3.0 INVESTIGATION HISTORY

Previous investigations have centered primarily on and around the former NWIRP McGregor site. These investigations have ranged from basic baseline surveys of media sampling to investigations aimed at determining the nature, extent, fate, and transport of various identified chemicals at the site. Due to potential contamination at the former NWIRP McGregor site, many of the previous owners have conducted environmental assessments there. A brief description of the previous investigations is presented in the *Final Conceptual Site Model* (MWH, 2002a). A summary of the previous investigations is also outlined in the *Draft-Final Groundwater Investigation Phase III Report* (EnSafe, 2003).

3.1 CONCEPTUAL SITE MODEL DEVELOPMENT

The project team developed a conceptual site model (CSM) for the Bosque and Leon River watersheds, as presented in *Final Conceptual Site Model* (MWH, 2002a), to provide a preliminary conceptual understanding of the relationship between contaminant sources, migration pathways, and exposures to human and ecological receptors. The CSM comprehensively incorporated available information on sources of perchlorate contamination and release, surface hydrology and hydrogeological characteristics of the Bosque and Leon River watersheds, the nature of perchlorate fate and transport, potential pathways of perchlorate migration within the study area, and the human receptors and environmental resources that may receive exposures to perchlorate. As such, the developed CSM combined previous watershed characterization information collected by the U.S. Navy with new watershed characterization information and analyses conducted by the USACE and its project team. The team used this information to identify data gaps in the understanding of perchlorate migration and exposure within the study area and to identify additional investigation activities aimed at filling such data gaps.

3.2 DATA COLLECTION AND REVIEW (BIBLIOGRAPHY)

The project team wanted to provide a detailed and comprehensive compilation and review of available data for the watershed study area coupled with a careful interpretation of relevant data for use during the CSM development. The team acquired data from the following sources during the study:

- EnSafe/U.S. Navy (NWIRP)
- CH2M Hill
- Texas Commission on Environmental Quality (TCEQ)
- Fort Hood
- USACE
- Texas State Soil and Water Conservation Board (TSSWCB)

- Natural Resources Conservation Service (NRCS)
- Black Lands Research Center
- Brazos River Authority
- City of Waco
- Baylor University, including Dr. Yelderman and Dr. Lind
- U.S. Geological Survey (USGS)
- County Appraisal Districts
- Texas Parks and Wildlife
- U.S. Fish and Wildlife Service
- Southern Nevada Water Authority

Various types of data were accumulated as part of this effort. A summary of data types collected is provided below.

- Existing reports
- Electronic databases
- GIS coverage and themes
- Groundwater quality data
- Perchlorate plume delineation
- Soil and sediment data
- Lakes Waco and Belton water quality data
- Intake structure water quality data
- Water level data
- Well location and survey information
- Precipitation data
- Species occurrence lists
- Threatened and endangered species lists
- Geologic and geophysical data
- Toxicology data
- Water budget information
- Lake flow pattern models
- Lake outflow data
- Flow patterns
- Bathymetric surveys

- Topographic information
- Regional groundwater flow data
- Land use data
- Stream gaging

A searchable data repository was established based on the existing study area data reviewed and a bibliographic summary of the compiled data was prepared by the project team. This summary included information regarding the source of the information, the format, the type, and a brief description of the data itself. An overview of the data repository is provided in **Appendix A**. This information was then compiled into a Microsoft Access database to help querying for a particular data set or searching for a particular type of report. This was a prerequisite to the development of a meaningful and representative CSM.

3.3 DATA GAP ANALYSIS

A draft CSM was prepared prior to a meeting among technical members of the USACE project team on February 21, 2002. The primary goal of the draft CSM was to provide a preliminary conceptual understanding of potential human and environmental exposures to perchlorate in the Lake Belton and Lake Waco study area. Based on the draft CSM, the project team concluded that a significant potential exists for human and ecological receptors inhabiting or using the study area to receive exposures to perchlorate through a variety of pathways. The project team also concluded that substantial data gaps exist in the available information regarding the occurrence, migration, and fate of perchlorate within the Bosque and Leon River watersheds. Data gaps as identified in this draft CSM are described in the following subsections.

