THE AUTHORIZED RED RIVER CHLORIDE CONTROL PROJECT WICHITA RIVER ONLY PORTION

ENVIRONMENTAL OPERATIONAL PLAN

Prepared by:
URS Corporation
1437 S. Boulder, Ste 660
Tulsa, OK 74119

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AUTHORIZED RED RIVER CHLORIDE CONTROL PROJECT, WICHITA RIVER ONLY PORTION,

ENVIRONMENTAL OPERATIONAL PLAN

BACKGROUND

The Wichita River Basin Chloride Control Project was initiated in 1998. The project originated from the Red River Chloride Control Project (RRCCP) which had been ongoing since approximately 1957. A final environmental statement (FES) was filed for the entire RRCCP project in 1977 and had the concurrence of all Federal and State resource agencies. Because of design changes in the project, changes in without-project conditions for the project area, and amendments to the Endangered Species Act, the U.S. Army Corps of Engineers (USACE) recoordinated the authorized and partially constructed project with the U.S. Fish and Wildlife Service (USFWS), the Texas Parks and Wildlife Department (TPWD), and the Oklahoma Department of Wildlife Conservation (ODWC).

Since 1991, State and Federal fish and wildlife agencies have expressed concerns about the potential impacts of chloride control on the Wichita and Upper Red River Basin ecosystems. On December 1, 1995, a Steering Committee (SC) was formed to address the various agencies' concerns for the entire RRCCP. The SC was composed of representatives from the USACE; the USFWS; the Red River Authority of Texas (RRA); the ODWC; and the TPWD. The SC developed a mission statement for the project, which reads:

> *"Provide for the timely development of a Supplement to the Final Environmental Statement (SFES) supported by the USFWS, the District, the RRA, the ODWC, and the TPWD that characterizes all environmental issues and provides a full and fair discussion of the environmental impacts related to the chloride control measures. The SFES should include a commitment to a full range of actions, including possible modification/suspension of project construction and/or operation, which avoid or significantly reduce environmental impacts caused by the chloride control measures."*

Three workgroups were formed by the SC to address selenium, Lake Texoma productivity, and the Upper Red River Basin ecosystem. Generally, these assignments consisted of evaluating the issues; determining baseline conditions; and/or establishing thresholds and safeguards. The assignments also consisted of formulating recommendations for the SC. The ultimate goal was to develop an Environmental Operational Plan (EOP) acceptable to all agencies for inclusion into the SFES. The original Red River EOP has been modified to include the Wichita River only portion of the project. The purpose of the EOP was to provide protection against unacceptable changes in the Upper Red River Basin. This EOP was completed for the RRCCP project.

As planning for the RRCCP was discontinued, the full EOP for the project was never adopted. However, many of the components of the plan are applicable to the Wichita River only portion of the project and monitoring in some areas has been conducted in the Wichita River Basin. Where applicable, portions of the original RRCCP EOP have been adopted for this EOP for the Wichita River only portion

The following EOP for the Wichita River Basin should therefore be implemented by the USACE to obtain baseline data, monitor the impacts of the chloride control measures, and define long-term impacts attributable to the chloride control measures. A list of plan components, implementation dates, reporting requirements, and studies and dates has been incorporated into the plan. The plan also contains an Implementation Schedule delineating monitoring plan components, implementation dates, and reporting requirements. The following chapters describe those components.

CHAPTER 1

STREAM WATER QUALITY MONITORING

1.0 INTRODUCTION

A stream-monitoring program would be continued for the chloride control measures to monitor project impacts on water quality and stream flow and to measure plan effectiveness. Data collected as a part of this program would be used to monitor chloride removal efficiency as well as potential changes in water quality resulting from secondary project impacts. This program has been in place continuously since 1996.

2.0 MONITORING PROGRAM

Twelve gaging stations have been established in the Wichita and Upper Red River Basin (Figure 1). Data collection platforms would be present at each location and would collect hourly measurements of discharge, water temperature, and specific conductance. In addition, water samples would be collected for analysis of the following parameters:

- pH
- Dissolved oxygen
- Total suspended solids
- Total hardness
- Alkalinity
- Total nitrite + nitrate-nitrogen
- Total ammonia + organic-nitrogen
- Chlorides
- Fluorides
- Dissolved metals: Ca, Mg, Na, K
- Sulfates
- Silica
- Total Dissolved Solids
- Total and Dissolved Metals: Ba, Mn Zn, Ni, Se, As, Fe, Hg, Ag, Cd, Cu, Pb, Cr
- Turbidity
- Total Phosphorus

Samples would be collected at 4 to 6 week intervals. Finally, water samples for chlorinated pesticides analyses (Environmental Protection Agency [EPA] Method 8080) would be collected twice per year (spring and fall) at each gage. This program would be funded by the USACE, but data collection, chemical analysis, and maintenance activities would most likely continue to be accomplished by the U.S. Geological Survey (USGS) under contract to the USACE. Alternatively, the USACE may conduct this monitoring in the future. Annual reports of water quality data collected at these gages would be published by the USGS or the USACE. The program would be subject to annual evaluation, with potential revision of gage locations and/or water quality parameters based on monitoring results.

Water quality data have been collected as part of the USACE's monitoring program and have included selenium (Se) data for brine source areas as well as for Truscott Brine Disposal Reservoir (USACE 2001). Limited Se data were collected at Area VII at Y Ranch (USGS gage #07311600), Area VIII at Bateman Pump Station (#07311782) and Area X at Lowrance Station (#07311630) by the USACE as part of initial evaluations for Crowell Lake in 1992. As part of a long-term monitoring effort, monthly water sample collection and Se analyses by the USGS under contract to the USACE was initiated at all potential brine collection areas in the basin beginning in November 1996. This monitoring effort continues to the present.

3.0 LITERATURE CITED

U.S, Army Corps of Engineers (USACE). 2001. Selenium Monitoring Results: Truscott Brine Disposal Reservoir, TX and Associated Brine Collection Areas, 1997-1998. Tulsa District Corps of Engineers, Tulsa, OK.

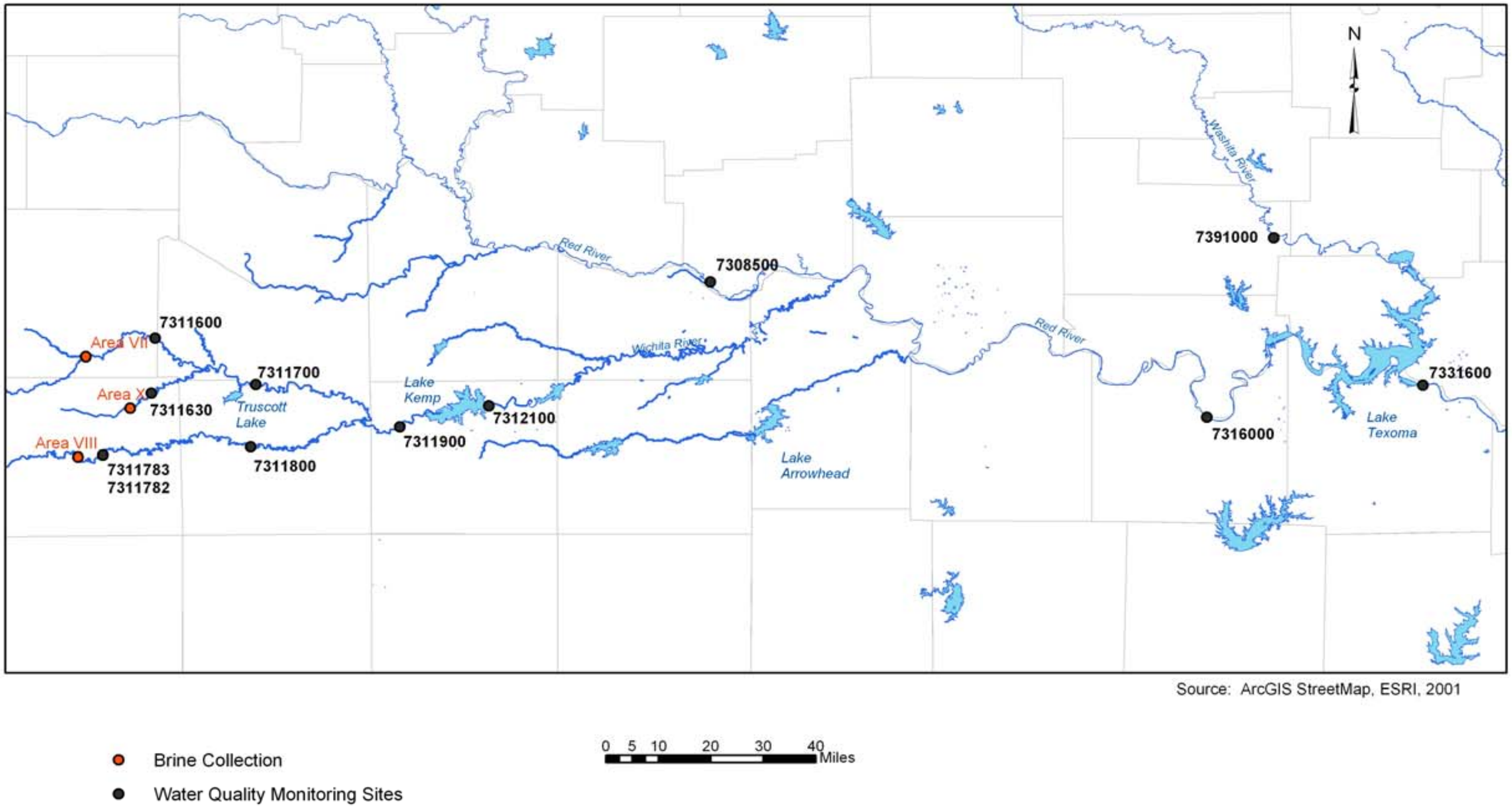

Figure 1. Stream water quality monitoring sites. Numbers are USGS gage designations.

CHAPTER 2

LAKE KEMP WATER QUALITY MONITORING

1.0 OBJECTIVE

The primary objective of this plan is to continue monitoring of the physical-chemical-biological limnology of Lake Kemp that began in 1997. This monitoring program would provide additional data on the limnology of Lake Kemp and provide information with which to assess potential effects of the chloride control structures on water quality and productivity of the lake.

2.0 DESCRIPTION OF THE STUDY AREA

Lake Kemp is a moderately large impoundment of the Wichita River located in north central Baylor County, Texas, at river mile 126.7. Lake Kemp is approximately 8 miles north of Seymour, TX, and 40 miles southwest of Wichita Falls, TX. The lake was impounded in October 1922, but the dam was not completed until August 1923. The height of the dam was increased by approximately 16.5 feet in 1973. The dam now is 8,888 feet long and rises 115 feet above the bed of the Wichita River. The spillway is located at an elevation of 1,183 feet National Geodetic Vertical Datum (NGVD) above sea level. At top of the conservation pool, the water level is at an elevation of 1,144 feet NGVD. Lake Kemp has a surface area of 15,590 acres, a volume of 268,000 acre-feet, and mean and maximum depths of 31.5 feet (Ground and Groeger 1994) and 55.8 feet (Wilde 1999), respectively.

Lake Kemp was impounded for flood control and irrigation. The lake is operated by the City of Wichita Falls and the Wichita County Water Improvement District No. 2. Waters from the lake currently are used for irrigation in the Wichita River Valley, for oil field operations, and municipal and industrial uses. Flood storage in Lake Kemp is managed by the USACE. The drainage area of Lake Kemp is 2,086 square miles and is composed primarily of range (86.7%) and cropland (13.3%). Compared with other Texas river basins, the Wichita River drainage basin is highly erodible (Greiner 1982). Most erosion (71%) in the basin is sheet and rill erosion, both of which are associated with overland runoff following rain events.

3.0 PREVIOUS SAMPLING ACTIVITIES

3.1 Baldys and Kidwell (USGS, 1995)

Water quality in Lake Kemp was previously reported by Baldys and Kidwell (1995). They were able to detect significant decreases in conductivity, dissolved solids and dissolved chloride loads from the Benjamin gage (#07311800) on the South Wichita River 50.4 miles downstream from the Bateman Pump Station (#07311782) when comparing a five-year (1982-87) pre-versus a post-chloride control five-year period (1987-92). However, they were not able to detect a statistically significant decrease in dissolved solids or chloride loads at the Maybelle station (#073122100) on the Wichita River just below Lake Kemp. There was a statistically significant decrease in concentration of dissolved solids and chlorides at the station below the dam for the five-year post- versus the five-year pre-chloride control period. But this could have been coupled with a significant increase in discharge at Maybelle during the five- year post-control period, rather the effect of constructed portions of the chloride control project.

A preliminary study of the effects of the Bateman chloride control facility on water quality in Lake Kemp (Baldys et al. 1995) was inconclusive. Baldys et al. (1995) found weak evidence of a decrease in chloride and dissolved solids concentrations in Lake Kemp and strong evidence of a decrease in these parameters in the Wichita River downstream from the lake. However, high runoff early in their study led them to question whether these decreases were due to chloride control or dilution.

