1.0 INTRODUCTION

1.1 BACKGROUND

Parsons is under contract with the U.S. Army Corps of Engineers (USACE), Fort Worth District (CESWF), Contract DACA87-02-D-0005, Task Order (TO) DY01, to provide investigations and environmental services for waste sites at Camp Stanley Storage Activity (CSSA) U.S. Army in Boerne, Texas. The requirements for the TO DY01 scope of work, which includes characterization of selected waste sites and preparation of appropriate documentation, including an ecological risk assessment (ERA), are described in the *Final TO DY01 Work Plan Addendum* (Parsons, 2007a). All work performed under the TO DY01 work plan and this work plan, which describes the ERA approach, will be in accordance with requirements of the Resource Conservation and Recovery Act (RCRA) 3008(h) Order in effect for CSSA and in accordance with 30 Texas Administrative Code (TAC) §350, the Texas Risk Reduction Program (TRRP) of the Texas Commission on Environmental Quality (TCEQ).

This work plan was requested in response to items discussed during the September 14, 2007 meeting held at the Parsons office in Austin, Texas. Meeting attendees included representatives from CSSA, the U.S. Environmental Protection Agency (USEPA) Region VI, TCEQ, USACE CESWF, Noblis, Weston Solutions, and Parsons. The main objective of the meeting was to discuss the ERA for the North Pasture and to obtain technical input from the USEPA and TCEQ for the ERA approach. It was suggested that an ERA work plan be developed to document the technical approach. Minutes of the meeting are presented in Appendix B.

This work plan also incorporates information discussed at the November 29, 2007 meeting held at CSSA in Boerne, Texas. The objectives of this meeting were to further discuss the ERA for the North Pasture, including this draft work plan, and to visit the solid waste management units (SWMU) and make field observations regarding the vegetation and other environmental conditions within and near the North Pasture. The meeting attendees, primarily the same participants that were present at the September 14th meeting, provided technical input on several items to be addressed in this work plan. A copy of the meeting minutes is provided as Appendix C.

Specifically, this work plan provides the technical approach for performing an ERA using a Tier 2 Screening Level Ecological Risk Assessment (SLERA) for SWMUs B-2, B-8, B-20/21, and B-24. These four SWMUs are located in the North Pasture at CSSA. Based on site similarity, and with USEPA and TCEQ concurrence, the North Pasture SWMUs will be combined into one SLERA. The SLERA will support development of the Affected Property Assessment Report (APAR) for these four sites. The SLERA report will be presented as part of the APAR document.

1.2 OBJECTIVES

This work plan sets out the technical approach for the SLERA activities. The primary objective of the SLERA is to assess whether chemicals of potential concern (COPC) at the four SWMUs in the North Pasture may cause potential adverse effects to ecological receptors. The SLERA will evaluate potential impacts to ecological receptors due to the presence of affected surface soil at the sites. The ecological receptors selected for this SLERA include the white-footed mouse, short-tailed shrew, gray fox, American robin, bobwhite quail, black-capped vireo, golden-cheeked warbler, and red-tailed hawk.

In addition to the specific activities of the SLERA, the ERA will be used to develop ecological protective concentration levels (PCL) that can be used in conjunction with human health PCLs to determine nature and extent of contamination. Any soils remaining at the sites that have COPCs that exceed Tier 1 residential PCLs are planned for excavation and removal. As funding allows, the ERA will also be used for planning and conducting excavation and removal activities.

As discussed at the project meetings, some of the main items that are addressed and documented in this work plan include the following:

- Technically describe why the four SWMUs in the North Pasture can be treated as one area-wide risk assessment (*e.g.*, based on site histories, site contaminant similarities, types and levels of clean-up, environmental setting, *etc.*). Also explain why the one remaining area of concern (AOC) located in the North Pasture (AOC-73) will not be included in the SLERA.
- Evaluate the environmental setting, potential ecological receptors and home range of the species for the North Pasture and immediate surrounding areas.
- Describe the methodology for COPC selection and data evaluation, including development of the ecological data set and the initial screening process, development of exposure point concentrations (EPC) including calculation of 95 percent upper confidence levels (95% UCL), use of TCEQ established ecological benchmarks, development of ecological PCLs for chemicals that exceed the TCEQ benchmarks, and comparison of the EPCs to PCLs.

1.3 OVERVIEW OF ECOLOGICAL RISK ASSESSMENT

In September 1999, the TCEQ adopted new rules to establish requirements for response actions at sites where release of a COPC has impacted human health and/or the environment. The adopted rule, commonly referred to as the TRRP rule and codified in 30 TAC §350, outlines a comprehensive program that addresses the investigation of contaminated sites, establishes reasonable standards for notice, provides flexibility in calculating site-specific cleanup levels, and establishes requirements for corrective actions to address contamination.

The ERA is a process that evaluates the likelihood that adverse ecological effects are occurring or may occur as a result of exposure to one or more COPCs detected at a waste site.

The TRRP rule defines a three-tiered approach for evaluating risks to ecological receptors. The three tiers are described below.

Tier 1 – Exclusion Criteria Checklist. Tier 1 sets forth conditions under which an affected property may be excluded from further ecological assessment, based on the absence of any complete or significant ecological exposure pathways. Affected properties that do not meet specific exclusion criteria will require further evaluation under Tier 2 and/or Tier 3, unless a reasoned justification and/or an expedited stream evaluation (for surface water and sediment release to intermittent streams without perennial pools) are appropriately used to conclude the ERA.

Tier 2 – Screening-Level Ecological Risk Assessment. Under Tier 2, COPCs that are not bioaccumulative may be screened from further evaluation based on comparison to ecological benchmarks established by TCEQ. If COPCs are not excluded on this basis, an ecological conceptual site model (ECSM) will be developed to characterize complete exposure pathways and representative receptors. EPCs will be compared to literature-based effects levels using conservative exposure assumptions that may later be refined with available site- or area-specific information. The Tier 2 SLERA should scientifically eliminate COPCs that do not pose an ecological risk, and define PCLs for COPCs that are retained.

Tier 3 – Site-Specific Ecological Risk Assessment (SSERA). Under Tier 3, ecological risks indicated from previous tiers may be compared to site-specific "weight-of-evidence" information regarding the presence or absence of ecological effects. Such site-specific assessments may include analysis of tissue samples, toxicological testing of affected media, comparison of species diversity to reference areas, and/or other appropriate analyses. Site-specific data may be employed to derive Tier 3 PCLs for any relevant receptors and exposure media. Tier 3 is the most involved assessment and in general is not necessary for the majority of waste sites.

This work plan discusses the technical approach for performing a Tier 2 SLERA for the North Pasture at CSSA using soil data collected at the four identified SWMUs. If an unacceptable risk is determined from the Tier 2 SLERA, coordination with concerned agencies will determine further risk management decisions.