3.3.1 Fate and Transport of Perchlorate

Chemical-specific characteristics that potentially affect the fate and transport of perchlorate were described in Section 4.0 of the *Final Conceptual Site Model* (MWH, 2002a). Identified data gaps in the understanding of perchlorate fate and transport included the following:

- Perchlorate is denser than water but little information is available regarding the potential for perchlorate to sink in groundwater, or undergo differential stratification in surface waters. Simple bench-top testing, or stratified water column testing in the field, would help to better understand the vertical transport of perchlorate in groundwater and surface water bodies within the watersheds.
- Information regarding the potential for perchlorate to undergo cation exchange with minerals in soil or sediment is not well documented. Such interactions may affect the fate of perchlorate in soil and sediment compartments and could be useful in the development of strategies to mitigate perchlorate transport. Simple bench-top testing, or field evaluation of cation

exchange capacity in watershed soils or sediments, would help to better understand the fate of perchlorate within these media.

- The potential for perchlorate to accumulate in soils following sequential irrigation and evaporation is currently unknown. Laboratory experiments, or sampling investigations in agricultural areas of the watersheds, would help to better evaluate the potential for accumulation of perchlorate in irrigated soils.
- Microbial degradation of perchlorate is an anaerobic process. Assessment of the anaerobic capacity of the watersheds would be helpful in evaluating the potential for perchlorate degradation to less toxic constituents.

3.3.2 Biological Uptake and Transformation

A summary of the biological uptake and transformation processes for perchlorate was presented in Section 4.3.2 of the *Final Conceptual Site Model* (MWH, 2002a). Identified data gaps in the understanding of perchlorate uptake and transformation included the following:

- Potential accumulation of perchlorate in terrestrial vascular plants, including home-grown produce, is unknown. Quantification of plant concentration factors would aid in determining exposure to human and ecological receptors through the food chain pathway.
- Data on accumulation in fish and other aquatic organisms are insufficient to evaluate exposures to organisms that feed on them. Laboratory or field assessments using methods designed to quantify aquatic organism concentration factors would facilitate this evaluation.
- Data on accumulation in litter feeding or herbivorous invertebrates are insufficient to evaluate exposures to mammals or birds that feed on these organisms. Laboratory or field assessments using methods designed to quantify litter feeding or herbivorous invertebrate concentration factors would help to better evaluate potential exposures to these receptors.

3.3.3 Toxicology of Perchlorate

The available toxicological information for perchlorate was briefly described in Section 4.5 of the *Final Conceptual Site Model* (MWH, 2002a). A thorough understanding of perchlorate-related risks requires knowledge of toxicity to all potential ecological receptors. Significant identified data gaps in the toxicological information for perchlorate included the following:

- Effects of perchlorate on algae and aquatic macrophytes are required to estimate risks to aquatic primary producers. Laboratory or field studies could be conducted to quantify effect levels for algae and aquatic macrophytes.
- Toxic effect levels in aquatic invertebrates are limited to daphnids. Laboratory toxicity studies or field assessments across several taxonomic groups would help to reduce the uncertainty in this limited database.
- USEPA's aquatic screening benchmark is based on subchronic fish data and only two taxonomic groups. Uncertainties related to the use of subchronic fish

data in the derivation of the aquatic screening benchmark (i.e., secondary chronic value, SCV) could be addressed through chronic effects testing in either laboratory studies or field assessments across several taxonomic groups.

- Data regarding the dose-response relationship for *Xenopus* are insufficient to properly evaluate potential impacts of perchlorate exposures on amphibians, including frogs. Additional FETAX studies would help to better evaluate the dose-response relationship for amphibians.
- Toxicity data for terrestrial plants are limited to a single study in lettuce. Effects testing for terrestrial plants across additional taxonomic groups and species would help to reduce the uncertainty in this value.
- Toxicity data for soil invertebrates are limited to a single study in the earthworm. Additional acute and/or chronic toxicity studies in soil invertebrates would help to reduce the uncertainty in USEPA's current soil screening benchmark.
- The USEPA's screening toxicity benchmark for herbivorous wildlife is based on laboratory rodent data. Laboratory or field assessments to evaluate the relevance of the rodent study and toxicity endpoints to herbivorous mammals would help to reduce the uncertainty in the current toxicity benchmark for herbivorous wildlife.
- Toxicity data are currently unavailable to evaluate potential impacts of perchlorate on aquatic or terrestrial birds. Laboratory toxicity studies or field assessments conducted in at least two species of birds would allow better evaluation.