3.2 Burks (1996)

Citing Baldys and Kidwell's previous study (1995), Burks recommended a strategy for monitoring water quality in Lake Kemp. This strategy was also used by Wilde (1999, 2000) in later monitoring. Burks stated that fixed sampling stations would be established at the following locations: one station in the riverine zone, three in the transition zone, and two in the lacustrine zone. These fixed stations would be sampled on a regular monthly basis from March through November and at periodic intervals following significant runoff events. At these "fixed location" sampling stations, one station within the three zones of the lake would be intensively sampled for the highly variable parameters chlorophyll *a* and turbidity. The number of replicates (see Section 4.2) for these "intensive stations" would be ten for chlorophyll *a* and turbidity and triplicates for all remaining parameters. The remaining fixed location stations would be designated as routine stations, where triplicate samples would be collected for all parameters. After the initial field collection trip, additional sampling stations would be established if field conductivity measurements indicated significant inputs of chemicals were occurring from other tributaries or from point sources along the shoreline.

3.3 Wilde (1999)

Wilde (1999) sampled Lake Kemp in 1997. In general, sampling was conducted in accordance with the monitoring plan developed by Burks (1996). Lake Kemp was sampled during the months of April through December 1997. Sampling sites were chosen to include two locations representative of limnetic conditions, two locations that were transitional between riverine and limnetic conditions, and two locations that were riverine in nature, for a total of six sampling sites, as opposed to the five sites originally recommended by Burks (1996). Based on a comparison of his results with those of previous studies, Wilde suggested that chloride loading into the lake may have decreased by as much as 33% between 1992 and 1997.

3.4 Wilde (2000)

Wilde sampled Lake Kemp again in 1999 - 2000. Again, sampling was conducted in accordance with the monitoring plan developed by Burks (1996), with the exception of the number of sites sampled. Sampling was conducted from June 1999 through February 2000 at approximately the same six locations on Lake Kemp as Wilde's previous study in 1997.

Compared with the 1997 results of Wilde (1999), concentrations of dissolved solids increased in Lake Kemp in 1999 – 2000 as shown in Table 2-1. Except for potassium, which was present in low concentrations, the increase in concentrations from 1997 to 1999 - 2000 ranged from 6 to 19%. The increase between studies was attributed, at least in part, to low runoff into Lake Kemp in 1999 - 2000 (Wilde 2000). As a result of reduced inflows into Lake Kemp during 1999 - 2000, the overflow, indicated by low conductivity waters, observed in 1997 did not develop in 1999.

TABLE 2-1

LAKE KEMP WATER QUALITY, 1997 TO 1999-2000

Parameter	1997 Concentrations (mg/l)	1999-2000 Concentrations (mg/l)	Percent Change (rounded)
TDS	2,781	3,131	13
Calcium	250	297	16
Potassium	8.1	12.0	32
Sodium	635	675	6
Chloride	1,021	1,170	13
Sulfate	791	867	9

Wilde (1999) suggested that several lines of evidence indicated that chloride concentrations in Lake Kemp had decreased since the mid 1980s, but that the available evidence was not conclusive because variation in sampling and analytical protocols, and seasonal and inflow (dilution) related variation in chloride concentrations might account for some of the observed temporal differences in chloride concentrations. Results of the 1999-2000 study, showing a lake-wide increase in chloride concentrations between 1997 and 1999-2000 further complicate any attempt to determine whether chloride concentrations in Lake Kemp have decreased since operation of the Bateman chloride control facility began. Continued monitoring of chloride concentrations at USGS gaging stations on the North and South Wichita rivers, or on the Wichita River upstream from Lake Kemp were recommended in conjunction with future limnological surveys of Lake Kemp. Available information was deemed inadequate to allow any assessment of potential changes in turbidity, nutrient concentrations, and phytoplankton productivity in Lake Kemp as a result of operation of the Bateman chloride control facility.

3.5 Wilde (2002, In Preparation)

Wilde sampled Lake Kemp again in 2001-2002 using methods employed in previous studies. A report on this effort is being prepared and will be available when completed.

4.0 LAKE KEMP MONITORING PROGRAM

4.1 Location of Sampling Stations

Fixed sampling stations would be established at the following locations on Lake Kemp: two locations representative of limnetic conditions, two locations that are transitional between riverine and limnetic conditions, and two locations that are riverine in nature, for a total of six sampling sites. Sampling sites would be those used by Wilde in previous investigations at Lake Kemp. At these "fixed location" sampling stations, one station within each of the three zones of the lake would be intensively sampled for the highly variable parameters chlorophyll a and turbidity. The number of replicates for these "intensive stations" would be ten for chlorophyll a and turbidity and triplicates for all the remaining parameters listed in Section 4.2. The remaining fixed location stations would be designated as routine stations, where triplicate samples would be collected for all the parameters.

4.2 Physical-Chemical Parameters

In-situ field analyses of pH, temperature, dissolved oxygen and conductivity at one-meter intervals from half a meter below the surface to half a meter from the bottom, would be performed. These field probes would be checked against a field standard, digitally recorded on a data logger, verified, and "backed-up" to disk in the field to prevent accidental loss of the data. At each station a global positioning satellite (GPS) meter would record the latitude and longitude to +/- 0.01 of a minute accuracy. Turbidity would be measured on-site with a portable nephelometric meter. If a portable nephelometric meter were not available, samples would be collected from half a meter from the surface and analyzed within 24 hours with a laboratory nephelometric meter. A Secchi disk reading would also be obtained to assist in correlation with historical records measured at some of the "fixed-location" stations. Light energy and attenuation would be measured with a submarine photometer, at the surface and then lowered to a depth where one percent of surface intensity occurs.

Water samples would be collected from half a meter below the surface and half a meter from the bottom and analyzed for the following parameters; chloride, sulfate, nitrite, nitrate and soluble ortho-phosphate. In addition, samples would be collected for subsequent digestion in the laboratory and analysis of total nitrogen (as N) and total phosphate (PO4-P). Additional samples would be collected and analyzed for alkalinity, hardness, total dissolved solids, total suspended solids and turbidity. Samples would also be collected for either atomic absorption and/or ICP analysis of calcium, magnesium, potassium and sodium.

The number of replicates for these "intensive stations" would be ten for chlorophyll *a* and turbidity and triplicates for all remaining parameters. The remaining fixed location stations would be designated as routine stations, where triplicate samples would be collected for all parameters listed.

4.3 Biological Parameters

Samples for chlorophyll *a* analysis at half a meter below the surface at each sampling station would be collected. Phytoplankton would also be collected from the surface at each sampling station. The dominant genera of algae would be identified and enumerated. In addition, vertical plankton net tows from the metaliminion to surface or from just below the euphotic zone (approximately 3X deeper than the Secchi Depth) to surface, for subsequent zooplankton characterization would be collected. The historical collections would be used as baseline data for comparison purposes.

4.4 Frequency of Sample Collection

The samples would be collected at all sampling stations on a monthly basis from March through November. The baseline monitoring program would be conducted for a period of five years (three have already been conducted) to provide an adequate database for trend analyses such as Kendal's tau, etc.

4.5 Replication of Sample Parameters

Triplicate samples would be collected at the routine monitoring stations and analyzed for all the parameters listed in Section 4.2. The chlorophyll *a* and turbidity at the "intensive locations" would be replicated with ten samples to obtain adequate power to detect statistically significant change. All the other parameters at the "intensive locations" would be collected in triplicate.

4.6 Quality Assurance/Quality Control

Ion probes used for field analyses would be calibrated with standard solution prepared in the lab or in case of dissolved oxygen meters, according to the manufacturers instructions for air calibration. A set of standards for pH and conductivity would be carried to the field on each sampling event and used to calibrate and verify the digital data logger prior to performing field measurements.

All sample bottles for nutrients, cation, and anion analyses would either be cleaned in accordance with APHA standard methods or purchased from a vendor certifying that the containers conform to specified minimum background levels of contamination. An extra set of bottles would be carried along on all collecting trips and analyzed along with the collected samples to serve as a trip blank.

4.7 Data Analysis

The field measurements of dissolved oxygen, temperature, conductivity, turbidity and pH would be entered into computer spreadsheets and graphed to illustrate vertical strata which might occur during the study. In addition, annual isobars would be plotted to determine seasonal influences upon vertical stratification in the reservoir.

The concentration of chloride, sulfate, sodium, calcium, and turbidity would be carefully analyzed to determine if any significant changes in concentration relative to historical data are occurring. The nutrient and chlorophyll *a* data would also be evaluated to determine if any statistically significant changes relative to historical data were occurring.

All data would be summarized in a final project report for each sampling period.

5.0 LITERATURE CITED

Baldys, S.L. and C. C. Kidwell. 1995. Dissolved-solids and chloride loads in the South Wichita River and Lake Kemp, North Texas, October 1982-September 1992. U.S. Geological Survey, Water-Resources Investigations Report 95, Austin, TX.

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CHAPTER 3

WICHITA RIVER ECOSYSTEM ENVIRONMENTAL OPERATIONAL PLAN

1.0 INTRODUCTION

Resource agencies have expressed concerns that chloride reduction, habitat alterations, and stream flow modifications resulting from chloride control measures construction and operation and increased agricultural irrigation would impact the Wichita River ecosystem. In response, this portion of the EOP has been developed.

2.0 GOALS AND OBJECTIVES

The goals and objectives for the monitoring programs include:

1. Identify existing available data and provide an accurate description of existing data and parameters for ecosystem components.
2. Establish baseline conditions and identify thresholds, with a decision program to recommend modification/suspension of project construction and/or operation that avoid or significantly reduce environmental impacts caused by the chloride control measures.
3. Develop an internal and external peer review process for evaluation of monitoring plan study results, modification of evaluation criteria, additional data needs, and collection and evaluation of those data for inclusion in the decision program.

To accomplish these goals, this section of the EOP was developed for monitoring, evaluation, and remediation of the Wichita River ecosystem, which consists of the following six programs: Baseline Development, Refugia Habitat Monitoring, Brush Management, Long-Term Monitoring, Threshold Decision, and Peer Review.

3.0 BASELINE DEVELOPMENT PROGRAM

3.1 General

Issues of high priority and biological evaluation criteria were used to develop the Baseline Development Program. The seven biological evaluation criteria used were:

- species composition;
- relative abundance of species;
- distribution of species;
- water quality factors that affect biotic communities;
- water quality and flow regime factors that affect biotic communities;
- habitat substrate; and
- determination of appropriate sampling times, locations, and efforts.

The Baseline Development Program is designed to assess how stream flow quantity (hydrology) and stream flow quality (water quality) factors affect ecosystem components of the Wichita River Basin and to provide baseline data that may be compared with long-term data to assess impacts related to operation of the chloride control measures. Available biological, hydrological, and water quality data would be synthesized in addition to collection of field data.

A faunal survey of Areas VII, VIII, and X would be conducted. The survey would focus on identification of unique spring inhabitants including fish, reptiles, amphibians, algae, and aquatic invertebrates. This survey would be conducted prior to further construction and would establish a baseline for analysis of potential project impacts.

A semi-permanent benchmark monument would be established at each baseline and long-term sampling location. This monument would facilitate consistent location of the site and provide a reference point for various data collection components.

During baseline and long-term data collection for ecosystem components, a photograph would be taken of each sampling site every time data is collected or samples are taken. Photographs would be taken with a digital camera and stored on CD's. The photograph would always be taken from the same location and perspective, which would be determined from the semi-permanent benchmark.

Instream habitat, substrate, and microhabitat would be documented for each sample site and season on an annual basis during baseline data collection and thereafter, in accordance with procedures outlined in the USGS's National Water-Quality Assessment Program (1993 Open File Report 93-408), "*Methods for Characterizing Stream Habitat as Part of the National Water-Quality Assessment Program".*

3.2. Ecosystem Components

3.2.1 Fish Communities

Fish communities in the Wichita River basin have been described by Lewis and Dalquest (1955, 1956, and 1957), Dalquest (1958), Dalquest and Peters (1966), Echelle *et al.* (1972), Matthews (1991), Echelle *et al.* (1995), Clyde (1996), and Gelwick *et al (*2000). Table 3-1 lists common and scientific names of fish species collected from specific reaches of the Wichita River. Figure 3-1 shows the different fish reaches. Fish communities in the basin are often subject to a high degree of variability in flow, temperature, turbidity, and salinity. Consequently, species composition and relative abundance can be highly variable among locations and seasons (Matthews 1991; Taylor *et al.* 1996) and may fluctuate widely over long periods of time (Wilde *et al.* 1996). Because of this, specific fish sampling events are heavily influenced by the environmental conditions in the river that preceded the sampling event. Therefore, results of fish collections must be interpreted with some level of caution regarding relative abundance of various fish species.