1.4 REFERENCE DOCUMENTS

The methodology for performing the Tier 2 SLERA will be in general conformance with TCEQ, USEPA and U.S. Army guidance documents. The work plan refers to the following documents as well as other documents cited in the references.

- *Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas*. Publication RG-263 (revised). December 2001. This is the primary ERA guidance document from TCEQ (2001).
- Update to RG-263 (revised) – January 2006 version. This is the most recent partial update to the main guidance (TCEQ, 2006).
- *Position Paper on Common Issues Encountered During the Review of Ecological Risk Assessments* (TCEQ, 2005).
- *A Guide to Screening Level Ecological Risk Assessment* (U.S. Army Environmental Center, 2005).
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, Interim Final (USEPA, 1997).
- *Guidelines for Ecological Risk Assessment* (USEPA, 1998).
- *ECO Update. The Role of Screening Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA, 2001).
- *Wildlife Exposure Factors Handbook, Volume 1 of 2* (USEPA, 1993).

1.5 WORK PLAN ORGANIZATION

This work plan was prepared following recommended guidelines published by the TCEQ for conducting Tier 2 SLERAs. The work plan consists of the following sections.

- Section 1: Introduction – This section gives an introduction to the proposed work, including background, objectives, an overview of the ERA tiered approach, the main reference documents used, and organization of the work plan.
- Section 2: Site characteristics – This section presents a brief description of CSSA and the four SWMUs in the North Pasture selected for the SLERA. A brief description of other sites in the North Pasture is also provided.
- Section 3: Steps of the SLERA process – This section describes the three phases of the SLERA process.
- Section 4: Problem formulation – This section presents the methodology for the first four required elements of a SLERA as per 30 TAC §350.77(c). This includes the technical approach for the screening analysis, an exposure pathway analysis, an ECSM, and a COPC fate and transport analysis.
- Section 5: Characterization of exposure – This section presents the methodology for exposure characterization, which identifies the magnitude and frequency by which target receptors are exposed to COPCs that have migrated, or that may potentially migrate, via complete exposure pathways to ecological receptors at the site.
- Section 6: Characterization of ecological effects – This section presents the methodology for risk characterization, which integrates the information from the problem formulation and the exposure and ecological effects characterizations to estimate the nature and extent of potential ecological risk.
- Section 7: References.

Most of the tables and figures are provided at the end of this work plan, or are included in Appendix A. Reference to the figure if located in Appendix A will be noted in the text of this work plan. The minutes of the two meetings, Appendices B and C, include the meeting minutes and slides, not additional handouts.

2.0 SITE DESCRIPTIONS AND FUTURE SITE ACTIVITIES

2.1 SOURCES OF INFORMATION

This section provides a brief summary of CSSA, the North Pasture and the four selected SWMUs within the North Pasture, and the status of other sites within the North Pasture. For more detailed information (*e.g.*, site soils, site geology) the following sources are available.

- General information regarding the history and environmental setting of CSSA is provided in the CSSA *Environmental Encyclopedia (Volume 1-1, Background Information Report*). Data regarding the geology, hydrology, and physiography are also available for reference. The report can be found at www.stanley.army.mil.

- Detailed information regarding previous investigations at each of the subject sites is described in the CSSA *Environmental Encyclopedia (Volume 3-3, Investigation and Closure Reports, Table of Contents).* The reports can be found at www.stanley.army.mil.

- Statistically calculated and TCEQ-approved background metal concentrations are reported in the *Environmental Encyclopedia (Volume 2)* at www.stanley.army.mil.

- The *Final TO DY01 Work Plan Addendum* (Parsons, 2007a) provides additional information on the status of the four selected SWMUs located in the North Pasture. The TO DY01 work plan includes descriptions of previous site investigations and findings, comparison of COPC concentrations to TRRP criteria, clean-up activities that have been performed, and work to be completed at the sites.

2.2 CAMP STANLEY STORAGE ACTIVITY

Camp Stanley Storage Activity is located in northwestern Bexar County, about 19 miles northwest of downtown San Antonio. The installation consists of approximately 4,004 acres immediately east of Ralph Fair Road, and approximately 0.5 mile east of Interstate Highway 10 (Figure 1). Camp Bullis borders CSSA on the east and south. The land was used for ranching and agriculture until the 1900s. During 1906 and 1907, six tracts of land were purchased by the U.S. Government and designated the Leon Springs Military Reservation. The land included campgrounds and cavalry shelters.

In October 1917, the installation was re-designated Camp Stanley. Extensive construction was started during World War I to provide housing for temporary cantonments and support facilities. In 1931, the installation was selected as an ammunition depot, and construction of

standard magazines and igloo magazines began in 1938. Land was also used to test, fire, and overhaul ammunition components.

The present mission of CSSA is the receipt, storage, issue, and maintenance of ordnance as well as quality assurance testing and maintenance of military weapons and ammunition. Because of its mission, CSSA has been designated as a restricted access facility. Limited wildlife hunting is allowed and is managed by the CSSA Wildlife Management Committee. No changes to the CSSA mission and/or military activities are expected in the future.

CSSA consists of numerous historical waste sites, including SWMUs, AOCs, and range management units (RMU). The locations and closure status of the sites are shown on Figure 2. The boundaries of the North Pasture and the sites within the North Pasture are also shown on Figure 2.

2.3 NORTH PASTURE SITES

The four SWMUs of concern in the North Pasture are SWMUs B-2, B-8, B-20/21, and B-24. Figure 3 provides an aerial photo of the area where the four SWMUs are located. Prior to 2004, RCRA facility investigations (RFI) and limited removal actions were conducted at these sites. Results of the previous RFI activities and removal actions can be found in the CSSA *Environmental Encyclopedia* as described above. In late February and early March 2008, further remedial activities and investigations were performed at SWMUs B-2, B-8, and B-24, as well as at an additional site in the North Pasture (AOC-73), which was a small area used by a former rancher for dumping household trash and metal debris (primarily miscellaneous old tools, bottles, and cans). All of these sites are subject to closure under TRRP. All other SWMUs and AOCs within the North Pasture have already been closed under previous TCEQ requirements. The sites were closed to Risk Reduction Standard 1 (RRS1) criteria, which included the use of CSSA background concentrations for metals (Parsons, 2002). RMU-5 is also located in the North Pasture but is no longer active.

