulfate occurred on 17 ans 18 September 2008 and 7and 8 April 2009
All concentrations are parts per million (ppm)
Depth = position in water column
n/a = not applicable

TABLE 3-4
ZEBRA MUSSEL VELIGER MONITORING RESULTS
LAKE OFFUTT
OFFUTT AFB

Date	Location	Approximate tow length (feet)	Approximate Water Volume Filtered (gallons)	Veligers Present?	Comments
10/15/2008	North of Peninsula	164	415	NO	
10/15/2008	Near Island	164	415	NO	
10/15/2008	South of Peninsula	164	415	NO	
6/9/2009	South of Peninsula	656	1659	NO	Many plankters, mostly copepods
6/9/2009	North of Peninsula	689	1742	NO	Many plankters, mostly copepods, some mites
6/9/2009	Near Island	525	1327	NO	Mostly rotifers and nauplii, some insects
7/8/2009	South of Peninsula	738	1866	NO	
7/8/2009	Near Island	656	1659	NO	
7/8/2009	South of Peninsula	623	1576	NO	
8/10/2009	Southeast Corner	410	1037	NO	Some cladocerans, copepods
8/10/2009	Southwest Corner	426	1078	NO	Many cladocerans, copepods, ostracods, rotifer
8/10/2009	North Shore	853	2157	NO	Some cladocerans and copepods

TABLE 3-5
FISH SPECIES COLLECTED FOLLOWING COPPER SULFATE APPLICATIONS
LAKE OFFUTT
OFFUTT AFB

Common Name	Scientific Name	Collected 2008	Collected 2009
Paddlefish	*Polyodon spathula*	X	
Shortnose gar	*Lepisosteus platostomus*	X	X
Longnose gar	*Lepisosteus osseus*	X	X
Gizzard shad	*Dorosoma cepedianum*	X	X
Common carp	*Cyprinus carpio*	X	X
Grass carp	*Ctenopharyngodon idella*	X	X
Bighead carp	*Hypophthalmichthys nobilis*	X	X
Smallmouth buffalo	*Ictiobus bubalus*	X	X
Bigmouth buffalo	*Ictiobus cyprinellus*	X	X
Black bullhead	*Ameiurus melas*	X	
Channel catfish	*Ictalurus punctatus*	X	X
Flathead catfish	*Pylodictis olivaris*	X	X
White perch	*Morone american*	X	X
Largemouth bass	*Micropterus salmoides*	X	X
Smallmouth bass	*Micropterus dolomieui*	X	X
Bluegill	*Lepomis macrochirus*		X
White crappie	*Pomoxis annularis*	X	X
Black crappie	*Pomoxis nigromaculatus*	X	X
Walleye	*Sander vitreus*	X	X
Saugeye	*Sander vitreus X S. canadense*	X	X
Freshwater drum	*Aplodinotus grunniens*	X	X

TABLE 3-6
FISH MORTALITY MONITORING RESULTS
LAKE OFFUTT
OFFUTT AFB

		2008 Treatment		2009 Treatment		Combined
Species	**Fish Type**	**Estimated Weight (lbs.)**	**Mortality Period (days post-treatment)**	**Estimated Weight (lbs.)**	**Mortality Period (days post-treatment)**	**Estimated Weight (lbs.)**
Buffalo (bigmouth and smallmouth)	Non-game	28,000	2 to 40	1,000	2 to 38	29,000
Bighead Carp	Invasive	6,000	3 to 25	250	Sporadic	6,250
Common Carp	Invasive	3,000	2 to 20	1,200	2 to 38	4,200
Freshwater Drum	Game	600	2 to 10	150	3 to 28	750
White Perch	Invasive	300	3 to 7	<20	6 to 26	<320
Gizzard Shad	Non-game	200	1 to 3	<10	Sporadic	<210
Grass Carp	Invasive	200	Sporadic	60	Sporadic	260
Paddlefish	Game	100	Sporadic	0	N/A	100
Walleye/Saugeye	Game	50	5 to 10	<20	Sporadic	<70
Bass (largemouth and smallmouth)	Game	<10	3 to 7	<30	Sporadic	<40
Bullhead	Game	<10	15 to 20	0	N/A	<10
Catfish (channel and flathead)	Game	<10	15 to 20	<10	Sporadic	<20
Gar (shortnose and longnose)	Non-game	<10	Sporadic	<20	Sporadic	<30
Crappie (black and white)	Game	<10	Sporadic	220	2 to 30	<230
Bluegill	Game	0	N/A	<10	Sporadic	<10
Estimated Total	**-**	**38,500**	**-**	**3,000**	**-**	**41,500**