FIGURE 3-1: FISH REACHES

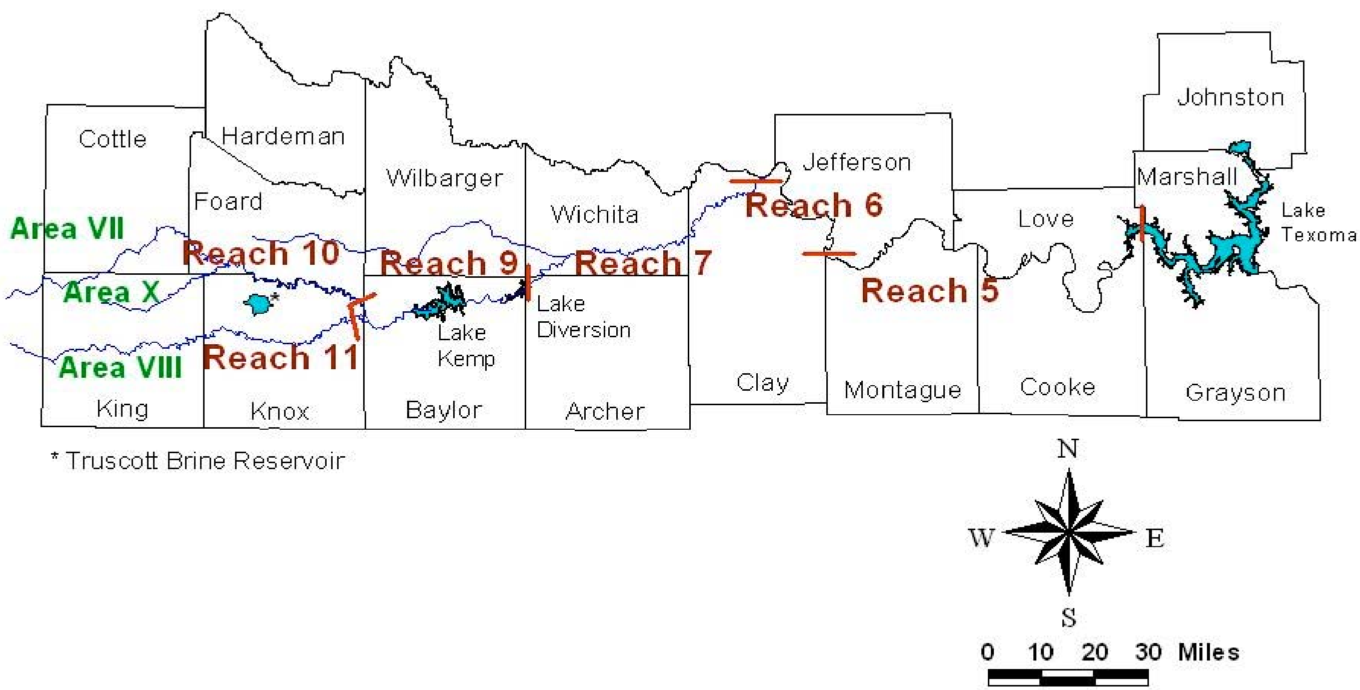

TABLE 3-1
COMMON AND SCIENTIFIC NAMES OF FISH SPECIES COLLECTED FROM SPECIFIC REACHES OF THE WICHITA RIVER

Common Name	Scientific Name	Reach 7	Reach 9	Reach 10	Reach 11
Paddlefish	*Polyodon spathula*		X		
Longnose gar	*Lepisosteus osseus*	X			
Shortnose gar	*Lepisosteus platostomus*	X			
Gizzard shad	*Dorosoma cepedianum*	X	X	X	X
Goldeye	*Hiodin alosoides*	X			
Red shiner	*Cyprinella lutrensis*	X	X	X	X
Blacktail shiner	*Cyprinella venusta*	X			
Common carp	*Cyprinis carpio*	X	X	X	X
Plains minnow	*Hybognathus placitus*	X	X	X	X
Speckled chub	*Macrhybopsis aestivalis*	X	X	X	X
Silver chub	*Macrhybopsis storeiana*	X			
Emerald shiner	*Notropis atherinoides*	X	X	X	
Red River shiner	*Notropis bairdi*	X	X	X	
Ghost shiner	*Notropis buchanani*	X	X	X	
Sharpnose shiner	*Notropis oxyrhynchus*	X	X	X	X
Chub shiner	*Notropis potteri*	X	X	X	
Sand shiner	*Notropis stramineus*	X	X	X	
Suckermouth minnow	*Phenaeobius mirabilis*	X	X	X	
Fathead minnow	*Pimephales promelas*	X	X	X	X
Bullhead minnow	*Pimephales vigilax*	X	X	X	X
River carpsucker	*Carpiodes carpio*	X	X		X
Smallmouth buffalo	*Ictiobus bubulas*	X	X		
Black buffalo	*Ictiobus niger*	X			
Black bullhead	*Ameiurus melas*	X		X	X
Yellow bullhead	*Ameiurus natalis*			X	
Channel catfish	*Ictalurus punctatus*	X	X		
Red River pupfish	*Cyprinedon rubofluviatilis*	X	X	X	X
Plains killifish	*Fundulus zebrinus*	X	X	X	X

Table 3-1 Continued

Common Name	Scientific Name	Reach 7	Reach 9	Reach 10	Reach 11
Mosquitofish	*Gambusia affinis*	X	X	X	X
Inland silverside	*Menidia beryllina*	X			
Striped bass	*Morone saxatilis*	X			
White bass	*Morone chrysops*	X	X		
Green sunfish	*Lepomis cyanellus*	X	X	X	X
Warmouth	*Lepomis gulosus*	X	X		
Orangespotted sunfish	*Lepomis humilis*	X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X
Lonear sunfish	*Lepomis megalotis*	X	X	X	X
Redear sunfish	*Lepomis microlophus*	X			
Spotted bass	*Micropterus punctulatus*	X			
Largemouth bass	*Micropterus salmoides*	X	X	X	
White crappie	*Pomaxis annularis*	X	X		
Bigscale logperch	*Percina macrolepida*	X			
Freshwater drum	*Aplodinotus grunniens*	X	X		

Source: Wilde 1996

In addition to the synthesis of historic collections, fish communities of the Wichita River would be sampled to further define species composition, distribution, relative abundance, life stages, size distributions, and spatial and temporal occurrence, and to monitor species abundance and community structure over time. If feasible, extensive sampling would occur for a five-year baseline period prior to operation of the proposed project and would continue after operation begins. Samples would be taken during three seasons annually (spring, summer, and fall) for the baseline period, and for a minimum of five years after operation of the chloride control measures begins. After at least five years of data collection subsequent to the beginning of chloride control measures operation, state and/or federal agencies may determine that sampling during three seasons annually is not necessary and adjust the sampling schedule accordingly.

Four to five sampling sites would be selected within each reach for baseline sampling, and three to four of the same sites per reach would be used for long-term monitoring. At least one sample site per reach that was sampled during the baseline period would not be sampled during long-term monitoring, but would be used as an alternate sample site in the event a permanent sampling site becomes unavailable in the future. Sampling sites would be selected based on the following criteria: 1) access; 2) long-term availability for sampling; 3) likelihood of consistently obtaining samples that adequately reflect fish communities within the reach; and 4) diversity of habitat types within the site location. Sites that have been previously sampled over time would be given priority, particularly the long-term collection sites used by Lewis and Dalquest (1955, 1956, and 1957), Dalquest (1958), Dalquest and Peters (1966), Echelle *et al.* (1972), Matthews (1991), Echelle *et al.* (1995), Clyde (1996), and Gelwick *et al.* (2000). Sample sites selected would be spatially distributed throughout each reach.

Sample sites would be selected to complement the collection of data for other components of the biological community. Consistency in sample sites would allow greater determination of the relationships of the fish community structure to other ecosystem components, including the algae/biofilm community, the benthic invertebrate community, the aquatic macrophyte community, instream habitat, and water quality.

Sampling methods would vary depending upon the physical characteristics of sampling reaches and stations and microhabitats present. Sampling methods and effort would be standardized within each sample site and would remain consistent, when possible, throughout both the baseline and long-term sampling periods. Sampling effort would be recorded for determination of catch-per-unit effort. All sampling would generally follow the protocol contained in the USGS's National Water-Quality Assessment Program (1993 Open File Report 93-104), "*Methods for Sampling Fish Communities as a Part of the National Water-Quality Assessment Program*".

All fish greater than 150 mm in total length collected during sampling would be identified by species, measured (total length in mm), and returned to the water. All fish less than 150 mm in total length, and those fish greater than 150 mm in total length that cannot be positively identified in the field, would be taken to a laboratory for positive identification. Total number of fish by species would be recorded for each site. If a fish species is collected within a reach during the baseline period and is not collected within any long-term sample at a particular site within the same reach, an immediate effort would be made to locate that species at that site. If any species is collected within a site that has not previously been collected within that site, voucher specimens of that species would be collected and archived.

Fish specimens collected and identified at the laboratory would be archived as specimens in an accredited zoological museum. Where possible, entire collections would be deposited. Where large numbers of specimens of a given species are collected simultaneously, logistical practice would allow archival storage of voucher specimens, being sure that the archival sample includes an array of sizes approximating natural densities of the species. It would be the responsibility of personnel making fish collections and providing initial identification and enumeration to confer with taxonomic experts in the archival museum to resolve any uncertainty of identification.

3.2.2. Wetlands/Riparian

For the purposes of this study, the wetland/riparian zone is defined as the "stream-side community," or that portion of the floodplain originating form the edge of the stream landward to the high bank of the floodplain. Baseline sampling stations would be selected by reach, while long-term monitoring stations would be determined by stratified random sampling based upon information collected during the baseline study. Study reaches would be selected to complement collection of data for other ecological components.

Baseline studies would be accomplished using a combination of digital maps, satellite imagery, air photography, and field verification. A set of digital base maps, derived from USGS 7.5-minute quadrangle sheets at a scale of 1:24,000, would be developed. The baseline studies would be completed prior to project construction, and updates would be performed at 5-year intervals throughout the life of the project. Multispectral and panchromatic satellite imagery would be referenced to the base maps. At selected sites, high-resolution air photography would be used to enhance the accuracy of base maps and to improve habitat identification on satellite imagery. Field verification of environmental conditions would be performed at control sites in each major reach of the project.

When possible, the digital base maps would be obtained directly from the USGS. In the majority of cases, however, digital maps must be created by the Geographic Information Systems (GIS) staff in the USACE office. The image archives of the French SPOT satellite and the U.S.LANDSAT satellite would be searched for suitable scenes. The imagery must be nearly cloud free and must have been imaged when leaves were on tree stands and the river was not in an extreme low- or high-flow condition.

Environmental baseline conditions in the project area would be determined by developing a supervised land cover classification from the satellite image maps. Using information obtained from field observations and high-resolution air photography, areas of known vegetation cover type would be identified on the satellite imagery. These areas are referred to as training sites. The spectral characteristics of the training sites are analyzed to obtain an electronic signature that corresponds to a particular vegetation cover type. Imagery analysis software is then used to search for additional occurrences of the desired signature.

Supervised land cover classification is an iterative process. Areas identified by the classification process as matching a particular signature would be checked against the base maps and air photographs for accuracy. Field checks would be made to verify the classifications. The electronic signatures would be revised as new information is obtained. Succeeding rounds of land cover classification would continue until a quantifiable acceptable level of accuracy is reached.

Using supervised land cover classification and field verification, the extent of roosting, perching, nesting, and foraging habitat in the area of the monitoring program would be determined. Length, width, and area of the riparian corridor; average wetted perimeter; wetlands; river channel; floodplain; and sandbars would be mapped. The resulting map and supporting data should define baseline environmental conditions for the project area. Draft land cover maps would be available for review throughout the study phases of land cover classification, mapping, and data analysis. Review comments would be incorporated into succeeding parts of the study.

Beginning five years after completion of the environmental baseline study, and continuing at five-year intervals throughout the life of the project (estimated at 100 years), the maps and data on environmental conditions would be updated. New imagery of the study area would be obtained, field checks would be made to ensure accuracy of data, and differences between new and old imagery would be analyzed and quantified. If significant differences are discovered, an attempt would be made to determine the cause of the change and especially to determine whether the project has had an influence on the observed changes. Stream habitat variables would be monitored every five years, and riparian habitat variables would be monitored every ten years. If, after a reasonable time, it can be shown that no impacts are occurring as a result of implementation of the chloride control measures, consideration may be given to reducing or eliminating these requirements.

To establish baseline trends, satellite imagery for the July-August time period would be used, if available since this time frame is usually the critical period for water. Imagery at 30-meter resolution from about 1990 and 2000 would be analyzed to determine if significant changes in land cover have taken place during this period. If significant differences are found between these two time periods, an additional imagery analysis would be done for 1995 to help establish the rate of change. For the period prior to about 1990, the USACE would acquire one set of 80 meter imagery (only 80 meter imagery is available) at the earliest date for which it is available. If significant differences are seen in land cover between the earliest available imagery date and about 1990, additional imagery analysis would be done for periods between those two dates. Studies of imagery from additional dates would continue until the rate of land cover change is well established.

If possible, the land cover classification categories and methods used in the GAP analysis for the State of Texas would be used for this analysis. This would ensure use of a well-established standard methodology and would permit direct comparison of data between the chloride control measures and the GAP programs.

4.0 REFUGIA HABITAT MONITORING PROGRAM

4.1 General

Refugia habitat monitoring would be conducted if indicated by the results of the fish monitoring program. If the monitoring plan finds the proposed project significantly affects fish communities then USACE would invoke the refugia habitat monitoring program. The proposed project would impact flows of the Wichita River during low flow periods, primarily as a result of expected irrigation development and use of river alluvium. Historically, the Wichita River has been subject to annual periods of low and zero flow conditions. The frequency and duration of such periods is highly variable spatially within the basin, temporally, and among individual tributaries. Full development of potential irrigation use is expected to increase the duration of low or zero flow periods and the frequency of low flow conditions on the Wichita River.