An APAR is planned for the area and will include the four SWMUs identified within the North Pasture. These four SWMUs have similar chemical constituents (primarily metals) and have had similar removal actions previously performed (primarily sifting actions). The primary COPCs at the four SWMUs are nine metals, particularly lead. The other eight metals include arsenic, barium, cadmium, chromium, copper, mercury, nickel, and zinc. These nine metals are common to many of the SWMUs at CSSA. Specifically, at the four SWMUs in the North Pasture, there are four metals that exceed human health PCLs, ecological benchmarks, and/or background concentrations. These four metals are barium, copper, lead, and zinc. Mercury had at one time been considered as a potential COPC; however, the levels detected were lower than the final TCEQ-approved background concentrations for CSSA (Parsons, 2002). A description of the sites and the chemical constituents remaining in soils at the sites above TCEQ screening criteria are given below.

The following sections briefly describe the status of the four selected SWMUs, AOC-73, and other sites in the North Pasture. Additional information on the history of the sites is

provided in the sources listed above. A summary of the site work most important to the SLERA, including status of the sites, ecological COPCs, as well as work to be completed at the sites is provided below. The information is primarily taken from the TO DY01 work plan. The data from the February/March 2008 field activities are still preliminary and only briefly discussed. All investigations/remedial action results will be updated and incorporated in the Tier 2 SLERA report.

In the TO DY01 work plan, maximum detected concentrations of the COPCs were used in the comparisons to TRRP criteria (human health and ecological). The human health criteria included Tier 1 PCLs, and in some cases preliminary Tier 2 PCLs. (The human health results are briefly summarized in this work plan because, like ecological results, they are being used to determine where additional soil removal activities, and additional confirmation samples, will take place.) The ecological criteria that were used in the initial analyses were the ecological screening benchmarks developed by TCEQ. Background levels were also used for both human health and ecological screening.

For both the human health and ecological risk assessments, the most current criteria (*i.e.*, Tier 1 human health PCLs, ecological benchmarks) and all of the information used in Tier 2 calculations will be presented.

2.3.1 SWMU B-2

SWMU B-2 was a small arms ammunition trench and burning area. Investigations were initiated in 1995 with a soil gas survey and the drilling and sampling of soil borings. In 1997, excavation of the trenches was initiated to determine if buried waste included munitions. Although some munitions debris was encountered, excavation was temporarily suspended due to funding limitations. Excavation recommenced in 2003. All of the waste material was removed, but some surface soil results exceeded RRS1 criteria, preventing closure of the site under RRS1 before the grandfather period ended in May of 2005.

2.3.1.1 Comparison of COPCs to TRRP Criteria (SWMU B-2)

Based on soils that were remaining at the site, prior to the February/March 2008 field activities, the only COPC exceeding TCEQ ecological screening criteria was lead. For human health, only five surface soil sample results (not previously excavated) exceeded the residential Tier 1 PCL for lead and one sample exceeded the Tier 2 PCL for 2,4-dinitrotoluene (2,4-DNT).

2.3.1.2 Work to be Completed for TRRP Closure (SWMU B-2)

Work to be completed for the site includes surface soil sampling, with limited removal action, and human health and ecological risk assessments. The removal action and resulting investigations were performed in February/March 2008. The excavation area and sample locations are shown in Figure 1 of Appendix A. Surface soil near the five previous sample points with high lead concentrations was excavated. Five confirmation samples were collected at the previous sample locations and analyzed for lead for confirming removal actions. These

investigation data will be provided and used in the SLERA report, along with previous sample results from soils remaining at the site. Sample results for soils that have been excavated/removed from the site will not be evaluated in the SLERA.

2.3.2 SWMU B-8

SWMU B-8 was a popping furnace and fired small arms ammo brass disposal area, with piles of fire bricks and ammo shells located at the site. Investigation of the site began in 1997 with soil sampling and an unexploded ordnance (UXO) survey. In 2003, additional soil surveying and UXO surveys were completed.

2.3.2.1 Comparison of COPCs to TRRP Criteria (SWMU B-8)

Based on soils that were remaining at the site prior to the February/March 2008 field activities, COPCs exceeding TCEQ ecological screening criteria included lead, barium, copper, and zinc. These same compounds also exceeded the residential PCLs.

2.3.2.2 Work to be Completed for TRRP Closure (SWMU B-8)

Work for the site includes surface soil sampling and human health and ecological risk assessments. Based on previous analytical results at SWMU B-8, the lateral extent of the area had not been fully delineated. However, the COPCs for the site had been identified and only included the nine metals commonly found at CSSA. The previous soil borings had results that were non-detect at depths lower than surface soils; therefore the vertical extent of contamination has been determined. The removal action area for the February/March field effort is shown in Figure 1 of Appendix A. Metals impacted soils were removed and managed on-site in the East Pasture range area. Data resulting from planned investigations will be provided and used in the SLERA report, along with previous sample results from soils remaining at the site. Only the sample results for soils that remain at the site will be evaluated in the SLERA.

2.3.3 SWMU B-20/21

SWMU B-20/21 is located in the northeast portion of the North Pasture and is comprised of approximately 35 acres. Records indicate that between 1946 and 1987 the site was used for demolition activities and periodic open burning/open detonation (OB/OD) of conventional ordnance. During this period, ordnance was detonated, buried, and disposed of on the ground surface at the site. The site is now vegetated with native grasses, isolated clusters of live oak stands, and juniper. The south, west and north boundaries of the site are bordered by gravel roads. Extensive investigations and UXO removal actions have been completed. Both scrap metal and sifted soils were removed from the site.

2.3.3.1 Comparison of COPCs to TRRP Criteria (SWMU B-20/21)

COPCs exceeding TCEQ ecological screening criteria within the sifted soils were lead and copper. These two COPCs also exceeded the residential human health criteria. Mercury had at

one time been considered as a potential COPC at this site; however, the levels detected were lower than the final TCEQ-approved background concentrations (Parsons, 2002).

2.3.3.2 Work to be Completed for TRRP Closure (SWMU B-20/21)

This site was not included in the February/March 2008 field effort. Work planned for the site includes additional soil sampling and human health and ecological risk assessments. It is not anticipated, but if UXO is encountered during field activities, UXO support will be provided. Additional surface and subsurface sampling is needed to confirm that removal efforts at the site addressed the contamination. Based on analytical results of sifted soil samples, sampling will only include analyses for the nine CSSA metals. Proposed sample locations for SWMU B-20/21 are shown in Figure 2 of Appendix A. This figure is from the *Final TO DY01 Work Plan Addendum* (Parsons, 2007a). These samples will be used in the SLERA, along with previous samples from soils remaining at the site. Sample results for soils that have been excavated/removed from the site will not be evaluated in the SLERA.

2.3.4 SWMU B-24

SWMU B-24 is a former waste site for spent ammo and metal scrap and is approximately 5 acres in size. Initially, spent ammunition, and other metal scrap was observed on the ground surface. Sparse vegetation and some ground disturbance were also noted. Previous investigations at the site included geophysical surveys, surface and subsurface sampling, trenching, soil removal, and UXO removal actions.