3.3.4 Hydrologic Conceptual Model

Identified data gaps in the hydrologic conceptual model for the Bosque and Leon River watersheds included uncertainties in the hydrogeologic features of the watersheds, modeled water budgets, and surface water attributes of Lake Waco and Lake Belton. These data gaps are described in the following subsections.

3.3.4.1 Hydrogeology

A detailed, hydrogeologic conceptual model for the watersheds was developed, as described in Section 5.2 of the *Final Conceptual Site Model* (MWH, 2002a). Data gaps identified while developing this model included the following:

- The only values of hydraulic conductivity (K) for high groundwater levels are estimations used in model calibration runs. Direct measurements of K would be helpful in refining the actual variations. These data should be collected with enough measurements to permit statistical evaluation.
- The chemical fluctuations that result from recharge events need to be better understood. Chemical data should be collected during different recharge events, and at different levels within the aquifer. Tracers could be used to determine the flow paths of contaminants as a result of recharge events.

- Groundwater velocities also need to be measured during recharge events; tracers could be used for these measurements as well.
- Finally, groundwater-stream interactions need to be investigated during recharge events and during different times of the year.

3.3.4.2 Water Budget Modeling

An integrated, groundwater-surface water budget model was used to better understand the inflows to Lakes Waco and Belton within the Bosque and Leon River watersheds as described in Section 5.3 of the *Final Conceptual Site Model* (MWH, 2002a). Several data gaps were found to limit the usefulness of these models for assessing the potential impact of any perchlorate detected in streams on the lakes, as follows:

- Stream gauges at various locations record measurements of rainfall, stream stage (or level), velocity, and flow rate every 15 minutes. Unfortunately, the duration of recorded measurements from these stream gauges is at most eight months long. In order to better quantify flows on these streams, the measurement period should be extended to at least one year.
- Installation of stream gauges and collection of data from additional streams flowing into Lake Waco and Lake Belton would more accurately determine the water budgets for these watersheds. In particular, the contribution of flow from streams originating on NWIRP McGregor may be better understood if permanent stream gauges were established on Harris and Willow Creeks and the South Bosque River in the Lake Waco watershed, and on Station Creek in the Lake Belton watershed.
- Collection of surface flow measurements in conjunction with perchlorate sampling of surface water would allow for correlations between concentrations and flows. At a minimum, such co-located flow and concentration sampling should be conducted at the confluence of tributaries.
- Longitudinal sampling along main tributaries and streams could be conducted to validate results of surface modeling. Comparison of actual concentrations with modeled concentrations can help to identify the relative contributions of groundwater contamination to surface water concentrations of perchlorate.
- Lake elevation measurements are collected once per day and represent a data gap in storage calculations. Collection of more frequent elevation measurements would help to refine the water budget.

3.3.4.3 Surface Water Attributes

Principal surface water attributes that may affect the fate and transport of perchlorate within Lake Waco and Lake Belton were characterized in Sections 5.4.1 and 5.4.2 of the *Final Conceptual Site Model* (MWH, 2002a). Identified data gaps in the understanding of these features limit an accurate assessment of potential fate and transport processes for perchlorate within these watersheds. These data gaps included the following:

- Clay and silt particles are generally charged and are often capable of sorbing charged and/or polar molecules of anthropogenic origin to their surfaces. Such

binding may serve as either a sink or a source of pollutants to biota. Although perchlorate has been measured in surface water samples collected from Lake Waco, the *bioavailability* of perchlorate within this surface water body is currently unknown.