Reaches of special concern were identified as stream reaches of high concern or risk to increase duration and frequency of low or zero flow conditions and salinity. Reaches of special concern are the North Wichita River (Reach 10), and the South Wichita River (Reach 11). Fish communities within these reaches are confined to pools and creek mouths as a refuge during periods of zero flow. These refugia pools are vital habitat for survival of fish and other aquatic communities during zero flow conditions and for subsequent recolonization to areas subject to complete drying.

As stated, the chloride control measures would increase the frequency and duration of periods of zero flows. In addition to zero flows, increased withdrawal from the river alluvium would reduce the number and mean depth of refugia pools. The potential effect of these reductions in flows are refugia pools on fish survival and aquatic community structure is yet unknown. To determine the magnitude and direction of such effects and to provide appropriate remedial action, the distribution and quality of refugia pool habitats in relation to fish survivability must be determined.

4.2. Objectives

The objectives of monitoring refugia pools within the reaches of special concern would be: 1) to identify potential refugia pools and fish use and survivability therein; 2) to determine physical and water quality characteristics of potential refuge pools; 3) to determine conditions that would require implementation of actions to maintain aquatic communities with reaches of special concern, such as flow augmentation; and 4) to determine the viability of any such actions.

Identification of the frequency and distribution of potential refugia pools, as well as the monitoring of selected refugia pools, would be conducted during a baseline study prior to operation of the chloride control measures. Long-term monitoring of refugia pools would identify habitat and aquatic communities at risk and trigger implementation of appropriate actions to sustain communities during critically dry conditions.

4.3 Identification of Refugia Pools

The abundance and distribution of pools would be estimated from sampling three segments within each reach of special concern. The segments to be sampled would be determined using stratified random techniques. Pools would be identified during periods of zero flow by helicopter or airplane flyover of the reach segments. Video would be used to document pool numbers and distribution within the sample reach segments. The location, area, mean, and maximum depth, as well as temperature and dissolved oxygen profiles, would be determined for each pool within the sampled segment by field crews. Thus, the number, distribution, and mean depth of refugia pools within each reach would be estimated from sample segments.

In addition to pools, primary feeder creeks near the main stem river may also be valuable refugia for fish. All creeks within a reach of concern would be sampled by a field crew one time during base flows or lower to identify pools with a maximum depth of greater than one meter for a distance of two kilometers. Such pools would be concurrently sampled for fish to determine species composition and relative abundance.

4.4 Baseline Characterization of Refugia Habitat

Refugia habitat would be identified from segments within each of the identified reaches of special concern for detailed physical, water quality, and biological monitoring. Potential refugia pools of various sizes and depths would be included in baseline monitoring.

Baseline characterization would include a broad scope of physical, chemical, and biological parameters. Data collection would focus on periods expected to experience zero flows and maximum temperature (July through September), which are considered most critical for fish survival. Initial physical parameters to be measured include a determination of pool area, mean and maximum depth, presence of flow, and substrate type. From July through September, sampling would be conducted twice monthly. Samples taken would include temperature and dissolved oxygen profiles from the surface to the maximum depth in ten-centimeter intervals. These profiles would be taken at least twice diurnally and would attempt to include minimum and maximum values. Corresponding measurements of ambient air temperature would also be taken concurrent with other measurements. Other water quality parameters to be collected include pH, turbidity, flow, and conductivity.

In addition, fish communities within the pools would be sampled to assess any changes that correspond with physical and chemical parameters. A standardized fish sample would be collected and would include all habitat type(s) found within the pool. Fish sampling would generally follow the protocol contained in the USGS's National Water-Quality Assessment Program (1993 Open File Report 93-104), "*Methods for Sampling Fish Communities as a Part of the National Water-Quality Assessment Program"*.

Baseline monitoring data would also be used to evaluate the viability and effectiveness of potential remedial actions to maintain refugia pools. A minimum of ten refugia sites within reaches of special concern combined would be established. Measures would be implemented at these sites to attempt to provide refugia for fish under dry conditions. Measures under consideration include pumping of water from the surrounding alluvium into refugia pools, aeration and recirculation of water within refugia pools, and temporary releases from storage reservoirs to augment both flows and pools.

4.5 Long-Term Monitoring

Long-term monitoring during operation of the proposed plan at identified refugia pools would allow identification of aquatic habitat and communities at risk within reaches of special concern. Subsequent appropriate preemptive actions to sustain those communities within that refuge pool or series of pools in the affected reach would then be implemented. Criteria developed from the baseline characterization program would be used to determine when preemptive actions would be required within each reach. Monitoring would continue through implementation of preemptive actions to determine the effectiveness of the actions. Long-term monitoring would follow methodologies developed and implemented during the baseline monitoring process.

5.0 LOW FLOW ANALYSIS PROGRAM

5.1 General

The chloride control would impact flows of the Wichita River during low flow periods, primarily as a result of expected irrigation development and use of river alluvium. Historically, the Wichita River has been subject to annual periods of low and zero flow conditions. The frequency and duration of such periods is highly variable spatially within the basin, temporally, and among individual tributaries. Full development of potential irrigation use is expected to increase the duration of low or zero flow periods and the frequency of low flow conditions on the Wichita River.

Reaches of special concern were identified as stream reaches of high concern or risk to increase duration and frequency of low or zero flow conditions and salinity. Reaches of special concern are Gainesville (Reach 6), the Terral (Reach 7), and the Wichita Falls (Reach 8).

5.2 Objectives

Several resource agencies have expressed concern over the projected increase in zero flow days on the upper Wichita River if the proposed chloride control measures were implemented. The resource agencies were concerned that increases in zero flow days could impact species adapted to the brine flows of the Wichita River. An investigation was initiated to assess the impact of a brush management program on low flow days projected for the proposed plan.

The objectives of monitoring the brush management program within the reaches of special concern would be to document changes in land use, i.e. conversion of brush to grass over time. Monitoring of the brush management program would be conducted during a baseline study prior to operation of the chloride control measures.

5.3 Brush Management Program

The Texas Legislature designated the Texas State Soil and Water Conservation Board (TSSWCB) as the lead agency to conduct watershed studies in conjunction with the Texas Agricultural Experiment Station and Extension Service, river authorities, and other local entities. The study was accomplished under the direction of the TSSWCB in partnership with the RRA, Texas Agricultural Experiment Station and Texas Agricultural Extension Service, the USDA Natural Resource Conservation Service (NRCS), Blackland Research Center and local Soil and Water Conservation Districts.

The results of the studies revealed that implementation of the proposed brush management program may be expected to provide a net increase in overall watershed yield at Lake Kemp between a minimum of 27.6% to a maximum of 38.9% based on the report's estimated average inflow into Lake Kemp of 119,100 acre feet per year.

The NRCS performed the watershed modeling for the brush control program using the Soil and Water Assessment Tool (SWAT) model. The SWAT model predicts the impacts of watershed management activities on watershed yield and sedimentation of large unmeasured watersheds. The USACE requested the SWAT model output for three USGS stream gaging stations within the Wichita basin. These gages were the Truscott gage (#07311700) on the North Fork of the Wichita River, the Benjamin gage (#07311800) on the South Fork of the Wichita River, and the Seymour gage (#07311900) on the Wichita River. The model output included flows for the with brush condition, the without brush condition, and the historical flows for each gage.

The low flow modeling performed to assess impacts of the chloride control project indicated that the project would have minor impacts at the Benjamin and Seymour gages. A comparison of the period of record flow totals for the historical and with brush condition to the without brush condition revealed a 121% increase in flow for the Truscott gage. Using the assumption that brush control would only be applied below the collection areas, a drainage area ratio was created for the Truscott gage. The drainage area ratio was applied to the total flow increase percentage to obtain a final flow increase percentage of 1.45.

The brush control program has currently been included in Texas Senate Bill 1 and the Region B Water Plan. Implementation of the program is expected to occur regardless of decisions made for chloride control. The brush control program is expected to alter future without-project conditions. Low flow modeling was performed for the stream reaches above Lake Kemp to estimate the program's impact. Assuming only a 50% program implementation for the areas above Lake Kemp and below the collection areas, the brush management program would decrease the number of future zero flow days in Reach 11 (Benjamin gage, South Fork of the Wichita River) by 9.8-11.3% as compared the proposed plan without brush management and would improve the number of low flow days with the project over current conditions. Brush management would only minimally affect the main stem of the Wichita River (Reach 9, Lake Kemp gage) with zero flow day reductions of less than 1/100 of a percent. Implementation of the brush control program on the North and Middle Wichita Forks of the Wichita River (Reach 10, Truscott gage) has the potential of reducing the number of zero flow days by 45.7-61.1% as compared to the proposed project without brush management. Implementation of the brush control program on the North and Middle Forks of the Wichita River is a technically feasible alternative to reducing with-project zero flow day impacts.

5.4 Baseline Characterization of Brush Management Program

Baseline studies would be accomplished using a combination of digital maps, satellite imagery, air photography, and field verification. A set of digital base maps, derived from USGS 7.5-minute quadrangle sheets at a scale of 1:24,000, would be developed. The baseline studies would be completed prior to project construction, and updates would be performed at 5-year intervals throughout the life of the project. Multispectral and panchromatic satellite imagery would be referenced to the base maps. At selected sites, high-resolution air photography would be used to enhance the accuracy of base maps and to improve surface area identification on satellite imagery. Field verification of environmental conditions would be performed at control sites. When possible, the digital base maps would be obtained directly from the USGS. In the majority of cases, however, digital maps must be created by the GIS staff in the USACE office. The image archives of the French SPOT satellite and the U.S.LANDSAT satellite would be searched for suitable scenes. The imagery must be nearly cloud free.

Environmental baseline conditions in the project area would be determined by developing a supervised land cover classification from the satellite image maps. Using information obtained from field observations and high-resolution air photography, areas of known vegetation cover type are identified on the satellite imagery. These areas are referred to as training sites. The spectral characteristics of the training sites are analyzed to obtain an electronic signature that corresponds to a particular vegetation cover type. Imagery analysis software is then used to search for additional occurrences of the desired signature.

Supervised land cover classification is an iterative process. Areas identified by the classification process as matching a particular signature would be checked against the base maps and air photographs for accuracy. Field checks would be made to verify the classifications. The electronic signatures would be revised as new information is obtained. Succeeding rounds of land cover classification would continue until a quantifiable acceptable level of accuracy is reached.

Using supervised land cover classification and field verification, the extent of brush land and native grass cover in the area of the monitoring program would be determined. Acreage in the study area would be mapped. The resulting map and supporting data would define baseline environmental conditions for the project area. Draft land cover maps would be available for review throughout the study phases of land cover classification, mapping, and data analysis. Review comments would be incorporated into succeeding parts of the study.

To establish baseline trends, satellite imagery for the May-June time period would be used, if available, since native grass growth is most apparent in this time frame. Imagery at 30-meter resolution from about 1990 and 2000 would be analyzed to determine if significant changes in land cover have taken place during this period. If significant differences are found between these two time periods, an additional imagery analysis would be done for 1995 to help establish the rate of change. For the period prior to about 1990, the USACE would acquire one set of 80 meter imagery (only 80 meter imagery is available) at the earliest date for which it is available. If significant differences are seen in land cover between the earliest available imagery date and about 1990, additional imagery analysis would be done for periods between those two dates. Studies of imagery from additional dates would continue until the rate of land cover change is well established.

If possible, the land cover classification categories and methods used in the GAP analysis for the State of Texas would be used. This would ensure use of a well-established standard methodology and would permit direct comparison of data.

5.5 Long-Term Monitoring

Beginning five years after completion of the environmental baseline study, and continuing at five-year intervals throughout the life of the project (estimated at 100 years), the maps and data on environmental conditions would be updated. New imagery of the study area would be obtained, field checks would be made to ensure accuracy of data, and differences between new and old imagery would be analyzed and quantified. Because the Reevaluation has assumed 50% implementation of the brush management program, the study area land use would be reviewed to confirm conversion of brushland over time.

6.0 LONG-TERM MONITORING PROGRAM

The Baseline Development Program identifies seven ecosystem components of high priority with respect to potential chloride control measures impacts. Baseline data for these components would be collected within a 5-year period prior to operation of the chloride control measures. Times and methods of sampling vary among the components. Both baseline and long-term monitoring would be done on a reach-by-reach basis. Identical protocols developed in the Baseline Development Program would be applied in the Long-Term Monitoring Program and would be determined upon completion of the Baseline Development Program.

The Long-Term Monitoring Program would be used to detect ecosystem changes attributable to the chloride control measures. Long-term data would be evaluated in the context of baseline data. Thresholds established in the Threshold Decision Program that indicate unacceptable changes would be developed.

7.0 THRESHOLD DECISION PROGRAM

Upon completion of baseline surface cover evaluation, and after the Chloride control measures becomes operational, long-term monitoring of surface cover would continue. If long-term changes in surface cover attributable to the chloride control measures are observed and deemed to be unacceptable, mitigation or remedial actions would be recommended. Likewise, in the event that change is noted and additional information is required to make recommendations for mitigation or remediation, additional studies may be recommended.