2.3.4.1 Comparison of COPCs to TRRP Criteria (SWMU B-24)

Previous data collected at the site showed that no chemicals had been detected above the ecological or the human health criteria.

2.3.4.2 Work to be Completed for TRRP Closure (SWMU B-24)

Work for the site includes additional sampling and human health and ecological risk assessments. The February/March field activities included further investigation of a potential trench on the eastern portion of SWMU B-24 to identify if any waste materials were present (see Figure 1 of Appendix A for location of survey area). Investigation of this area included removal of the vegetation (primarily Ashe juniper) and a UXO/visual survey to determine if buried waste was present. However, no buried waste was found during the survey. Further investigation activities are expected for the site. These results will be included in the SLERA, along with previous sampling results of soils remaining at the site.

2.3.5 AOC-73 and Other Sites in North Pasture

As was shown on Figure 2, there are other SWMUs and AOCs in the North Pasture. All of these, except AOC-73 have been closed or investigated under previous TCEQ requirements.

Investigation and remedial activities were performed at AOC-73 during the February/March 2008 field activities. The site is a small area (less than ½ acre) that was used by a former rancher for dumping general household trash and metal debris. This trash (primarily miscellaneous old tools, bottles, and cans) was removed and 10 surface soil samples were collected and analyzed for VOCs, SVOCs, and metals. No VOCs or SVOCs were detected and the levels of metals were very low, below PCLs and/or background, including the Tier 1 residential PCLs for the combined soil PCL ($^{Tot}Soil_{Comb}$) and the groundwater soil ingestion PCL ($^{GW}Soil_{Ing}$). TCEQ-approved background concentrations for CSSA were used as the PCLs if the background values were higher than the Tier 1 residential PCLs.

RMU-5 is also located in the North Pasture and is no longer active. The area was identified as an ammunition range on a 1953 map of CSSA and consists of approximately 19 acres. Several UXO items were discovered during cedar clearing/land management activities at this unit. The items found were given to 137th Explosive Ordnance Disposal (EOD). Specific data regarding all site activities may be found in the *Environmental Encyclopedia* RMU-5 links.

Future plans at RMU-5 include field mapping the site, conducting a geophysical survey to determine if any spent ammunition is buried at the site, UXO clearance if necessary, and collection of surface soil samples. This work is tentatively planned, but it is not currently included in any delivery order. If the site is found to meet closure criteria after this work is completed, a closure report will be prepared in accordance with TCEQ requirements.

3.0 STEPS OF SLERA PROCESS

The TRRP rule at §350.77(c) states that the SLERA contains three phases. These three phases include:

- **Problem formulation** – Establishes the goals, breadth, and focus of the ERA;
- **Analysis (exposure characterization)** – Consists of the technical evaluation of data for both the exposure of the ecological receptor to a COPC and the potential adverse effects; and
- **Risk characterization** – Evaluates the likelihood of adverse effects occurring as a result of exposure to a COPC.

The sections below describe the three phases of the SLERA for the CSSA North Pasture.

4.0 PROBLEM FORMULATION

Problem formulation is the first phase of the SLERA that includes the exposure assessment and development of the ECSM, including the food web model(s) that are applicable for the area. The exposure assessment identifies the exposure setting, the distribution of COPCs, and the potential ecological receptors. This process characterizes, either qualitatively or quantitatively, the potential exposure of ecological receptors to the COPCs detected in the area and identifies the primary routes of exposure by which the potential species may be exposed. In this process,

several species are selected to represent different trophic levels inhabiting the site; these species are referred to as "indicator" species.

The following components are addressed as part of the ECSM exposure assessment.

- Environmental setting.
- Identification of potential ecological receptors.
- Selection of indicator species.
- Contaminant fate and transport mechanisms that may exist at the site – identification of complete or reasonably anticipated complete exposure pathways.
- Identification of bioaccumulative COPCs.

The information presented in the following sections was obtained from available literature or was collected during numerous site investigations and site visits. Various biological investigations have been conducted at CSSA and also at neighboring Camp Bullis, which has similar environmental setting and ecological habitat. Over the years, these investigations have provided a considerable amount of information about the habitats. Two new reports from the CSSA investigations include the *Final Integrated Natural Resource Management Plan* (INRMP) for CSSA (Parsons, 2007b) and the *Draft Species and Habitat Distributions of Black-Capped Vireos and Golden-Cheeked Warblers, 2007 Breeding/Nesting Season* (Parsons, 2007c). The black-capped vireo (BCVI) and golden-cheeked warbler (GCWA) are endangered species and are discussed in more detail below. Weston Solutions, Inc. also recently performed a SLERA at Camp Bullis (Weston, 2006). The Camp Bullis SLERA report utilized a food web model and documented various biological studies that are applicable to both Camp Bullis and CSSA.

The ECSM for the North Pasture is based on the Upland Forest food web model presented in the TCEQ (2001) guidance. This model is considered representative of the North Pasture conditions given the predominance of live oak and Ashe juniper around the SWMUs under consideration, as well as the North Pasture in general. This food web is illustrated on Figure 4. The ECSM shows the interactions between the various feeding guilds selected for the area and the transfer of energy from the food sources (*e.g.*, plants, invertebrates) to a series of organisms. The food chain shows the importance of the exposure pathways dependent on the receptor's diet. The purpose of the food web in the ERA is to define the direct and indirect exposure pathways, formulate the assessment endpoints, and develop relationships among feeding guilds for estimation of exposure. Individual species are selected from the feeding guilds in the food web model to be indicator species. The indicator species are then evaluated as representative of the complete animal population of a given trophic level in the site ecosystem. The selection and description of indicator species is presented in Section 4.3.

As shown on Figure 4, the soil invertebrates and vegetation may be directly exposed to COPCs present in soil either by ingestion or absorption. The next trophic level of organisms includes amphibians, birds, and mammals, which may be exposed indirectly to COPCs through ingestion of vegetation and invertebrates or though incidental ingestion of surface soil. Upper

trophic level carnivores and omnivores may be exposed by ingestion of lower trophic level animals, or through incidental ingestion of surface soils.

4.1 ENVIRONMENTAL SETTING

The following sections provide a summary of the ecological resources for the area within and around the North Pasture and CSSA. The terrestrial environment is the key habitat for the area. Groundwater and surface water exposure pathways are not considered complete. Depth to groundwater in the North Pasture ranges from approximately 125 feet below ground surface (bgs) to approximately 275 feet bgs depending on rainfall. Surface water is described in more detail in Section 4.1.2.

4.1.1 Vegetation

CSSA is located within the Balcones Canyonlands subregion of the Edwards Plateau region. Evergreen woodlands and deciduous forests dominate this area. Grasslands are restricted primarily to drainage ways, usually in the context of open woodlands or savannas. Some of the woodlands and a majority of the native grasslands on the Edwards Plateau have been removed by historic human settlement.