Notes:
lbs. = Pounds
N/A = Not Applicable

Point #5

	7/30/08	9/19/08	10/15/08	4/2/09	4/9/09	4/11/09	4/14/09	5/6/09
top	0.00	0.41	0.15	0.01	0.45	0.34	0.30	0.33
middle	0.00	0.00	0.07	0.08	0.34	0.41	n/a	0.28
bottom	0.00	0.11	0.11	0.03	0.47	0.13	0.25	0.36

Point #7

	7/30/08	9/19/08	10/15/08	4/2/09	4/9/09	4/11/09	4/14/09	5/6/09
top	0.00	0.35	0.11	0.11	0.27	0.29	0.33	0.28
middle	0.00	0.00	0.11	0.00	0.35	0.17	n/a	0.19
bottom	0.42	0.00	0.12	0.01	0.30	0.37	0.24	0.30

Point #6

	7/30/08	9/19/08	10/15/08	4/2/09	4/9/09	4/11/09	4/14/09	5/6/09
top	0.06	0.32	0.14	0.11	0.28	0.68	n/a	0.29
middle	0.23	0.30	0.11	0.01	0.31	0.43	n/a	0.30
bottom	0.06	0.22	0.15	0.06	0.26	0.29	n/a	0.31

Point #1

	7/30/08	9/19/08	10/15/08	4/2/09	4/9/09	4/11/09	4/14/09	5/6/09
top	0.45	0.32	0.20	0.03	0.34	0.44	0.33	0.31
middle	0.10	0.31	0.14	0.08	0.38	0.26	0.27	0.23
bottom	0.74	0.31	0.20	0.06	0.37	0.26	0.29	0.15

Point #4

	7/30/08	9/19/08	10/15/08	4/2/09	4/9/09	4/11/09	4/14/09	5/6/09
top	0.06	0.00	0.04	0.02	0.56	0.30	0.28	0.39
middle	0.00	0.25	0.04	n/a	n/a	n/a	n/a	n/a
bottom	0.35	0.41	0.04	0.00	0.32	0.37	n/a	0.36

Point #2

	7/30/08	9/19/08	10/15/08	4/2/09	4/9/09	4/11/09	4/14/09	5/6/09
top	0.10	0.38	0.09	0.02	0.30	0.38	0.34	0.17
middle	0.00	0.13	0.10	0.05	0.21	0.27	0.30	0.22
bottom	0.04	0.00	0.14	0.05	0.28	0.30	0.30	0.30

Point #3

	7/30/08	9/19/08	10/15/08	4/2/09	4/9/09	4/11/09	4/14/09	5/6/09
top	0.06	0.38	0.04	0.02	0.32	0.44	0.41	0.26
middle	0.06	0.35	0.05	0.07	0.15	0.24	0.19	0.21
bottom	0.17	0.73	0.04	0.10	0.16	0.20	0.06	0.27

URS

Figure 3-1
Copper Monitoring Results

Designed By:	SP
Drawn By:	SP
Checked By:	BO
Submitted By:	BO

Zebra Mussel Eradication
Offutt AFB, Nebraska

Projection: NAD83 HARN State Plane, Nebraska, Feet

Legend

- water quality point 2008
- water quality point 2009

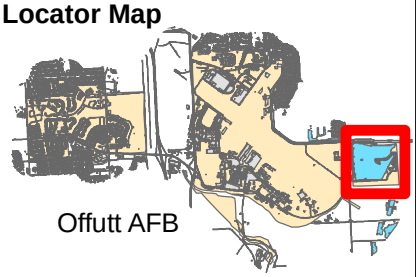
N

	7/30/08
top	0.06
middle	0.06
bottom	0.17

7/30/08 = date of sample
position in water column
copper concentration (ppm)

0 500 1,000 Feet

Locator Map



4.1 SUMMARY

This summary describes the general observations and presents conclusions reached on the effectiveness of the treatment activities. Recommendations for future activities are presented in Section 4.3.