Criteria defining thresholds would be developed in the context of existing data and data to be collected during baseline habitat evaluation and would be determined prior to operation of the chloride control measures. The objectives of these thresholds are to protect Wichita River communities from unacceptable changes attributable to construction and operation of the chloride control measures. The biological objectives are threefold: 1) to protect Wichita River ecosystems from large changes in structure, total abundance, and species composition; 2) to protect significant community species in terms of abundance and biomass from very large reductions in abundance; and 3) to protect all species from reach-wide extirpation resulting from the chloride control measures.

Conservative thresholds provide a holding place for establishment of empirically-based thresholds derived after evaluation of data produced during the Baseline Development Program. The Threshold Decision Program would provide a multi-component mechanism for detecting impacts to the Wichita River ecosystem caused by the chloride control measures and a decision process for recommending modification/suspension of chloride control measures construction and/or operation. Two stages of concern are recognized, preliminary evidence of change and threshold violation. When preliminary evidence of change is observed, intensive monitoring would be initiated to determine the status (distribution, health, and abundance) of an ecosystem component or species. Preemptive actions may be immediately necessary to identify and rectify the cause of an observed negative change or trend to avoid violation of threshold. When thresholds are violated, remedial actions would be taken to improve impacts before significant, irreversible impacts occur and to achieve recovery.

Recovery is defined simply as the restoration of baseline conditions and consists of both temporal and spatial components. Remedial actions must restore baseline conditions at two or more of the three sites in an affected reach. Recovery must occur for the relevant time period necessary to initially cause the violation of threshold. For example, if a threshold is based on two seasonal samples, then two seasonal samples must show recovery before remedial actions are ceased.

For fish communities, recommended thresholds are defined in Table 3-2. These thresholds incorporate standard deviations of mean baseline data to help control inherent variability. In addition, they are to be calculated for each long-term monitoring sample site, where appropriate, to reflect that site's unique characteristics and to eliminate variability among sites from threshold criteria. Finally, they incorporate all threshold community protection.

TABLE 3-2
RECOMMENDED THRESHOLDS FOR FISH COMMUNITIES IN THE WICHITA RIVER BASIN

Measure	Protects Fish Communities	Threshold
Similarity Indices. Would use at least two to be determined at the end of baseline sampling. Percent Similarity Index and Quotient of Similarity are recommended.	Against changes in overall species composition of communities.	If all similarity indices are less than one standard deviation below the mean baseline similarity indices (based upon pair-wise comparisons of all baseline samples) for three consecutive years, at two sites within a reach concurrently, and for the same season, a threshold has been met for that reach. If these conditions are met for two consecutive years, preliminary evidence of change is indicated.
Abundance of a perennial species. Perennial species are defined as those that were collected at least four of the five baseline study years at a particular site.	Against change in the abundance of a perennial species. Also provides some protection against species composition changes and total biomass reductions.	If the abundance (defined as catch per unit of effort [CPUE]) of a perennial species is less than one standard deviation below the mean baseline CPUE for that species, for two consecutive years, at all sites within a reach concurrently, and for the same season, a threshold has been met for that reach. If these conditions are met within one year, preliminary evidence of change is indicated.
Absence of any species present within a reach. Species present within a reach are defined as those collected at any time at any site within a reach during the baseline-sampling period.	Against species extirpation within a reach.	If any species present within a reach is not collected within that same reach within one year, an intensive sampling effort is made within that reach to attempt to verify the species presence. If the species is not verified within the reach, this is considered preliminary evidence of its disappearance from the reach. If any species present within a reach is not collected within that same reach for two consecutive years, a threshold has been met for that reach.

7.1 Preemptive/Remedial Actions

If long-term monitoring data causes thresholds to be triggered, actions may be recommended which include implementation of additional studies to confirm impacts for problem areas; recommendations for operational modification of the chloride control measures; implementing measures such as flow augmentation from reservoirs, including acquisition of water supply storage from existing lakes; and recommendations to suspend operation of existing project components or construction of uncompleted authorized plan components.

7.2 Peer Review

A peer review panel would be responsible for interpreting study findings; reviewing, establishing, and modifying thresholds for ecosystem components and hydrology; recommending changes to baseline and long-term programs; and making recommendations for preemptive/remedial actions, mitigation, project operational modification, or project suspension.

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CHAPTER 4

SELENIUM MONITORING PLAN

1.0 OVERVIEW

This document describes a monitoring plan for evaluating potential selenium Se- related impacts associated with the chloride control measures. Details of this monitoring plan are similar to those originally developed by an interagency workgroup assigned to this and related environmental concerns associated with the RRCCP, as originally formulated. In addition, this plan is similar in design to that employed for initial baseline selenium monitoring for the chloride control measures during 1997 and 1998 (USACE 2001). The purpose of this document is to summarize details of a proposed design for monitoring for initial consideration by the Se action plan panel. A process-based action plan incorporating Se monitoring for addressing Se-related concerns for the chloride control measures is included as Appendix A of this EOP. This monitoring plan represents an initial design, which could be modified by the action plan panel as appropriate.

2.0 OBJECTIVES

The overall, long-term objective of Se monitoring would be to collect data capable of supporting technically-based decisions aimed at avoiding development of toxic concentrations of Se to biota residing at or temporarily using chloride control measures areas. As such, it is the intent of this plan to generate data appropriate for documenting the need for as well as the success of any action-based response to potential Se-related impacts, would they appear likely. Associated with this overall objective would be complementary goals of determining temporal trends in Se dynamics, establishment of site-specific Se-related relationships among abiotic and biotic system components, evaluating Se concentrations relative to threshold action values, and estimating variability in Se concentrations in environmental media at project areas.

3.0 GEOGRAPHIC SCOPE

Because the chloride control measures incorporate multiple project features varying in design characteristics and geographic location, it is necessary to define monitoring requirements for several general types of project areas. Design and location of these areas are briefly identified below for purposes of summarizing required monitoring locations. Complete design details and locations for all facilities can be found in chloride control measures design documents.

3.1 Truscott Brine Disposal Reservoir

The brine disposal reservoir associated with the chloride control measures is Truscott Brine Disposal Reservoir, a constructed reservoir that has been operational since 1987. Truscott Brine Disposal Reservoir is designed for evaporative reduction in brine volume and is operated as a total retention (no outflow) system.

3.2 Brine Collection Facilities

Brine collection areas include one completed and operational facility (Area VIII on the South Fork of the Wichita River, TX), one area with completed collection facilities but no pipeline (Area X on the Middle Fork of the Wichita River, Texas), and one proposed collection facility on the North Wichita River, Texas (Area VII). In general, collection facilities incorporate collection of brines by means of inflatable weirs that pool waters for pumping to disposal areas during low flows, but provide for normal passage of waters during high flows. Due to high flow flushing and constant pumping of brines during collection periods, collection facilities are not designed as total retention systems.

3.3 Irrigation Return Flow Areas

Implementation of the chloride control measures would result in improved quality of waters available for irrigation in the basin. This could potentially increase loading of Se and other contaminants via irrigation return flows. Magnitude of potential increased discharge resulting from irrigation return flows by stream reach is provided in the FSES for the project. In addition, identification and quantification of areas of increased irrigation associated with the chloride control measures would be accomplished via GIS imagery similar to that discussed in Chapter 3, Sections 3.2.2 and 5.4 as the project progresses. This process would help in identification of areas for focused monitoring for potential irrigation-related impacts.

3.0 MONITORING COMPONENTS

Ecosystem components to be monitored are summarized below. Collectively, these media were chosen to provide an overall assessment of Se partitioning among system components and to provide data for key components necessary for risk evaluations.

4.1 Water

All water samples would be collected by subsurface filling of sample containers and would be analyzed initially for total Se (unfiltered samples) in waters where concentrations are consistently below analytical quantitation limits. Such conditions were observed in Truscott Brine Disposal Reservoir during 1997-1998 monitoring efforts (USACE 2001). For waters where concentrations exceed analytical quantitation limits, analyses would include both total and dissolved (0.45 um filtered) Se. Analyses for these samples would also include total suspended solids to facilitate evaluation of solid/dissolved phase partitioning. While methods for Se analysis would be chosen based on best available detection limits for a brine matrix, it is anticipated that EPA Method 7742 (hydride generation) would be used. For quality assurance/quality control (QA/QC) purposes, triplicate samples would be collected at an approximate 10% frequency. Quality control samples would be analyzed as field duplicates by the primary laboratory, while a separate laboratory would analyze quality assurance samples. Laboratory QA/QC procedures would include method blank and matrix spike analyses. All analytical data collected as part of this monitoring plan would be subjected to data validation procedures.

4.2 Sediment

If possible, all sediment samples would be collected as core samples, with the upper 8 cm analyzed for total Se (dry weight basis). This depth is within the general range reported as the active sediment layer for Se processes in aquatic systems (Rudd et al. 1980; Oremland et al. 1989, 1990). In depositional areas of Truscott Brine Disposal Reservoir, samples from sediment depths (1 to 4 cm) would be analyzed as an aid in evaluating depositional patterns. Sediment samples would also be analyzed for total organic carbon (TOC) and subjected to particle size analyses. For QA/QC purposes, triplicate samples (following homogenization) would be collected at an approximate 10% frequency. Quality control samples would be analyzed as field duplicates by the primary laboratory, while a separate laboratory would analyze quality assurance samples.

4.3 Fish

Fish would be analyzed for Se concentrations on a whole-body basis. Seining or other appropriate collection methods would obtain fish. If multiple species are available, those most representative of common forage species for birds would be collected. Fish would be analyzed as distinct samples unless compositing is required to obtain adequate sample mass for analysis. For the sake of consistency, every attempt would be made to collect fish of the same species and size at all sites throughout the monitoring study period.

For initial monitoring efforts during 1997 and 1998, the Red River pupfish (*Cyprinodon rubrofluviatilis*) and plains killifish (*Fundulus zebrinus*) were the only species identified for collection at Truscott Brine Disposal Reservoir and the Area VIII collection facility. A wider range of species was present at Area X (USACE 2001).

4.4 Invertebrates

While collected species would likely vary by season and sampling location, every attempt would be made to collect a species representing a common forage organism. Every attempt would be made to collect similar taxa (at least to genus or family level) at all sampling sites. Depending upon the species available, it may be necessary to composite individuals (of the same taxa) to obtain sufficient sample mass for analysis.

During initial monitoring efforts (USACE 2001), invertebrates of suitable mass for Se analyses could not be located at Truscott Brine Disposal Reservoir or the Area VIII collection facility. Specific studies aimed at more detailed evaluation of presence and seasonality of invertebrates might be necessary for future monitoring efforts if these organisms are to be included for Se analyses.

4.5 Avian Eggs

Bird eggs would be analyzed as a measure of Se transfer to avian species breeding at and around proposed project areas. An important consideration for this sampling effort would be selection of bird species that represent maximum potential for Se exposure. In general, maximum exposure occurs to sedentary species, which spend the majority of foraging time in highly localized environments (Skorupa and Ohlendorf 1991). Following initial surveys of breeding bird use, species with highest potential for Se accumulation would be selected for egg analyses. Logistical considerations (anticipated nest numbers, acceptability of egg sacrifice, etc.) would also be evaluated. For the sake of consistency, every attempt would be made to collect eggs of the same species throughout the monitoring period.

If possible, two avian species (one piscivorous and one invertebrate-eating) would be selected for egg analyses. If available, 1 egg would be randomly selected from 12 individual nests for each species (total of 24 eggs) and analyzed for total Se (dry weight basis).

For initial monitoring efforts during 1997 and 1998, intensive bird surveys revealed that breeding semi-aquatic birds were limited in both species and numbers of individuals at Truscott Brine Disposal Reservoir. The red-winged blackbird (*Agelaius phoeniceus*), an insectivore during the breeding season, was the only relatively sedentary insectivorous species observed breeding in the vicinity of the reservoir and was selected for egg collection and analysis. No sedentary piscivorous birds were observed nesting near Truscott Brine Disposal Reservoir for either year. Eggs of the great blue heron (*Ardea herodias*) and double-crested cormorant (*Phalacrocorax auritus*), both mobile piscivores, were collected and analyzed for Se as no sedentary fish-eating species were observed nesting in the area.

5.0 SAMPLING LOCATIONS AND FREQUENCIES

Anticipated sampling locations and frequencies for all project areas are summarized below. In general, it is initially estimated that monitoring activities would be conducted once every three years over the life of the project. This frequency could be based on observed results and modified by the Se action plan panel as appropriate.

5.1 Truscott Brine Disposal Reservoir

Initial sampling at Truscott Brine Disposal Reservoir was conducted in 1997 and 1998 (USACE 2001). Baseline data from this impoundment would provide valuable information on estimated variability in Se concentrations for various system components. Anticipated locations and frequencies for monitoring components associated with Truscott Brine Disposal Reservoir are summarized below.