Overall, the vegetation at CSSA is similar to that of the region. There are four vegetation communities at CSSA: woodlands, shrublands, and savannas, and an herbaceous community that is predominantly composed of bluestem grasses. Past land uses at CSSA have resulted in a patchwork of open grassland/disturbed savanna delineated by stands of Ashe juniper-oak woodlands. The North Pasture area is predominantly woodland, while the sites within the North Pasture are predominantly composed of herbaceous grass cover (Figure 5).

Each of the four vegetation communities at CSSA can be further divided into community types. Eight vegetation community types were mapped as part of the BCVI and GCWA surveys conducted in 2005 and 2007 (Figure 5) (Parsons, 2007b). Table 1 lists each vegetation community type with calculated areas. A description of the community types is also provided below.

- **Juniper-Live Oak Woodlands** – Woody species ranging between 3-10 meters tall, with a canopy closure of 71-100 percent. Ashe juniper dominates with a large live oak component.
- **Juniper Woodlands** – Woody species ranging between 3-10 meters tall, with a canopy closure of 71-100 percent. Ashe juniper dominates; few other woody species are present.
- **Live Oak-Juniper Woodlands** – Woody species ranging between 3-10 meters tall, with a canopy closure of 71-100 percent. Live oaks (*Quercus fusiformis*) dominate with a large Ashe juniper component. Other oak species persist in lower abundance, such as Spanish oak (*Quercus buckleyi*) and shin oak (*Quercus sinuata*).

- **Juniper Dominant Shrublands** – Ashe juniper dominates and is less than 3 meters tall; few other woody species are present.
- **Live Oak Dominant Shrublands** – Live oaks and shin oaks under 3 meters tall, with other shrubs and shorter-statured tree species, such as flame-leaf sumac (*Rhus lanceolata*), Texas persimmon (*Diospyros Texana*), and agarita (*Berberis trifoliolata*).
- **Herbaceous Bluestem and Short Grass Prairie** – Woody species composed of less than 25 percent ground cover, dominated by herbaceous vegetation, including grasses of varying heights.
- **Mixed Oak Savanna** – Woody species composed of 25-50 percent cover dominated primarily by live oak, shin oak, Texas persimmon, and Ashe juniper.

4.1.2 Surface Water

Surface water and sediment pathways are not considered complete in the North Pasture. Salado, Leon, and Cibolo Creeks drain surface water from CSSA (Figure 6). In the undeveloped areas of CSSA, such as the North Pasture, runoff flows overland to natural channels. The North Pasture is in the Salado and Cibolo Creek drainage basins. All creeks at CSSA are intermittent and only contain water during and immediately following rain events. Thus, the creeks do not sustain a surface water or sediment habitat for ecological receptors. Based on a wetland delineation for CSSA, there are also no wetlands within the boundaries of the SWMUs and no significant wetland habitat in the North Pasture (SAIC, 1997a).

There are two small ponds in the North Pasture, the northwest pond (also referred to as the drop zone tank) and the northeast pond (also referred to as the windmill tank) (Figure 6). Both ponds are small and not considered as significant habitat for the SLERA evaluation.

The northwest pond is less than ½ acre in size and is located approximately 2,400 feet from the closest SWMU (B-24). It is not within the drainage path of this SWMU. The only site that is upgradient of this pond is AOC-73 (approximately 1,540 feet upgradient). As discussed above in Section 2.3.5, the February/March field activities at AOC-73 found no contaminants of concern at the site. During the November 29, 2007 CSSA meeting, which included a field visit to the sites and ponds in the North Pasture, surface water and sediment sampling were not considered necessary.

The northeast pond is approximately 0.91 acre in size (when full) and is located approximately 650 feet downgradient from SWMU B-20/21. Sediment and surface water samples have been collected in this area. The sample results were discussed at the November 29th CSSA meeting. The results and a figure showing the sample locations are provided at the end of this work plan. Sediment results are provided in Table 2, surface water results are provided in Table 3, and the sample locations are shown on Figure 7. The analytical results indicate that further sediment and surface water sampling is not necessary in this area. In only one sample, cadmium and lead were the only chemicals detected in sediment above the soil

background concentrations and ecological benchmarks. This sample was collected at a former crater within the boundary of SWMU B-20. All craters at the site were leveled in 1997 and have not provided a surface water or sediment habitat since that time. The sample results were also relatively low (the sample with the exceedances was a duplicate of another sample where results were not above the soil background or ecological benchmarks). Cadmium and lead were also the only chemicals present in surface water above the ecological benchmarks. With the exception of one of the surface water sample locations, the detections were also at former craters within the B-20 boundary. One small low area near the intermittent stream had a slight exceedance for lead. However, this area has been dry for many years and also does not support a surface water or sediment habitat. Sediment and surface water samples taken outside of the SWMU boundary, and nearest to the northeast pond, were not above soil background concentrations or the ecological benchmarks.

4.1.3 Other Environmental Features

Although caves and other karst features are present in some areas of CSSA, there are no known caves in the North Pasture. This assessment is based on the draft report for the Phase 1 Karst Hydrogeologic Investigation conducted at CSSA in 2002 (Veni, 2002).

4.2 IDENTIFICATION OF ECOLOGICAL SPECIES AT CSSA

4.2.1 Birds and Other Wildlife

Bird surveys conducted at CSSA between mid-March and early June of 2005 and 2007 documented 106 bird species at the installation. The list of observed species is provided in the species and habitat distribution report (Parsons, 2007c) and is also included as Appendix D of this work plan. The list includes two federally listed endangered species, the BCVI and the GCWA. These two species are discussed in more detail below.

CSSA is expected to support a variety of wildlife similar to the surrounding region. Several game species are known to occur at the installation, including: white-tailed deer (*Odocoileus virginianus*), axis deer (*Axis axis*), wild turkey (*Meleagris gallopavo*), dove (*Zenaida macroura*), ducks, quail, rabbits (*Lepus californicus* and *Sylvilagus floridanus*), squirrel (*Sciurus niger*), raccoon (*Procyon lotor*), and coyotes (*Canis latrans*). Other species likely to be found at CSSA include skunk (*Mephitis mephitis*), opossum (*Didelphis marsupialis*), ring-tailed cat (*Bassariscus astutus*), bobcat *(Lynx rufus*), and a variety of rodent species (SAIC, 1997b).

4.2.2 Threatened, Endangered, and Rare Species

Several surveys have been conducted at CSSA for threatened and endangered (T&E) species. A general habitat evaluation was conducted in December 1992 and detailed bird surveys were conducted in the spring of 1993 (Stewardship Services, 1993). More recently, presence-absence surveys for BCVI (*Vireo atricapillus*) and GCWA (*Dendroica chrysoparia*) were conducted between mid-March and early June 2005 and again in 2007 (Parsons, 2007c).