- Lake Waco is classified as moderately eutrophic and, as such, supports seasonal algal blooms. The extent to which these conditions may affect the bioavailability of perchlorate and either hinder or promote transfer to biota is unknown. The potential effects of the diffuser system operated within Lake Waco on the lake's trophic state, flow patterns, or other attributes is also unknown.
- Lake Belton is characterized as a warm monomictic reservoir, and the warm temperature of the bottom is believed to result in high deep-water bacteria metabolism. This phenomenon contributes to oxygen depletion that generally follows a heterograde pattern. As a result, the water column supports a complex redox pattern, potentially affecting both the solubility and metabolism of contaminants. The extent to which these attributes may affect perchlorate solubility and/or metabolism is currently unknown.
- Linear differences in sedimentation, stratification, turbidity and trophic state along the 21-mile length of Lake Belton result in taxonomic differences, as assessed by phytoplankton types. The extent to which such differences may affect surface water concentrations and bioavailability of perchlorate within different portions of this watershed are unknown.
- Evaluation of the bacteria-oxygen relationship of the hypolimnion suggests that the thalweg (old river channel) within the upper portion of Lake Belton may be transporting organic materials of river origin rather than lake origin. Based on water temperature (density), such underflows can transport river-borne materials great distances without mixing with the mass of reservoir water. More research into this phenomenon would allow evaluation of potential impacts on water budgets and potential downstream exposures.

3.3.4.4 Nature and Extent of Perchlorate Contamination

Identified data gaps in the available information regarding the nature and extent of perchlorate contamination and in the migration pathway analysis for the Bosque and Leon River watersheds included the following:

- Portions of the study area with measured or potential concentrations in surface water or groundwater exceeding the 'interim action level' of 4 µg/L require better characterization to evaluate potential impacts to human health and the environment.
- Portions of the study area with measured or potential concentrations in soil or sediment exceeding the screening benchmark of 1 mg/kg perchlorate require further characterization in order to evaluate potential impacts to human health and the environment.

- Dug wells, private groundwater wells, and springs that occur in areas likely to contain greater than the 'interim action level' of 4 µg/L perchlorate require characterization to evaluate potential impacts to human health and the environment.
- Evaluation of the significance of elevated reporting limits during the 1998 and 1999 groundwater sampling events would allow determination of whether or not re-sampling of groundwater would be beneficial at specific locations.
- Evaluation of the significance of elevated reporting limits during collection of the 1998 and 1999 surface water and stock pond grab samples would allow determination of whether or not re-sampling of surface water would be beneficial at specific locations.
- Characterization of tributaries originating on, or in the vicinity of, Fort Hood would allow characterization of potential discharges of perchlorate from this facility to the Lake Belton Watershed.

3.3.5 Exposure Assessment

Information regarding the potential impact of perchlorate releases from the former NWIRP McGregor or other sources on media within the Bosque and Leon River watersheds was used to evaluate potential exposures of human or ecological receptors that may come in contact with these media. The uncertainties and data gaps in the information needed to complete more detailed assessments of exposure and risk to human and ecological receptors are described in the following subsections.

3.3.5.1 Human Health Exposure Analysis

Identified data gaps related to the human exposure assessment included the following:

- Drinking water intake structures located within Lake Belton, downstream of Lake Belton, and within Lake Waco provide the sole-source drinking water supply for nearly 500,000 people in the surrounding communities. Measured or modeled concentrations of perchlorate at these in-take structures would allow quantitative evaluations of exposure and risk to users of public water supplies. Knowledge regarding potential mixing of water sources to achieve contaminant compliance goals, or specific perchlorate monitoring data collected by the utilities, would allow for a refined assessment of public health risks.
- Surface water obtained from springs and some dug wells is also used for human consumption in areas not connected to public water supplies. The extent to which supplies with known or potential contamination are used for potable purposes is unknown.
- Humans may potentially consume home-grown produce or livestock products that are irrigated with contaminated water. Sources of water for irrigation or stock ponds and their relationship to contaminated areas of the watersheds are unknown.

- Recreational users of the Lake Waco and Lake Belton watersheds are susceptible to perchlorate exposures while swimming, fishing, or hunting in contaminated areas. Additional characterization data would allow evaluation of such potential exposures. Data currently being collected by TIEHH should be helpful in an evaluation of recreational exposures through consumption of wildlife.