5.1.1 Water

Water samples would be collected at four locations at Truscott Brine Disposal Reservoir. These locations would be those used for initial monitoring and would be located at an open water location near the dam, at mid-lake, near the upper end of the impoundment, and at a near-shore location in the extreme upper end of the lake near the area of brine inflows. On each sampling date, two water samples would be collected at the two deep, down-lake sites: one at a depth of 0.5 m below the surface and one at a depth approximately 0.5 m above the sediments. Owing to shallow water depths, surface samples only would be collected at the two up-lake sites. Accordingly, a total of six water samples (exclusive of QA/QC samples) would be collected on each sampling date. Water samples would be collected once a month for a consecutive period of 12 months.

5.1.2 Sediments

If possible, sediment samples would be collected at seven locations. Sampling sites would include those established for water sample collection as well as three longitudinally intermediate locations. During each 1-year monitoring period, sediment samples would be collected at each of the seven sites on two sampling dates: once when the reservoir is vertically mixed and once during a period of thermal stratification (summer). During initial monitoring efforts, sediment sample collection was sometimes difficult owing to dense submersed aquatic vegetation at sites near the upper end of the reservoir.

5.1.3 Fish and Invertebrates

For each monitoring period, fish and invertebrate (if possible) samples would be collected on one sampling date each. These biota would be collected from areas receiving maximum bird use (shorelines). Sampling periods would most likely coincide with periods of maximum abundance (particularly for invertebrates). If possible, 30 fish samples (15 individuals of 2 species) and 20 invertebrate samples would be collected on each of the sampling dates.

5.1.4 Avian Eggs

Bird eggs would be collected at Truscott Reservoir over the breeding season (spring to early summer) during each 1-year monitoring period. Exact dates would coincide with availability of eggs for selected species. If possible, 12 eggs would be randomly selected from 12 nests of 2 avian species (1 fish-eating and 1 invertebrate-eating). Accordingly, total number of eggs collected during each year-long monitoring period at Truscott Brine Disposal Reservoir would be 24, if logistically possible.

If present, the red-winged blackbird would be selected for the insectivorous species as this bird was used for initial monitoring efforts. If nesting by sedentary piscivorous species is observed, these birds would be selected for egg analyses. If such species are not present, the value of using more mobile species (e.g., cormorants, great blue herons) would need to be discussed by the Se action plan panel as uncertainties are associated with egg Se data for these species.

5.2 Collection Facilities

Sampling locations at brine collection facilities would vary according to operational status (complete vs. proposed). Details for baseline sampling of all media at collection facilities are provided below.

5.2.1 Water

On each sampling date, one water sample would be collected at operational brine collection facilities at three locations: at an area upstream of the collection "pool" area, within the collection pool, and at an area downstream of the collection facility. While distances between sites would be dependent upon site-specific geography and access, the intent is to evaluate potential differences in concentrations due to ponding and evaporative effects at collection areas through comparison with up- and downstream "control" areas. At areas proposed for collection facility construction, one water sample would be collected at the proposed construction location. Once constructed, sampling locations would be three in number as described above. For all facilities (constructed and proposed), water sampling frequency would be once a month for a baseline period of 12 months.

5.2.2 Sediments

One sediment sample would be collected at locations described above for water samples (dependent upon operational status). Sampling frequency would be two sample collection events over a 1-year monitoring period. As thermal stratification is not anticipated at collection facilities, samples would be collected once during the summer and once during winter.

5.2.3 Fish and Invertebrates

Fish and invertebrate samples at brine collection facility locations would be collected at sites described above for water samples (dependent upon operational status). At each location, 10 individuals each of two species and 10 invertebrate samples would be collected. For all facilities (constructed and proposed), samples would be collected twice during the 1-year monitoring period.

5.2.4 Avian Eggs

Bird eggs would be collected in the vicinity of brine collection facilities over the breeding season (spring to summer) during each 1-year monitoring period. Exact dates would vary according to egg availability for selected species. If possible, egg numbers described above for reservoir sampling (2 species - 12 eggs each) would be collected from the vicinity of each brine collection facility. However, due to their limited size and varying habitat at these areas, collected egg numbers may be dependent upon available nests of breeding birds present in the area.

Intensive bird surveys during 1997 and 1998 failed to locate any semi-aquatic nesting birds in the vicinity of Area VIII. If these patterns persist at this location or are similar at other brine collection facilities (which they may or may not be), bird egg sampling may be limited for these project features.

5.3 Irrigation Return Flow Areas

A stream water quality-monitoring program has been implemented for the proposed project to monitor project impacts on water quality, stream flow, and plan effectiveness (see other chapters of this EOP). Gaging stations have been established in the Wichita River Basin for monitoring stream flows and water quality on stream segments associated with this project. Gage locations and data collection details are provided in other portions of this EOP. Gage maintenance and data collection are to be performed by the USGS under contract to the USACE.

In summary, in-situ information (flow, temperature, and conductivity) is available at each gage on a continuous hourly basis accessible via satellite. Chemical quality data consisting of various nutrients (nitrogen and phosphorus), chlorides, pH, total hardness, alkalinity, sulfates, silica, fluorides, total dissolved solids, total suspended solids, calcium, magnesium, sodium, and potassium would be collected at 4- to 6-week intervals. In addition, total and dissolved metals (barium, manganese, zinc, selenium, nickel, arsenic, iron, mercury, silver, cadmium, copper, lead, chromium) would also be collected at 4- to 6-week intervals. Pesticides would be measured twice a year. This program is anticipated to continue throughout the life of the project. While biological data are not available through this program, baseline data for water quality in project areas would be generated through these efforts.

Future increases in irrigated cropland and changes in irrigation patterns would be monitored through survey and GIS-based studies. Details of these monitoring efforts are provided in other chapters of the EOP. This process would help in future identification of areas for focused monitoring of irrigation return flow-related impacts.

6.0 BREEDING BIRD SURVEYS

In addition to sampling activities described above, breeding bird surveys are an integral part Se monitoring efforts for this project. While initial bird surveys would be necessary for selection of species for avian egg analyses, more detailed surveys aimed at determining actual bird use (species and numbers) of Truscott Brine Disposal Reservoir and collection facilities would be critical in data interpretation, impact analysis, and evaluation of corrective action measures, if required. Intensive bird surveys were conducted during initial monitoring efforts for the project (see Appendix A of USACE (2000) for methods and results). Surveys employing similar methodology would initially be employed for future monitoring efforts. Survey methodology design could be modified by the Se action plan panel as appropriate. These surveys would most likely be designed and implemented by ornithologists under contract to the USACE.

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CHAPTER 5
IMPLEMENTATION SCHEDULE FOR CHLORIDE CONTROL MEASURE MONITORING

Component	Component Implementation Date	Monitoring Implementation Date	Reporting Requirements	Checkpoints
I. Stream water Quality Monitoring Plan	1996	Life of the Project, Annually	Annual Data Report	Peer Review Process.
II. Lake Kemp Water Quality Study				
A. Baseline	1997, 1999, 2001, 2003*, 2005*		Annual Report for each effort.	Report of Findings made available for Peer Review Process.
B. Monitoring	Upon project implementation.	Extensive monitoring every 3 years. Selected parameters sampled annually.	Report of findings every third year.	Report of Findings made available for Peer Review Process.
III. Wichita River Basin Monitoring Plan				
1. Wichita River Baseline Study	2002*			
A. Imagery Acquisition	2003*			
B. Mapping	2004*-2007*			
C. Stream Variables		Every 5 years to commence upon project completion.	Report of Findings every fifth year.	Report of Findings made available for Peer Review Process.
D. Riparian Habitat Monitoring		Every 10 years to commence upon project completion.	Report of Findings every tenth year.	Report of Findings made available for Peer Review Process.
E.Brush Management		Every 5 years to commence upon project completion.	Report of Findings every fifth year.	Report of Findings made available for Peer Review Process.

Component	Component Implementation Date	Monitoring Implementation Date	Reporting Requirements	Checkpoints
2. Fish Community Structure Study				
A. Baseline	2002*-2004*		Report of Findings.	Report of Findings made available for Peer Review Process.
B. Monitoring		Every 3 years, to commence upon project completion.	Report of Findings.	Report of Findings made available for Peer Review Process.
IV. Truscott Selenium Monitoring Plan				
A. Baseline	1997 - 1998		Report for Baseline Effort	Report of Findings made available for Peer Review Process. Review by Se Action Plan Committee.
B. Monitoring or Additional Baseline	As determined by Action Plan Panel	As determined by Action Plan Panel	Report of findings after every sampling event	Report of Findings made available for Peer Review Process. Review by Se Action Plan Committee.

* Contingent upon date of approval and funding.

(1) All studies are to be conducted throughout the economic life of the project (100 years) or until it can be shown there is no scientific reason for continuation of the studies. All studies subject to Congressional funding and/or revocation.

(2) Submission of Reports of Findings to the public and other interested State and Federal agencies is to ensure a set of checks and balances for operation of the Chloride control measures. If these documents show there is statistically valid scientific evidence to conclude that significant adverse impacts are occurring to the components being monitored as a result of construction and/or operation of the chloride control measures, the Corps would notify the natural resource agencies. If after review of the Reports of Findings the natural resource agencies or the public believe there is statistically valid scientific evidence to show significant adverse impacts are occurring to the components being monitored as a result of construction and/or operation of the chloride control measures, they may initiate a request to the District to modify operation of the project or recommend remediation/ mitigation of the impacts.

APPENDIX A

SELENIUM ACTION PLAN

SELENIUM ACTION PLAN

1.0 OVERVIEW

This document describes a process-based action plan for evaluating, anticipating, and addressing selenium-(Se) related impacts should they occur in association with the USACE Wichita River Basin Project. The action plan combines elements of environmental monitoring, periodic data review and trend analysis by a multi-agency panel, use of science contemporary to the evaluation period, and a process for selection and implementation of corrective action measures appropriate for anticipated conditions, should such action be necessary. This plan presents remedial activities that could conceivably be implemented for addressing Se concerns, but also provides reasons why definitive selection and design of specific response measures at this point in project implementation are not possible owing to the myriad possibilities of future physical, chemical, and biological conditions that could occur over the life of the proposed project and dictate appropriate response action(s). As an alternative, the plan outlines a flexible, process-based approach that provides for multi-agency input into decisions regarding definition of Se-related impacts and selection of actions, if necessary, to appropriately address these concerns. Finally, the plan definitively states the USACE's commitment to a science-based evaluation process and, if necessary, implementation of appropriate response activities to ensure that Se-related concerns are adequately addressed for the life of the project.

2.0 BACKGROUND

Selenium-related issues associated with the Wichita River Basin Project have been detailed in several documents prepared by the USACE. A complete overview of Se concerns associated with the entire Red River Chloride Control Project as originally formulated, a Se literature review, and a detailed description of evaluation methodology was initially provided in USACE (1993). While much of this evaluation focused on proposed Crowell Brine Lake, Texas, similar methodology has been applied to evaluation of project features of the Wichita River Basin Project – principally Truscott Brine Disposal Reservoir, Texas. The 1993 document should therefore be reviewed for a basic understanding of Se-related concerns associated with the project and methods used to evaluate potential Se-related impacts.

In 1997 and 1998, an intensive two-year monitoring study was conducted by the USACE to evaluate Se concentrations in a variety of environmental media at Truscott Brine Disposal Reservoir, TX and the current brine collection area (Area VIII on the South Fork of the Wichita River) in the Wichita River Basin (USACE 2001). Monitoring efforts included collection and Se analysis of water, sediment, fish, aquatic vegetation, and avian eggs, liver, and ingested food samples. In addition, a key component to the monitoring effort was an intensive, two-year bird survey with an emphasis on semi-aquatic breeding birds. The monitoring report (USACE 2001) should be thoroughly reviewed for an understanding of selenium-related conditions following approximately 11 years of project operation. Most significantly, this monitoring effort provided valuable site-specific data for further understanding of Se dynamics at Truscott Brine Disposal Reservoir and the Area VIII collection facility. These data were used for refinement of impact evaluations for proposed Wichita River Basin project features.

Finally, potential Se-related impacts associated with a variety of alternatives for chloride control in the Wichita River Basin were evaluated by the USACE (2000). Site-specific monitoring data described above were used to refine previous highly-conservative means of predicting future water and sediment Se concentrations in Truscott Brine Disposal Reservoir for an array of potential alternatives. In addition, findings from the scientific literature regarding threshold range concentrations for protection of fish and wildlife and published subsequent to earlier USACE reports were identified and added to impact analyses for alternatives. Methods, assumptions, and conclusions regarding these analyses are presented in USACE (2000) and should be reviewed for an understanding of Se-related issues for project alternatives.

Owing to extreme complexity of Se dynamics in aquatic systems, numerous conservative (i.e., intentionally biased toward environmental protection) assumptions were applied by the USACE in both predictive modeling of future potential water and sediment Se concentrations at Truscott Brine Disposal Reservoir, as well as selection of threshold values protective of breeding birds. Although this high degree of conservatism was somewhat reduced by application of site-specific monitoring data (USACE 2000), predictions are still believed to be defensively conservative. These assumptions and their conservative nature are thoroughly discussed in project-related documents (USACE 1993, 2000, 2001) but are often not considered when results of these evaluations are cited as definitive future project impacts. Recognition of both the complexity of this issue as well as the conservative nature of these evaluations should always accompany any discussion of potential Se-related impacts associated with the project.