Figure 8 provides a map showing detections and habitat of GCWA and BCVI at CSSA. This figure shows a comparison of the 2005 and 2007 survey results.

Table 4 provides a summary of federal and state listed species with potential to occur in Bexar County, Texas. This table is based on information obtained from the U.S. Fish and Wildlife Service (USFWS, 2004) and the Texas Parks and Wildlife Department (TPWD, 2005). The *Final Integrated Natural Resource Management Plan* for CSSA (Parsons, 2007b) provides a detailed analysis of the species listed in Table 4. Based on the known distributions, habitat requirements and existing habitat at CSSA, the listed species are not expected to occur at the installation. Of the species listed in Table 4, the BCVI and GCWA are the only species that have been documented at CSSA. The following paragraphs provide additional information for each species listed in Table 4 and discuss their potential to occur at CSSA.

4.2.3 Potential Presence/Absence of Federal and State Listed Species

Amphibians. From Table 4, two amphibian species (the black-spotted newt and the Comal blind salamander) are listed as potentially occurring in Bexar County. The black-spotted newt is typically found along the Gulf Coastal Plain south of the San Antonio River and is not expected to occur at CSSA. The draft report for the Phase 1 Karst Hydrogeologic Investigation (Veni, 2002) provided an evaluation of potential habitat for various species at CSSA, including many subterranean species. As stated above, there are no known caves in the North Pasture and the Comal blind salamander is not expected.

Arachnids and Insects. The nine invertebrates (arachnids and insects) listed in Table 4 are obligate (capable of surviving in only one environment) karst or cave-dwelling species (troglobites) of local distribution in karst terrain in Bexar County. As of early 2003, 74 caves in Bexar County were known to contain one or more of the listed invertebrates (USFWS, 2004). None of these known caves are located on CSSA. Critical habitat has also been designated under the Endangered Species Act (ESA) for seven of the nine listed invertebrates; however, no critical habitat has been designated on the installation. During the Phase 1 Karst Hydrogeologic Investigation conducted at CSSA in 2002, two caves and 94 potential karst features were found. However, the draft report (Veni, 2002) indicates that none of the caves or karst features are likely to contain endangered karst invertebrates due to CSSA's location outside of the zones where they occur. This finding is also supported by previous work conducted by Veni (1994) and Veni and Reddell (1999). There are also no known caves in the North Pasture.

Birds. Of the bird species listed in Table 4, the BCVI and GCWA are the only T&E species that have been documented at CSSA. These two species are thus selected as indicator species for the SLERA and are discussed in more detail in Section 4.3. The American and Arctic peregrine falcons potentially migrate through Bexar County. However, other than transient individuals, these species are not expected to occur at the installation. The white-faced ibis and wood stork require extensive wetland habitats, which are not present on CSSA. The only remaining natural breeding population of whooping cranes winters along the Texas Gulf Coast in and around Aransas National Wildlife Refuge, approximately 200 miles southeast of CSSA. The TPWD's rare species list for Bexar County (TPWD, 2005) indicates that whooping cranes are

potential migrants in Bexar County. During migration they often pause overnight to use wetlands for roosting and agricultural fields for feeding, but seldom remain more than one night (TPWD, 1996). The potential for migrating whooping cranes to use CSSA is low based on the lack of suitable foraging and roosting habitat. Although potentially suitable habitat for the zone-tailed hawk could occur at CSSA, this bird was not observed during the bird surveys conducted in 1993, 2005, and 2007. The compiled list of birds observed at CSSA in 2005 and 2007 is provided in Appendix D.

Fish. The toothless blindcat and widemouth blindcat are endemic to the San Antonio Pool of the Edwards Aquifer, located in the southwestern part of San Antonio. Therefore, these troglobitic catfish would not be expected to occur at CSSA.

Mammals. In Texas, the black bear inhabits desert lowlands and high elevation forests and woodlands. This large mammal has not been observed at CSSA and is not expected to be present.

Reptiles. Cagle's map turtle is endemic to the Guadalupe River system and requires riverine habitat with permanently flowing water. CSSA is located in the upper San Antonio watershed and outside of the known range for this species. In addition, all the streams at CSSA are intermittent. The indigo snake occurs in thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors. It is not likely that the distribution of this species reaches the Balcones Canyonlands in northern Bexar County, where CSSA is located. Therefore, this species is not expected to occur on the installation. Texas horned lizard habitat consists of open, arid, and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush, or scrubby trees. The habitat assessment conducted at CSSA in 1992 indicated that potentially suitable Texas horned lizard habitat exists at the installation. However, habitat is very limited and the species has not been sighted at the installation. The Texas tortoise is generally found south of a line connecting Del Rio, San Antonio, and Rockport. Therefore, it is not likely that the distribution of this species reaches the Balcones Canyonlands in northern Bexar County.

4.3 SELECTION OF INDICATOR SPECIES

In addressing the sensitivity of species to COPCs, it is important to note that the toxicity data are limited to available literature for the category of species being evaluated. The most sensitive species in the literature will typically be a function of the most frequently used test species. Thus, due to limitations in the literature, the most available or frequently used toxicity data for each constituent will be compared to the exposures for those species within the same phylogenetic class, not necessarily for the same species found in the area. Even though specific ecological receptors will be selected for evaluation in the SLERA, these species are selected to represent exposures to other (similar) species with comparable feeding guilds, thus serving as indicator receptors.

The following indicator species will be used to assess the potential for risk to the various species potentially inhabiting the North Pasture and surrounding area.

- Terrestrial mammals: white-footed mouse, short-tailed shrew, and gray fox.
- Birds: American robin, bobwhite quail, BCVI, GCWA, and red-tailed hawk.
- Reptiles: because toxicological data are limited for risk analyses for reptiles and amphibians, these species will be qualitatively evaluated using birds as the indicator species.

Some of the information presented in Section 4.3 was taken from a SLERA recently performed at Camp Bullis (Weston, 2006). The ecological habitat is similar and thus the same indicator species will be used for CSSA as were used for Camp Bullis. Inclusion of the white-tailed deer as a large herbivore was initially considered for the SLERA evaluation. This deer species, however, was subsequently excluded because all SWMUs under consideration are native-grassed areas. Grasses are not a significant component of the diet of white-tailed deer, as this species cannot efficiently grind up and digest tough fibers in grasses (Armstrong and Young, 2007).

4.3.1 Terrestrial Mammals

An ecological exposure pathway exists for terrestrial mammals that feed on plants, invertebrates, or other mammals and birds. Based on body size, likelihood of using the area of concern for foraging, available literature, and physiology, the white-footed mouse, the short-tailed shrew and the gray fox were selected as indicator species for mammals. Specific information on the selected indicator species is provided below.