3.3.5.2 Ecological Exposure Analysis

Identified data gaps in the ecological exposure assessment included the following:

- The ecological exposure analysis included an assessment of the biological resources within the study area. This evaluation resulted in the identification of several protected or special status species. Additional biological assessment including field surveys would allow identification of the co-occurrence of special status species with areas of elevated perchlorate contamination.
- Uptake of perchlorate by aquatic producers (e.g., phytoplankton and algae), submergent macrophytes, and emergent vegetation through foliar transport and/or root uptake is likely to occur within surface water bodies of the Bosque and Leon River watersheds. In addition, benthic invertebrates and omnivorous and carnivorous fish are exposed to these media. Additional characterization data would allow evaluation of such exposures in areas that have not been sampled.
- Little information is available regarding the uptake of perchlorate into phytoplankton and algae. It is possible that serial blooms of such organisms within Lakes Belton and Waco may serve to transfer perchlorate from the water column to planktivorous fish or waterfowl. Measurements of perchlorate uptake by phytoplankton and/or algae would help to identify whether or not this is a potentially significant fate process for perchlorate within these watersheds.
- Once absorbed by producer level receptors (e.g., plants), there is a potential for transfer of perchlorate to consumer level receptors and to higher trophic level receptors through the ecological food chain. The potential for transfer of perchlorate through the ecological food chain is relatively unknown.

3.4 DATA GAP PRIORITIZATION

The technical meeting also resulted in the prioritization of data gaps regarding available information on the occurrence, migration, and fate of perchlorate within the Bosque and Leon River Watersheds.

Table 3-1 provides a comprehensive list of all data gaps identified, general recommendations for resolving each data gap, and a consensus ranking of the importance of resolving each data gap, consistent with the outcome of the February 21, 2002 technical meeting. It also highlights the data gaps which were resolved as a result of this study.

Table 3-1
Data Gaps Summary

Data Gap Identified	Actions Needed	Priority	Work Performed	Data Gap Filled During Study
Fate and Transport of Perchlorate				
The potential for perchlorate to accumulate in soils following sequential irrigation and evaporation is currently unknown.	Conduct laboratory experiments, or sampling investigations in agricultural areas of the watersheds to evaluate the potential for accumulation of perchlorate in irrigated soils.	High	TIEHH Transformation Study (Section 5.2.3)	Partially
The extent to which conditions favorable to anaerobic degradation of perchlorate within portions of the watersheds associated with elevated perchlorate concentrations is currently unknown.	Conduct field assessments of current watershed conditions in areas with elevated perchlorate concentrations.	Medium	TIEHH Transformation Study (Section 5.2.3) and MWH Anoxic Study in Lake Belton (Section 5.2.2)	YES
Hydrologic Conceptual Model				
Groundwater-stream interactions during recharge events and during different times of the year needs to be better understood.	Seasonal measurements of groundwater and stream characteristics should be taken concurrently during known recharge events.	Medium	MWH Longitudinal Stream Sampling Study (Section 5.1.3)	YES
Water Budget Modeling				
The duration of recorded measurements of rainfall, stream stage (or level), velocity, and flow rate is insufficient to quantify flows on the streams.	Collect measurements of rainfall, stream stage (or level), velocity, and flow rate every 15 minutes for at least one year from stream gauges at various locations.	High	MWH Longitudinal Stream Study (Section 5.1.3)	YES
Water budgets for the watersheds are inaccurate due to absence of stream gauges and collection of data from certain streams flowing into Lake Waco and Lake Belton originating on NWIRP McGregor.	Permanent stream gauges should be established on Harris and Willow Creeks and the South Bosque River in the Lake Waco watershed, and on Station Creek in the Lake Belton watershed.	High	MWH Longitudinal Stream Study (Section 5.1.4, Section 6.4)	YES – Station Creek, South Bosque and Harris Creek NO – Willow Creek
A correlation between concentrations and flows is impossible due to the absence of co-located data for surface flow and perchlorate concentrations.	Conduct co-located flow and concentration sampling at the confluence of tributaries.	Medium	MWH Longitudinal Stream Study (Section 5.1.1.2, Section 5.1.4)	YES
It is not currently possible to evaluate the contribution of groundwater contamination to surface water concentrations based on current surface modeling results.	Longitudinal sampling along main tributaries and streams should be conducted to validate results of surface modeling. Compare measured concentrations with modeled concentrations.	Medium	MWH Longitudinal Stream Study (Section 5.1.1.2, Section 5.1.3)	Partially – Sampling was performed but due to concentrations detected, modeling was not conducted.