To date, conservative studies completed by the USACE conclude that the potential for Se-related impacts associated with this project is not excessive and that reasonable risks are associated with project implementation. However, it is certainly recognized that Se dynamics and potential impacts on wildlife, like many environmental issues, involve complex processes that are often site-specific, difficult to evaluate, and can most likely never be fully defined short of project construction and environmental monitoring. Accordingly, it is possible that conditions contributing to Se-related impacts to wildlife could develop over the life of the project. For this reason, a science-based process for both monitoring and implementing corrective measures appropriate for anticipated conditions should accompany project operation. This plan has been prepared to address these concerns.

3.0 PLAN OBJECTIVES

Objectives of the selenium action plan for the Wichita River Basin Project are to: (1) develop a procedural mechanism for monitoring Se-related conditions during project operations, (2) use resulting data for anticipating future conditions prior to expression of adverse impacts, and (3) if required, implement appropriate corrective measures based on input from a multi-agency panel of scientists. Specifically stated, the objective of this plan should be to:

> *Implement a multi-agency, process-based action plan to avoid, minimize, or compensate for (in that order) adverse selenium-related impacts to migratory birds resulting from operation of any project feature of the Wichita River Basin Project.*

While participation by other agencies should be an integral part of the process, the USACE should be responsible for funding, conducting, and summarizing results of monitoring studies, organizing the action plan process, and implementing appropriate response measures as needed.

4.0 RANGE OF FUTURE SCENARIOS

If required, selection of appropriate corrective measure(s) for mitigating Se-related impacts on breeding birds at Truscott Brine Disposal Reservoir (as well as other project features) should be dependent upon a combination of a wide range of environmental conditions that determine biological response to Se in the environment and impacts on avian species. A long list of these factors has been identified in the Se literature (see USACE 1993). The almost unlimited potential combinations of these conditions result in the extremely complex and site-specific nature of Se dynamics in aquatic systems and a commensurate range of potential remedial measures to address these concerns. The long-term nature of the Wichita River Basin Project as well as changing conditions as the project ages (e.g. changes in pool elevations and volumes) further complicate this issue. While certainly not all-inclusive, a partial list of factors which could influence future conditions and selection of appropriate Se-related response measures for Truscott Brine Disposal Reservoir and associated brine collection areas for the Wichita River Basin Project include the following:

- **Bird Use --** A range of possibilities for number of individuals, number of different species, feeding guilds of breeding birds present (i.e., insectivorous vs. piscivorous vs. herbivorous), mobile or sedentary nature of birds nesting at a facility, wide differences in Se sensitivity among avian species (see Skorupa et al. 1996), and presence/absence of endangered bird species are possible. While extensive bird use surveys over an initial two year period (1997-1998) at Truscott Brine Disposal Reservoir revealed that nesting by semi-aquatic birds was limited to only a few species and nest numbers among these species was low (USACE 2001), these use patterns could certainly change over the life of the project and dictate a wide range of potential remedial measures to minimize avian exposure.

- **Avian Habitat Conditions --** Changing conditions of nature and areal extent of habitat for semi-aquatic breeding birds (e.g., presence / absence of snags, mudflats, littoral vegetation) are possible over life of the project and could influence potential remedial measures for discouraging breeding bird use of project facilities if necessary to minimize Se exposure.

- **Avian Prey Species Composition –** Given anticipated changes in salinity in Truscott Brine Disposal Reservoir, abundance and species composition of prey items (fish, invertebrates, vegetation) available to semi-aquatic birds may vary over the life of the project. If amenable to control, composition of the prey base may be an important factor in selection of remediation options for minimizing avian exposure to dietary selenium. If it were to occur, elimination of certain prey organisms (e.g., fish) owing to extreme chloride concentrations could eliminate exposure to certain classes of birds (e.g., piscivorous species). Uncertainties are associated with composition of the prey base for aquatic birds over the life of the project.

- **Selenium Status of Surrounding Landscape --** The importance of "landscape mosaics" in influencing Se exposure in avian species has been documented (USFWS 1990). In addition, high concentrations of naturally-occurring Se in aquatic environments surrounding Truscott Brine Disposal Reservoir have been identified (USACE 2001). Relative changes in Se status of Truscott Brine Disposal Reservoir and surrounding environments over the life of the project may influence decisions regarding selection of appropriate remedial measures.

- **Speciation of Se in Project Waters and Sediments –** Selenium chemistry is highly complex owing to the existence of multiple oxidation states, numerous Se-containing organic compounds, and biogeochemical interactions among these forms. These forms also vary widely in their bioavailability and resulting toxicity to aquatic organisms (see discussion in USACE 1993). If identifiable and amenable to control, Se speciation may be an important factor in selection of remedial alternatives.

- **Level of Aquatic Productivity and Algal Species Composition --** Bioconcentration of Se by primary producers is a process potentially leading to expression of toxic effects in upper trophic levels of aquatic systems. Similarly, overall degree of productivity has been demonstrated to be an important factor in expression of Se toxicity in higher trophic levels. Influence of productivity and potential means of control may therefore play a role in determining appropriate response to Se-related issues for the project.

- **Vertical Stratification Patterns in Truscott Brine Disposal Reservoir** -- As Se is generally immobilized under reduced conditions (see discussion in USACE 1993), future stratification patterns (particularly permanent meromixis) could strongly influence Se conditions in Truscott Brine Disposal Reservoir and could likewise play an important role in remedial measure selection. While this could be of major importance, uncertainties exist as to future stratification patterns for the reservoir.

It is readily apparent that wide-ranging potential combinations of factors described above, over the life of the Wichita River Basin Project, are virtually limitless and impossible to predict. Accordingly, selection of a single remedial measure applicable to all future conditions is not possible and counterproductive at this stage in project development. A process-based plan based on careful monitoring, observed conditions, and application of changing science and technological advances is a more appropriate means for addressing these future concerns, should they occur. A process designed for accomplishing these goals is described in this plan.

5.0 ACTION PLAN PROCESS

The overall Se action plan for the Wichita River Basin Project should consist of multi-agency panel review of periodic monitoring data, existing environmental conditions, current state of science related to Se issues, definition of Se status of project features, and evaluation and recommendation of corrective measures, if required. Recommended specifics for each of these components of the action plan are described below.

5.1 Panel Composition.

A panel charged with implementation of this action plan should be composed of one representative from each of the following agencies: USACE, Ecological Services, Tulsa Office of the U.S. Fish and Wildlife Service (USFWS), Texas Parks and Wildlife Department (TPWD), Texas Natural Resource Conservation Commission (TNRCC), U.S. Geological Survey (USGS), and the Red River Authority (RRA) of Texas. Panel members familiar with Se-related issues should be selected for participation by each agency. The panel should be charged with responsibilities of evaluating adequacy of monitoring plans, reviewing monitoring data, predicting future conditions, calling on needed resources (e.g. subject matter experts) for assistance, and evaluating and recommending corrective measures if needed. Multi-agency membership on the panel should take advantage of various areas of expertise and agency perspective for a balanced evaluation of Se-related issues.

USACE responsibilities should include convening and organizing panel meetings, funding and conducting monitoring studies, preparing reports summarizing monitoring activities, conducting panel briefings on monitoring results, and implementing corrective measures and any associated studies as recommended by the panel. While panel meetings could be convened at the request of any member or as warranted by changing conditions, it is anticipated that the panel should initially meet once annually or more frequently as new data are available for review (see monitoring section).

5.2 Monitoring.

Initial monitoring associated with this action plan should be accomplished according to the USACE Se monitoring portion of the Environmental Operating Plan (EOP). Details of this plan are provided in this EOP. Initially, these monitoring activities should be very similar to those conducted for the Wichita River Project during 1997-1998 (USACE 2001) though the monitoring plan could be modified by the panel as appropriate to address changing concerns or conditions. In addition to basic monitoring described above, the panel could recommend and oversee additional monitoring efforts as appropriate. Responsibilities for funding and implementing all monitoring studies should rest with the USACE though other agencies could participate in sample collection or other monitoring activities as desired. Initial estimates of frequency of monitoring data collection are provided in the EOP but could be altered by recommendation of the panel.

5.3 Data Review

A primary role of the Se action plan panel should be review of periodic Se monitoring data for the project. This data review should provide an increasing understanding of site-specific Se dynamics for various project features (e.g. Truscott Brine Disposal Reservoir, brine collection areas) as the project progresses as well as provide valuable information for future trend estimation. Data review could also provide information for guiding future monitoring efforts, identifying a need for additional monitoring in specific areas, or justifying the need for corrective action. The USACE should be responsible for providing all raw data as well as a written summary report to the panel for all monitoring efforts. The format for this report should be similar to that provided for initial monitoring efforts (USACE 2001). The USACE should likewise prepare a visual presentation summarizing monitoring data for the panel. This presentation, as well as written monitoring reports, should be prepared in an electronic format suitable for electronic posting and review by the public and all resource agency personnel.

Upon review of monitoring data, the Se action plan panel might request assistance or guidance from national experts on Se-related issues. These experts could be asked to conduct a formal data review or attend meetings to discuss findings with the panel. If such assistance is required, the USACE should coordinate these efforts and provide needed funding for expert data review. Such assistance proved useful to a 1996 State and Federal interagency workgroup evaluating Se-related issues for the original Red River Chloride Control Project.

5.4 Definition and Anticipation of Conditions Requiring Corrective Action

An important function of this plan should be to define Se-related conditions requiring some form of corrective action and to anticipate these needs in advance of adverse impacts to migratory birds. An advantage to the process-based action plan should be the ability to use contemporary science as well as site-specific conditions and monitoring results in these evaluations. The Se action plan panel should be charged with making these determinations using information derived from the process described in this plan.

In 1996, a State and Federal interagency workgroup was formed to evaluate Se-related impacts for the entire Red River Chloride Control Project as originally formulated. One task considered by this workgroup was determination of threshold action concentrations for Se in various ecosystem components that were developed for protection of avian species based on current scientific literature. The workgroup defined "concern levels" as those that indicate component concentrations are approaching levels that may warrant increased monitoring / evaluation. "Action levels" were defined as those that require remediation / mitigation actions to reduce potential impacts. Resulting values for critical biological components as defined by this group are provided below.

Component	Concern Level	Action Level
Fish (whole body, dry wt)	3 ppm mean	5 ppm mean
Invertebrates (whole body, dry wt)	3 ppm mean	5 ppm mean
Avian Eggs* (dry wt)	5 ppm >25%	10 ppm**

* Sedentary, semi-aquatic species
** Geometric mean

These values are provided in this action plan as examples of threshold values that might be deemed currently appropriate for application to the Wichita River Basin project. Appropriateness of these values, derivation of potentially more appropriate indices, site-specific concerns, application of updated Se literature, and other matters pertaining to establishment of threshold conditions requiring corrective action should be a major component of this process-based action plan and the responsibility of the action plan panel.

5.5 Evaluation and Selection of Corrective Action Alternatives.

If required, a final responsibility of the Se action plan panel should be to evaluate a range of corrective measures appropriate for addressing Se-related concerns for specific features of the Wichita River Basin Project. This process should permit use of contemporary science and technology as well as site-specific conditions in selection of appropriate response measures. The USACE should be responsible for funding and conducting any studies needed for alternative evaluation. Finally, the panel should make recommendations for implementation of corrective measures as well as monitoring efforts required to ensure effectiveness of these measures.

5.6 Panel Decisions and Recommendations.

Action plan panel decisions and recommendations should be by consensus of panel members. If consensus cannot be reached on any subject matter, it is likely that the process should have provided the advantage of generating the necessary information and scientific data (based on input from all agencies) to facilitate science-based resolution of these matters in the most appropriate forum. Such information should most likely be lacking in the absence of a plan similar to that described here.

6.0 POTENTIAL REMEDIAL MEASURES

As outlined in Section 4 of this plan, an almost unlimited combination of conditions affecting Se-related impacts and selection of actions appropriate for addressing these concerns are possible for this project. Accordingly, selection of a single remedial measure appropriate for all conditions is not possible at this stage in project development. If required, identification of efficient and appropriate response action(s) should most effectively be accomplished by implementation of the process described in this plan.

While development of detailed plans for remediation of Se-related impacts are not feasible at this time, several general categories of potential measures are conceivable given current knowledge of the subject. These categories are provided in this plan as examples of potential measures for evaluation and implementation. Site-specific relevance as well as technical or economic feasibility should vary for these measures and may or may not be appropriate for this project. Brief descriptions of potential measures, if warranted, are provided below.

- **Habitat Alteration to Discourage Nesting of Impacted Bird Species.** If Se-related impacts associated with the project were to occur, these impacts should most likely be associated with decreased reproductive capacity of birds nesting near Truscott Brine Disposal Reservoir. If potentially-impacted species can be identified through monitoring, it may be possible to alter limited nesting habitat requirements to discourage nesting of these species in the project area. As a single example, if the affected species prove to be cormorants nesting in inundated dead snags, mechanical removal of these trees may be possible, forcing these birds to abandon the project area in search of more suitable nesting sites. Similar alterations (e.g., placement of riprap or control of shoreline slopes) to shorebird nesting habitat (if it exists and is limited in areal extent) could be implemented if monitoring identifies these species as affected.