4.3.1.1 White-footed Mouse

The white-footed mouse (*Peromyscus leucopus*) was selected as an individual species to represent the effects of the COPCs on an herbivore mammal.

White-footed mice average 17.3 centimeters (cm) in total length and 22 grams (g) in weight. In much of its range, this mouse is one of the most common of small mammals. White-footed mice are woodland dwellers. They are adept at climbing and often den in hollow trees out of danger from overflow waters. In areas not subject to inundation, the mice live in dens under logs, in stumps, brush piles, burrows, or buildings. The maximum home range of adult males is about 0.2 hectares (ha), that of adult females is about 0.15 ha. The mice seldom travel more than 50 meters once they are established in a suitable area. The dispersal of the population is generally due to movement of the unestablished young mice. While the diet of white-footed mice is varied, they rely on seeds, nuts, acorns, and pecans. When food is abundant, they store it in and around their nests for winter use. In spring and summer, they feed on insects, snails, fruits, and other invertebrates. White-footed mice serve as a valuable prey species to upper trophic levels such as raptors, coyotes, snakes, and foxes (USEPA, 1993).

4.3.1.2 Short-tailed Shrew

The short-tailed shrew (*Blarina brevicauda*) was selected to represent the effects of COPCs on insectivorous mammals.

The short-tailed shrew is approximately 8-10 cm long and weighs approximately 15-20 g. Its daily consumption consists of moth and beetle larvae, slugs, snails, and spiders, and often equals or exceeds its own weight. The shrew does not hibernate; it seeks out dormant insects for sustenance even during the coldest part of winter. It nests underground, maintaining underground runways within the top 10 cm of soil. Home ranges vary from 0.03 to 2.2 ha, depending on the season and breeding. Although they breed all year, peak breeding occurs from April to October. Peak population densities vary by habitat and season, but range between 2.5 to 45 shrews per ha. Predators include snakes, owls, hawks, and carnivorous mammals such as opossums, foxes, bobcats, weasels, and skunks.

4.3.1.3 Gray Fox

The gray fox (*Urocyon cinereoargenteus*) was selected to represent the effects of COPCs on omnivorous mammals.

The gray fox is approximately 97 cm in length and weighs approximately 3-5 kilograms (kg). The gray fox is essentially an inhabitant of wooded areas, particularly mixed hardwood forests throughout Texas. Gray foxes typically den in rock crevices, in underground burrows, under rocks, in hollow logs, or in hollow trees. In Texas, the breeding season begins in December and continues through March. Three to six pups are typically born in April or May after a gestation period of about 53 days. The gray fox is omnivorous; the food consumed varies with season and availability. Based on the stomach contents of 42 foxes examined in Texas, their food consists primarily of small mammals, with seasonal variations that include insects, birds, and acorns.

4.3.2 Birds

Ecological exposure pathways exist for birds that feed on plants, other birds, and mammals. Based on the overall ecology of the area and observations made during habitat studies, bird species may include shrikes, wrens, sparrows, hawks, doves, and the two endangered birds (BCVI and GCWA). Thus, the American robin, bobwhite quail, BCVI, GCWA, and red-tailed hawk, were all selected to represent different feeding guilds for the area. Specific information on the selected indicator species is provided below.

4.3.2.1 American Robin

The American robin (*Turdus migratorius*) was selected as an individual species to represent the effects of COPCs on predominantly insectivore bird species.

American robins range throughout most of the continental United States. They are common, medium-sized birds that eat worms, insects, and fruits, depending on the season and availability. Robins forage by hopping along the ground in search of ground-dwelling invertebrates and by searching for fruit and foliage-dwelling insects in shrubs and low tree branches. During the non-breeding season, plant material becomes a more significant component of the robin's diet. The American robin measures approximately 25 cm long and 77 g in weight. The robin's home

range is relatively small (<0.5 ha). Both male and female robins defend their territory, although sometimes territories can overlap. Although robins are often migratory, some individuals may remain in the same territory throughout the year. Prime nesting areas are dense coniferous forests, although they will nest in many trees, shrubs, and human constructed structures. Predation is the primary source of mortality for eggs and nestlings. Of the robins that survive to their first January, the average lifespan is 1.3 to 1.4 years.

4.3.2.2 Bobwhite Quail

The bobwhite quail (*Colinus virginianus*) was chosen to represent the herbivorous bird-feeding guild.

The bobwhite quail is primarily a ground dwelling bird approximately 25 cm in length and 150 to 200 g in weight. The quail's habitat varies by season, preferring grasslands, fields, and pastures for nests during the breeding season, often nesting in clumps of grass. Shrubby thicket areas are used for cover during midday. During the winter, they require wooded cover with understory for daytime cover, preferably near open fields for foraging. Quail habitat also varies during different parts of its life cycle, with pine, hedgerows, and shrub habitats used. The bobwhite eats seeds primarily, along with fruit, plant parts, spiders, and insects. More insects are eaten in the summer, and more seeds and other plant products are eaten in the winter. The bobwhite is a year-round resident throughout its range, but disperses locally to different cover types throughout the seasons. During the breeding season, the bobwhite's home range may encompass several hectares. Bobwhites nest on the ground and rear up to two broods per year.

4.3.2.3 Black-capped Vireo

The BCVI (*Vireo atricapillus*) was selected to represent the effects of COPCs on an insectivorous bird and because it is an endangered species.

The BCVI is a small migratory songbird, with a diet consisting entirely of insects (Graber, 1961). Typical nesting habitat is found in early successional shrubland. Structure of vegetation is more important than species composition, where shrub vegetation extends up to 6 feet from the ground. In the eastern portion of the BCVI nesting range (including Bexar County), the shrub layer is often combined with a sparse to moderate tree canopy. In these areas, open grasslands connect shrublands and woodlands. Common woodland species in BCVI habitat include various oaks, mountain laurel, various sumacs, redbud, Texas persimmon, mesquite, and agarita. Ashe junipers are often in this habitat; however, preferred areas usually have relatively lower Ashe juniper densities and cover (Guilfoyle, 2002).

Nesting season for BCVIs begins in Central Texas by late March or early April. BCVIs begin migration to Mexico in July, but may leave as late as mid-September. Returning to Texas in late March, BCVIs are thought to return to the same territories, or adjacent territories (USFWS, 1991)

4.3.2.4 Golden-cheeked Warbler

The GCWA (*Dendroica chrysoparia)* was selected to represent the effects of COPCs on a tree-dwelling insectivore and because it is an endangered species.