Data Gap Identified	Actions Needed	Priority	Work Performed	Data Gap Filled During Study
Surface Water Attributes				
The bioavailability of perchlorate within the surface water bodies of Lake Waco and Lake Belton watersheds is currently unknown.	Further studies on the bioavailability of perchlorate in the watersheds are necessary.	Medium	TIEHH Fish and Frog uptake studies (Section 5.4.1, Section 5.4.2)	Partially
The extent to which seasonal algal blooms may affect the bioavailability of perchlorate and either hinder or promote transfer to biota is unknown.	Studies of biota uptake should be conducted to compare uptake rates during and between algal blooms.	Medium	TIEHH Algae Uptake Study and MWH Lake Belton Delta Area Algae Study (Section 5.3.2)	Partially
The extent to which substantial deep-water bacteria metabolism in Lake Belton may affect perchlorate solubility and/or metabolism is currently unknown.	Laboratory tests must be conducted simulating the attributes present in Lake Belton to determine the expected affect on perchlorate.	Low	MWH Anoxic Study of Lake Belton (Section 5.2.2)	YES
Migration Pathway Analysis				
Characterization of perchlorate in surface water and groundwater is insufficient.	Portions of the study area with measured or potential concentrations in surface water or groundwater exceeding the 'interim action level' of 4 µg/L should be further characterized.	High	TIEHH stream and lake water grab sampling and MWH Longitudinal Stream Study and lake water sampling (Section 5.1)	YES – surface water Partially – GW sampling was not performed by the project team, but the U.S. Navy continued to characterize the GW contamination and provided data to the team.
Characterization of perchlorate in soil and sediment is insufficient.	Portions of the study area with measured or potential concentrations in soil or sediment exceeding the screening benchmark of 1 mg/kg perchlorate should be further characterized.	High	TIEHH sediment pore water studies in streams and MWH sediment pore water studies in Lake Belton and Lake Waco. (Section 5.2.1)	YES – Sediment pore water sampling Limited soil testing by TIEHH No sediment testing was performed by team but historical soil and sediment sampling data were provided by the U.S. Navy
Elevated reporting limits during collection of 1998 and 1999 surface water and stock pond grab samples create uncertainty.	The significance of elevated reporting limits should be further evaluated to determine if re-sampling of surface water is required at specific locations.	Medium	MWH Longitudinal Stream Study and lake water sampling (Section 5.1.1, Section 5.1.2)	YES
The flow patterns of streams running into Lake Belton and Lake Waco are poorly understood.	The flow patterns of streams impacted by perchlorate may be better understood by utilizing dye tracers and other related studies.	Medium	MWH Longitudinal Stream Study and ADCP study (Section 5.1.4)	YES