- **Food Chain Alteration / Elimination.** As Se-related impacts are largely related to food chain dynamics of aquatic systems, Se impacts could conceivably be mitigated by altering and/or eliminating specific populations of organisms (e.g., algae, invertebrates, fishes) resulting in Se bioaccumulation and transfer to higher organisms (most likely bird species). Due to high chloride levels, species diversity of these aquatic organisms should likely be limited (though numbers of individuals could likely be high) and subject to possible control through alteration in habitat or physicochemical means. Monitoring efforts could identify species for possible control.

- **Bioremediation.** Bioremediation techniques involve the use of aquatic organisms in reducing Se levels. Potential treatment systems using bacteria, algae, aquatic plants, and other organisms could be investigated for their applicability to the project. Phytoremediation using Se-accumulating plants (e.g., canola, kenaf) is an emerging technology receiving increased research attention and is proving promising for Se treatment under certain conditions (Terry and Zayed 1998). Brine inflows could potentially be transported through such systems for reduction of Se loading to Truscott Brine Disposal Reservoir if necessary.

- **Enhanced Volatilization.** Atmospheric volatilization has proven to result in significant loss of Se mass in certain aquatic systems (see discussion in USACE 1994). This technique is particularly favorable due to permanent loss of Se from these systems. Volatilization rates are dependent upon a number of physical, chemical, and biological interactions but have been artificially increased with certain amendments. Site-specific research and alteration of conditions favorable to volatilization could conceivably be used to reduce Se mass in project waters.

- **Alternate Habitat Construction Using Habitat-Based Protocol.** Another potential remedial technique for Se-related impacts associated with the Wichita River Basin Project could be implementation of habitat-based protocols for Se based on those developed by the U.S. Fish and Wildlife Service (1995a, 1995b). These protocols, one for determination of compensation habitat and the other for determination of alternative habitat required for impact avoidance, are based on the concept of landscape-level dilution of avian exposure to Se and have been applied in the San Joaquin Valley of California. These protocols could potentially be modified (if necessary) to be applicable to Truscott Brine Disposal Reservoir or other project features.

- **Hazing.** Hazing is the intentional disturbance of birds with the intent to keep them from inhabiting certain areas. Hazing has sometimes been employed to prevent crop destruction by birds. Hazing could potentially be employed during the breeding season as a low-cost and effective measure to prevent nesting by birds potentially at risk to Se exposure.

- **Induced Changes in Se Speciation.** While dynamics of Se speciation are currently poorly understood, it is known that certain Se species are more prone to bioaccumulation and manifestation of impacts on higher trophic level organisms. Current research indicates that organic forms may be the most environmentally damaging in this respect. As research on this subject progresses, it may be possible to artificially control Se speciation in order to maintain forms with less bioaccumulation potential. Research continues in this area.

- **Chemical Treatment.** A potential, but currently costly alternative to mitigating Se-related impacts might be chemical treatment of brines for Se removal. While technically feasible (using techniques such as chemical coagulation with ferric sulfate), these techniques are currently costly in terms of chemical requirements and operation and maintenance costs relative to other measures. However, monitoring data could identify a reduced level of treatment balancing treatment costs and protection of the environment from Se impacts. Emerging technology in this area is likely over the life of the project and could prove useful in addressing Se concerns.

- **<u>Alteration/ Management of Vertical Stratification Patterns in Truscott Brine Disposal Reservoir.</u>** Selenium species favored by chemically reduced conditions have low solubilities and may accumulate in deep sediments of vertically stratified aquatic systems. Removal of Se from the water column in these systems can reduce algal uptake, bioavailability, and impacts on higher trophic level organisms. It is very possible that permanent stratification due to brine-induced density differences may develop in Truscott Brine Disposal Reservoir, potentially reducing Se-related impacts. If needed, it is conceivable that stratification patterns favorable to Se reduction could be manipulated through future alteration of brine input elevations and flow patterns.

- **<u>Manipulation of Sulfur:Selenium Molar Ratios</u>.** Several authors have reported that sulfur may limit the bioavailability of Se (Maier et al. 1987) or provide significant protection against Se toxicity for certain organisms. Recent research has documented reduced Se bioaccumulation due to manipulation of sulfur:selenium ratios for both algae (Williams et al. 1994) and aquatic invertebrates (Hansen et al. 1993). Manipulation of elemental molar ratios could conceivably be used to minimize impacts in Truscott Brine Disposal Reservoir, if needed, and could prove particularly promising given high sulfate concentrations already present in this system.

- **<u>Operational Changes</u>**. Operational changes could include discontinued pumping of brines from one or more source areas. Ultimately, measures could include discontinuation of the project.

If measures listed above or other alternative means of control were employed, the range of potential remedial measures for alleviating Se concerns at Truscott Brine Disposal Reservoir or other project features could range from very simple and inexpensive to more complex, costly solutions. Based on current conditions and bird use patterns, some measure employing habitat alteration to discourage nesting semi-aquatic birds should appear particularly suitable for addressing Se-related impacts at Truscott Brine Disposal Reservoir. Intensive bird use surveys during 1997 and 1998 revealed semi-aquatic breeding birds at the lake were limited in both species and numbers and utilized a limited, narrow range of habitat. It is likely that habitat alteration could have been quickly and inexpensively implemented during this period had Se concerns called for such action. While habitat alteration might prove useful under current patterns of bird use and habitat, these conditions could certainly change over the life of the project and require alternate remedial measures. These changing conditions and corresponding corrective measures should be addressed most efficiently by a process-based action plan similar to that described here.

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APPENDIX B

EOP COSTS

Period	Year	Fish Community Structure (30 sites/3 seasons per year)	Land Cover Classification/Satalite Imagery/Brush Mgmt. Characterizatio	Stream Variable Monitoring	Riparian Habitat Monitoring	Refugia Pool Identification (Reach 10 and 11 only)	Baseline Characterization of Refugia Habitat (Reach 10 and 11 only)	Long-term Monitoring of Refugia Pool (if warranted)	Curation of Fish Collections	Data Compliation and Dissimination (All EOP Activities)	Crowell Mitigation Area OMRRR	COE Participation in EOP Steering Committee	Lake Kemp Water Quality Monitoring Studies	Wichita River Basin Selenium Monitoring Studies	Wichita River Water Quality/Gaging Stations	Total Annual Expense	Present Worth Factor 6-1/8%	Present Value
1	2005	$50,000	$40,000	$61,000	$40,000	$8,000	$21,500		$2,000	$25,000	$75,000	$40,000	$180,000	$60,000	$470,000	$1,072,500	0.942285041	$1,010,601
2	2006	$50,000	$40,000	$61,000	$40,000		$21,500		$2,000	$25,000	$75,000	$40,000	$180,000	$60,000	$470,000	$1,064,500	0.887901099	$945,171
3	2007	$50,000		$61,000			$21,500		$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$814,500	0.836655924	$681,456
4	2008	$50,000		$61,000			$21,500		$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$754,500	0.788368361	$594,824
5	2009	$50,000		$61,000			$21,500		$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$924,500	0.742867714	$686,781
6	2010	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.699993134	$512,395
7	2011	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.65959306	$443,247
8	2012	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.621524673	$548,185
9	2013	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.585653402	$428,698
10	2014	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.55185244	$370,845
11	2015	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.5200023	$469,562
12	2016	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.489990388	$358,673
13	2017	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.461710613	$310,270
14	2018	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.435063004	$383,726
15	2019	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.409953361	$300,086
16	2020	$50,000			$80,000				$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$752,000	0.38629292	$290,492
17	2021	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.36399804	$328,690
18	2022	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.342989908	$251,069
19	2023	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.323194259	$217,187
20	2024	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.304541116	$268,605
21	2025	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.286964538	$210,058
22	2026	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.270402392	$181,710
23	2027	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.254796129	$230,081
24	2028	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.240090581	$175,746
25	2029	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.226233763	$152,029
26	2030	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.21317669	$188,022
27	2031	$50,000			$80,000				$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$812,000	0.200873207	$163,109
28	2032	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.189279818	$127,196
29	2033	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.178355541	$161,055
30	2034	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.168061758	$123,021
31	2035	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.158362081	$106,419
32	2036	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.14922222	$131,614
33	2037	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.140609865	$102,926
34	2038	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.132494573	$89,036
35	2039	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.124847654	$112,737
36	2040	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.117642077	$86,114
37	2041	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.110852369	$74,493
38	2042	$50,000	$40,000		$80,000				$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$962,000	0.104454529	$100,485
39	2043	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.09842594	$72,048
40	2044	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.092745291	$62,325
41	2045	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.087392501	$78,915
42	2046	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.082348646	$60,279

Period	Year	Fish Community Structure (30 sites/3 seasons per year)	Land Cover Classification/Satalite Imagery/Brush Mgmt. Characterizatio	Stream Variable Monitoring	Riparian Habitat Monitoring	Refugia Pool Identification (Reach 10 and 11 only)	Baseline Characterization of Refugia Habitat (Reach 10 and 11 only)	Long-term Monitoring of Refugia Pool (if warranted)	Curation of Fish Collections	Data Compliation and Dissimination (All EOP Activities)	Crowell Mitigation Area OMRRR	COE Participation in EOP Steering Committee	Lake Kemp Water Quality Monitoring Studies	Wichita River Basin Selenium Monitoring Studies	Wichita River Water Quality/Gaging Stations	Total Annual Expense	Present Worth Factor 6-1/8%	Present Value
43	2047	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.077595897	$52,144
44	2048	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.073117453	$64,490
45	2049	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.068897483	$50,433
46	2050	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.064921067	$43,627
47	2051	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.06117415	$55,240
48	2052	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.057643487	$42,195
49	2053	$50,000			$80,000				$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$752,000	0.054316595	$40,846
50	2054	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.051181715	$45,142
51	2055	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.048227765	$35,303
52	2056	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.045444301	$30,539
53	2057	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.042821485	$38,668
54	2058	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.040350045	$29,536
55	2059	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.038021244	$25,550
56	2060	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.035826849	$31,599
57	2061	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.033759104	$24,712
58	2062	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.031810699	$21,377
59	2063	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.029974746	$27,067
60	2064	$50,000			$80,000				$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$812,000	0.028244755	$22,935
61	2065	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.02661461	$17,885
62	2066	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.025078549	$22,119
63	2067	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.023631141	$17,298
64	2068	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.022267271	$14,964
65	2069	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.020982116	$18,947
66	2070	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.019771134	$14,472
67	2071	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.018630044	$12,519
68	2072	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.017554812	$15,483
69	2073	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.016541637	$12,108
70	2074	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.015586937	$10,474
71	2075	$50,000		$61,000	$80,000				$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$983,000	0.014687337	$14,438
72	2076	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.013839658	$10,131
73	2077	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.013040903	$8,763
74	2078	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.012288248	$10,838
75	2079	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.011579032	$8,476
76	2080	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.010910749	$7,332
77	2081	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.010281035	$9,284
78	2082	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.009687666	$7,091
79	2083	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.009128543	$6,134
80	2084	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.008601689	$7,587
81	2085	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.008105243	$5,933
82	2086	$50,000			$80,000				$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$752,000	0.007637449	$5,743
83	2087	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.007196654	$6,499
84	2088	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.0067813	$4,964
85	2089	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.006389917	$4,294

Period	Year	Fish Community Structure (30 sites/3 seasons per year)	Land Cover Classification/Satalite Imagery/Brush Mgmt. Characterizatio	Stream Variable Monitoring	Riparian Habitat Monitoring	Refugia Pool Identification (Reach 10 and 11 only)	Baseline Characterization of Refugia Habitat (Reach 10 and 11 only)	Long-term Monitoring of Refugia Pool (if warranted)	Curation of Fish Collections	Data Compliation and Dissimination (All EOP Activities)	Crowell Mitigation Area OMRRR	COE Participation in EOP Steering Committee	Lake Kemp Water Quality Monitoring Studies	Wichita River Basin Selenium Monitoring Studies	Wichita River Water Quality/Gaging Stations	Total Annual Expense	Present Worth Factor 6-1/8%	Present Value	
86	2090	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.006021123	$5,311	
87	2091	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.005673614	$4,153	
88	2092	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.005346162	$3,593	
89	2093	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.005037608	$4,549	
90	2094	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.004746863	$3,475	
91	2095	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.004472898	$3,006	
92	2096	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.004214745	$3,717	
93	2097	$50,000			$80,000				$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$812,000	0.003971491	$3,225	
94	2098	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.003742277	$2,515	
95	2099	$50,000		$61,000					$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$903,000	0.003526291	$3,184	
96	2100	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.003322772	$2,432	
97	2101	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.003130998	$2,104	
98	2102	$50,000	$40,000						$2,000	$25,000	$75,000	$40,000	$180,000		$470,000	$882,000	0.002950293	$2,602	
99	2103	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000	$60,000	$470,000	$732,000	0.002780017	$2,035	
100	2104	$50,000							$2,000	$25,000	$75,000	$40,000	$10,000		$470,000	$672,000	0.002619568	$1,760	
		$5,000,000	$720,000	$1,220,000	$720,000	$8,000	$107,500	$0	$200,000	$2,500,000	$7,500,000	$4,000,000	$6,780,000	$2,100,000	$47,000,000	$77,855,500		$13,192,824	<-- **TOTAL PRESENT WORTH**
																	0.061411	**$810,184**	<-- **AVERAGE ANNUAL**