Copper sulfate pentahydrate crystals were applied to Lake Offutt over two treatment periods, 17 and 18 September 2008 and 7 and 8 April 2009. All work was completed in accordance with the work plan (URS 2008a) and the Special Local Need Label (Appendix A). Copper sulfate was applied to the lake at an elemental concentration of 1 ppm, although the measured concentration of the lake did not exceed 1 ppm during post-application sampling. The concentration of copper was monitored for 30 days following each treatment, with residual copper concentrations decreasing slowly with time.

Zebra mussel monitoring occurred after both treatments to determine the effectiveness of the copper sulfate treatment. In 2008, post-treatment monitoring (live-colony, coupon, and veliger monitoring) indicated that the treatment was effective for the control of zebra mussels. Additional post-application monitoring could not be performed due to the onset of winter conditions. Therefore, total eradication could not be verified and it was determined that a second treatment in the spring of 2009 was warranted. This treatment was completed in accordance with the Special Local Need Label (Appendix A). Zebra mussel monitoring after the 2009 treatment included collecting water samples for veliger analysis and monitoring pre-placed coupons at 60, 90, and 120 days post- treatment. **The results from comprehensive monitoring in 2008 and 2009 indicate that copper sulfate was effective at killing zebra mussels in Lake Offutt as no live zebra mussels have been detected.** It should be noted that while initial monitoring indicates the treatment was effective, additional monitoring will be required to determine if complete eradication was achieved.

4.1.1 Non-Target Species Impacts

While discussion on fish mortality was included in the Special Local Need Label, the extent and duration of the non-target mortality of fish from the copper sulfate application was unknown at the project onset. Approximately 38,500 pounds of fish were killed following the initial treatment with an additional 3,000 pounds of fish killed following the 2009 treatment. The majority of fish killed during the treatments were non-game fish (buffalo, bighead carp, and common carp). Although game fish were killed, a fish survey completed in May 2009 (NHU 2009) indicated that a healthy and sustainable population of game fish (bass, crappie, bluegill, and catfish) continues to exist at the lake. The fish survey also indicated that buffalo and common carp are still abundant in the lake, even after over 300 pounds per acre of these species were removed.

4.2 CONCLUSIONS

Although the effectiveness of the copper sulfate treatment cannot be completely ensured without future long-term monitoring, some interim conclusions can be made, including:

- Copper sulfate application at 1 ppm elemental copper is an effective means to control zebra mussel populations. Further monitoring is needed determine whether the treatment was 100 percent effective.
- Lake Offutt monitoring results strongly suggest that non-target fish mortality will occur when treating a water body to 1 ppm elemental copper.
- Based on the results of the post-treatment fisheries survey, a healthy fishery remains in Lake Offutt.

4.3 RECOMMENDATIONS

Initial monitoring for zebra mussels following the treatment of Lake Offutt indicates that the treatment was likely successful. However, the complete eradication of zebra mussels cannot be confirmed in only one year of monitoring. It is possible that a few zebra mussel individuals are still alive but not reproducing. Therefore, it is recommended that monitoring continue for at least two additional years (through 2011). This monitoring should include veliger sampling, coupon sampling, or inspection of existing substrate along the shore. Because zebra mussels quickly propagate and infest water bodies, it is assumed that if zebra mussels have not been detected in Lake Offutt by 2011 the treatment was 100 percent effective.

It is recommended that while this monitoring continues, the short-term control measures (i.e., plugging of outlet pipes, restriction on personal boats) continue. The lake should remain isolated until it can be confirmed with certainty that zebra mussels have been eradicated.

Long-term recommendations for management of zebra mussels include restricting boat access to the lake. Ideally, personal boats would not be allowed on Lake Offutt. This would eliminate this potential vector for re-infestation, which would reduce the probability for future lake treatment. However, if it is determined that allowing personal boats onto the lake is necessary, decontamination and control procedures should be implemented. Recommended procedures include:

- Require all watercraft to be decontaminated prior to entering and upon exiting Lake Offutt. All bilges and live wells should be drained, the boat should be checked and weeds removed.
- The boat should be cleaned using a steam cleaner with a temperature setting of at least 140°F. All live wells and bilges should be sprayed with a 10 percent bleach solution.
- Boats should not be stored in the water for an extended period of time. All personal boats should be removed from the lake daily to reduce the potential for zebra mussels to attach to the boat.

In addition to the zebra mussels that were killed, approximately 41,500 pounds of fish biomass was removed from Lake Offutt due to the copper sulfate treatment. This reduction in the lake biomass offers a unique opportunity to enhance the lakes sport fishery with the stocking of desired game fish species. Suggested species and quantities are provided in the 2009 fisheries survey (NHU 2009).