Data Gap Identified	Actions Needed	Priority	Work Performed	Data Gap Filled During Study
Perchlorate detections in the southern portion of Lake Belton suggest potential contamination from another source.	Tributaries in the vicinity of Fort Hood should be characterized to evaluate potential discharges of perchlorate from this facility to Lake Belton.	High	MWH Longitudinal Stream Study and lake water sampling (Section 5.1.1, Section 5.1.2)	Partially – Limited perchlorate testing performed along Cowhouse Creek. Lake Water was also sampled.
Exposure Assessment				
Further knowledge regarding potential mixing of water sources to achieve contaminant compliance goals or specific perchlorate monitoring data collected by the utilities is necessary for assessment of public health risks.	Measured or modeled concentrations of perchlorate at the Lake Belton and Lake Waco in-take structures will be needed to conduct quantitative evaluations of exposure and risk to users of public water supplies.	High	MWH Intake and lake Sampling Studies (Section 5.1.2)	YES
The potential uptake of perchlorate in plants and agricultural products through irrigation of food crops needs to be better understood.	Conduct laboratory or field assessments using methods designed to quantify perchlorate uptake in agricultural products.	High	TIEHH Lab and field plant uptake data (Section 5.3)	Partially – Not all food crops were sampled during the study
Exposure of humans to perchlorate in surface water, sediment and biota associated with recreational uses of the Lake Waco and Lake Belton watersheds is incomplete.	Additional characterization data are needed to in areas that have not been sampled. Data currently being collected by TIEHH should be useful to an evaluation of exposures through consumption of wildlife.	Medium	TIEHH Beef cattle data, market basket survey and catchable fish fillets. MWH Longitudinal Stream Study and lake water sampling (Sections 5.1.1, 5.1.2, 5.3.4, 5.4.1, and 5.5.3)	YES
Measurements of perchlorate uptake by aquatic producers (e.g., phytoplankton and algae), submergent macrophytes, emergent vegetation, benthic invertebrates and omnivorous and carnivorous fish are limited.	Studies of this phenomenon are currently being conducted by TIEHH. This information should be useful to an evaluation of ecological exposures through food chain transfer. Additional biological sampling may be required.	High	TIEHH algae uptake study (Section 5.3.2)	Partially
The extent to which phytoplankton and algae may serve to transfer perchlorate from the water column to planktivorous fish or waterfowl is currently unknown.	Measurements of perchlorate uptake by phytoplankton and/or algae would help to identify whether or not this is a potentially significant fate process for perchlorate within these watersheds.	Medium	TIEHH algae uptake study and MWH Delta Area Algae Study in Lake Belton (Section 5.3.2)	YES
Biological Uptake and Transformation				
Data on perchlorate accumulation in aquatic plants are insufficient to assess exposures to primary consumers (i.e., planktonic and benthic invertebrate communities).	Conduct laboratory or field uptake and accumulation studies using methods designed to quantify aquatic plant concentration factors.	Medium /High	TIEHH aquatic plant study (Section 5.3)	YES

Data Gap Identified	Actions Needed	Priority	Work Performed	Data Gap Filled During Study
Data are insufficient to determine whether perchlorate bioconcentrates in aquatic organisms.	Conduct laboratory or field assessments using methods designed to quantify aquatic organism concentration factors under steady state conditions.	Medium /High	TIEHH aquatic organism study (Section 5.4)	YES
Data on accumulation in fish and other aquatic organisms are insufficient to evaluate exposures to organisms that feed on them.	Conduct laboratory or field uptake and accumulation studies using methods designed to quantify aquatic plant concentration factors across multiple trophic levels.	Medium /High	TIEHH plant uptake and accumulation studies (Section 5.3)	YES
Data on perchlorate accumulation in terrestrial vascular plants are insufficient to evaluate potential exposures to terrestrial herbivores.	Conduct laboratory or field assessments using methods designed to quantify terrestrial herbivore concentration factors.	Medium /High	TIEHH plant studies (Section 5.3)	YES
Data on the fate of perchlorate in irrigated soils and plants are insufficient to evaluate potential exposures to humans through agricultural products.	Conduct laboratory or field assessments to determine effects of perchlorate in irrigated soils and concentration factors in terrestrial plants.	Medium /High	TIEHH terrestrial plant studies and market basket survey (Section 5.3.3, Section 5.3.4)	YES
Ecotoxicology				
USEPA's aquatic screening benchmark is based on subchronic fish data and only two taxonomic groups.	Conduct chronic laboratory toxicity studies or field assessments across several taxonomic groups.	Medium	TIEHH toxicity studies	YES
Data regarding the dose-response relationship for Xenopus are insufficient to properly evaluate potential impacts of perchlorate exposures on amphibians, including frogs.	Conduct additional FETAX studies to better evaluate the dose-response relationship for amphibians.	Medium	TIEHH amphibian studies (Section 5.4.2)	YES
The USEPA's screening toxicity benchmark for herbivorous wildlife is based on laboratory rodent data.	Conduct laboratory or field assessments to evaluate the relevance of the rodent study and toxicity endpoints to herbivorous mammals.	Medium	TIEHH small mammal studies (Section 5.5.1)	YES
Toxicity data are currently unavailable to evaluate potential impacts of perchlorate on aquatic or terrestrial birds.	Conduct laboratory toxicity studies or field assessments in at least two species of birds.	High	TIEHH bird studies (Section 5.5.1)	YES