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SPECIAL LOCAL NEED LABELING
FOR DISTRIBUTION AND USE ONLY IN THE STATE OF NEBRASKA

COPPER SULFATE CRYSTALS

EPA Reg. No. 56576-1

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Directions For Use:
Location: Offutt Air Force Base, Bellevue, NE.
Use Site: Offutt Air Force Base Lake and all inlets, shallows, and shorelines.
Target Pest: Zebra Mussels (*Dreissena polymorpha).*

Use Rate: Apply Copper Sulfate Crystals as a whole lake treatment by boat or aircraft so that the average elemental copper concentration does not exceed 1 ppm. At 25% elemental copper, Copper Sulfate Crystals requires 10.8 pounds of product to treat one acre foot of water to obtain 1 ppm elemental copper. No more than two whole lake treatments may be made prior to the label expiration date of May 1, 2009.

Method of Application: Application either by boat or by aircraft (helicopter), in order to treat the entire lake within a 24-48 hour period.

Additional Requirements: Due to the possibility of aircraft collisions with scavenging birds, applicator or other designated persons must monitor the lake during and after treatment for dead fish during daylight hours. All dead fish must be collected and disposed by burial or landfill until no dead fish are found over a 48-hour period.

Due to concerns for human contact, fish consumption, and drinking water standards, swimming in the lake and eating fish from the lake is prohibited during and after lake treatment until the water concentration of copper is at or below 1.3 ppm. Efficacy monitoring by SCUBA divers is allowed at all times after treatment. Treated lake water cannot be used as a direct or indirect source of human or animal drinking water until copper concentration is at or below the 1.3 ppm MCL. Warning signs informing the public or base personnel about the lake treatment are to be placed at the entrance to the lake and at all boat ramps and beaches, at least during the application and until water copper concentration is determined to be at or below 1.3 ppm.

This label expires May 1, 2009, or immediately upon completion of the second lake treatment, or sooner if suspended or cancelled by the EPA, the manufacturer, registrant or Nebraska Department of Agriculture. All applicable directions, restrictions, and precautions on the EPA registered label are to be followed.

This labeling must be in the possession of the user at the time of pesticide application.

Neither the manufacturer, registrant, nor the Nebraska Department of Agriculture makes any warranty of merchantability, fitness of purpose, or otherwise, expressed or implied, concerning the use of this pesticide in accordance with these provisions. The user acknowledges the preceding disclaimer and accepts liability for any possible damage resulting from this use.

This product manufactured for
CHEM ONE LTD
HOUSTON, TEXAS 77040-6519
TEL. (713) 896-9966

CHEM ONE

EPA SLN No. NE-080003
Expiration Date:12/31/2008

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project Number:
ACC Contract FA8900-04-D-0005 9 D.O. 6U09	Lake Offutt Offutt Air Force Base, Nebraska	16170345

Photo No. 1	Date: 9-19-08

Description:

Live zebra mussel colonies were deployed in minnow buckets attached to buoys prior to the 2008 copper sulfate treatment. The colonies were monitored for mortality after the copper sulfate treatment.

Photo No. 2	Date: 9-17-08

Description:

Copper sulfate pentahydrate crystals were applied to Lake Offutt using boat mounted vortex spreaders.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project Number:
ACC Contract FA8900-04-D-0005 9 D.O. 6U09	Lake Offutt Offutt Air Force Base, Nebraska	16170345

Photo No. 3	Date: 9-19-08

Description:

Dead fish were collected from the shore and gathered in plastic tubs.

Photo No. 4	Date: 4-10-09

Description:

Dead fish were buried in a pit adjacent to the lake at the end of each collection day.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project Number:
ACC Contract FA8900-04-D-0005 9 D.O. 6U09	Lake Offutt Offutt Air Force Base, Nebraska	16170345

Photo No. 5	Date: 4-8-09

Description:

Multitudes of empty zebra mussel shells were observed around the Lake Offutt shore in 2009.

Photo No. 6	Date: 8-10-09

Description:

Coupons samplers were deployed and monitored for any new infestations of adult zebra mussels.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project Number:
ACC Contract FA8900-04-D-0005 9 D.O. 6U09	Lake Offutt Offutt Air Force Base, Nebraska	16170345

Photo No. 7	Date: 9-18-08

Description:

All equipment was decontaminated after being removed from Lake Offutt**.**