The GCWA is a small migratory songbird with a diet consisting almost entirely of spiders, caterpillars, beetles, and other foliage-dependent insects. Nesting season begins in mid-March and lasts through late June, and may extend through late July. GCWAs begin migration in late June from Texas to wintering grounds in the pine-oak woodlands of southern Mexico, Guatemala, Honduras, and Nicaragua. Banding studies show that males will return to the same territories in the subsequent breeding season (Guilfoyle, 2002). Male GCWAs generally arrive first to establish territories, and their vocalizations attract females migrating through.

Typical nesting habitat is found in tall, dense, mature, closed-canopy stands of Ashe juniper (commonly called cedar), mixed with various oaks (USFWS, 1992). Other associated tree types include Texas ash, cedar elm, hackberry, bigtooth maple, sycamore, Arizona walnut, escarpment cherry, and pecan. Combined with a sloping topography, this habitat is generally seen as ideal habitat for the GCWA. GCWA occurrences have also been reported in drier topographically flat upland juniper-oak woodlands (Grzybowski, 1995).

4.3.2.5 Red-tailed Hawk

The red-tailed hawk (*Buteo jamaicensis*) was selected to represent the effects of COPCs on upper trophic level carnivorous birds.

The red-tailed hawk is a moderately large, soaring hawk that inhabits open or semi-open areas. Red-tailed hawks are part of the family that is the most common daytime avian predator on ground-dwelling vertebrates, particularly rodents and other small mammals. Red-tailed hawks are distributed throughout most wooded and semi-wooded regions of the United States. They appear to prefer mixed landscapes containing fields, wetlands, and pastures for foraging, interspersed with groves of woodlands, bluffs, and stream sides for perching and nesting. Red-tailed hawks hunt primarily from elevated perches near woodland edges. Small mammals that are important prey include mice, shrews, voles, rabbits, and squirrels. In general, hawks are opportunistic and will feed on whatever species are most abundant. Hawks are territorial, with home ranges varying from a few hundred ha to over 1,500 ha.

4.3.3 Reptiles and Amphibians

Exposure pathways may exist for reptiles and amphibians that feed on plants, invertebrates, mammals, birds, or even other smaller reptiles or amphibians. Based on site observations and ecology of the area, these species may include snakes, turtles, frogs, and lizards. Since toxicological data are not available for reptiles and amphibians, these species will be assessed qualitatively, not quantitatively. The risk to reptiles is assumed to be similar to birds; therefore a bird with similar eating habits will be assessed as a reptile surrogate. Reptiles onsite, including

lizards and snakes are primarily insectivores, and therefore will be assessed qualitatively though the assessment of small insectivorous birds such as the American robin, BCVI, and GCWA.

4.4 IDENTIFICATION OF COMPLETE EXPOSURE PATHWAYS

The oral exposure route is the primary route of exposure for wildlife. Oral exposure occurs through dietary ingestion of plant or prey tissues containing COPCs that have bioaccumulated in tissue from the source media. Oral exposure can also occur through ingestion of the source media, such as incidental ingestion of the media from feeding, burrowing, or grooming behaviors. Because the oral exposure route is the primary exposure route for wildlife, toxicological data for most common COPCs are available to evaluate risk.

Dermal exposure is assumed to be negligible since COPCs are unlikely to be absorbed through skin. The feathers of birds and the fur of mammals reduce the likelihood of significant dermal exposure by limiting the contact of skin with contaminated soil. Furthermore, data necessary to estimate dermal exposure for wildlife species is generally not available (USEPA, 1993).

Inhalation exposure is assumed to be negligible because the COPCs identified in the North Pasture are not volatile (the primary COPCs are metals) and because there is abundant vegetation (native grass cover) to minimize the potential for inhalation of volatiles and particulates. In addition, in comparison to dietary and incidental ingestion, the effects of exposure through inhalation of COPCs are minimal. Toxicity data necessary to estimate inhalation exposure are generally not available for wildlife (USEPA, 1993).

4.5 COPC FATE AND TRANSPORT ANALYSIS

A qualitative evaluation of contaminant fate and transport will be performed for COPCs retained for the SLERA analysis in the North Pasture soils. This determination will be indicative of COPCs that are likely to persist, be degraded, or move beyond the extent of contamination, and will be based on physical and chemical processes likely to influence movement, persistence, form, toxicity and availability of COPCs. Toxicological profiles will be used as the basis for assessment of screened COPCs likely to persist, be degraded, or move beyond currently identified areas. Table 5 illustrates example key factors that modify the bioavailability and toxicity of COPCs as relevant to the types of chemicals detected at the North Pasture sites.

Table 5 Example Modifying Factors in the Transfer of Inorganic COPCs from Soils to Plants and Herbivores

Element	Potential for Uptake by Vegetation	Potential for Toxicity to Herbivores
Chromium (trivalent), mercury, lead	Not taken up by the roots, or not transported from roots to shoots.	Minimal potential: plants do not absorb the element or chelate it in the roots.
Copper and nickel	Minimum transfer from roots to shoots and leaves: root cell sap contains high levels of organic acids and amino acids that chelate (bind) many elements.	Low potential: element levels in plant foliage are generally safe for herbivores due to phytotoxicity limits.
Zinc	Readily transported from roots to shoots and leaves.	Moderate potential due to phytotoxicity limits.
Cadmium	Readily transported from roots to shoots and leaves.	High potential: plant residue levels often reported as causing toxicity to herbivores.
Cadmium, zinc	Variable transport to fruits and seeds: many plants restrict entry of various elements and compounds into reproductive structures.	Variable, depending on plant-specific concentration in fruits and seeds, and degree of consumption by birds and mammals.

4.6 IDENTIFICATION OF BIOACCUMULATIVE COPCS

Several biological processes, such as bioaccumulation and food chain transfers, also affect COPC fate and transport in the environment. Due to sequestration in certain tissues, bioaccumulative COPCs tend to increase in concentration in some organisms relative to dietary sources and concentration in environmental media. Biomagnification (*i.e.*, bioaccumulation in successive trophic levels of a food chain) can result in concentrations of COPCs that are many times greater than found in environmental media.

Bioaccumulative COPCs will be identified from the list of COPCs detected in soils in the North Pasture. Based on extensive literature searches, the TCEQ has identified and listed specific COPCs that are bioaccumulative (TCEQ, 2001). Any bioaccumulative COPC will be retained for food chain analysis regardless of its concentration relative to the ecological benchmark. For further evaluation of risk to higher trophic levels, bioaccumulative metals should be present above background concentrations.

5.0 CHARACTERIZATION OF EXPOSURE

The characterization of exposure identifies the magnitude and frequency by which target receptors are exposed to COPCs that have migrated or that may potentially migrate via complete exposure pathways to the ecological habitat at the site. This involves site-specific quantification of the levels of constituents present in the environment as well as site-specific quantification of the levels of constituents that may be entering each individual target receptor.

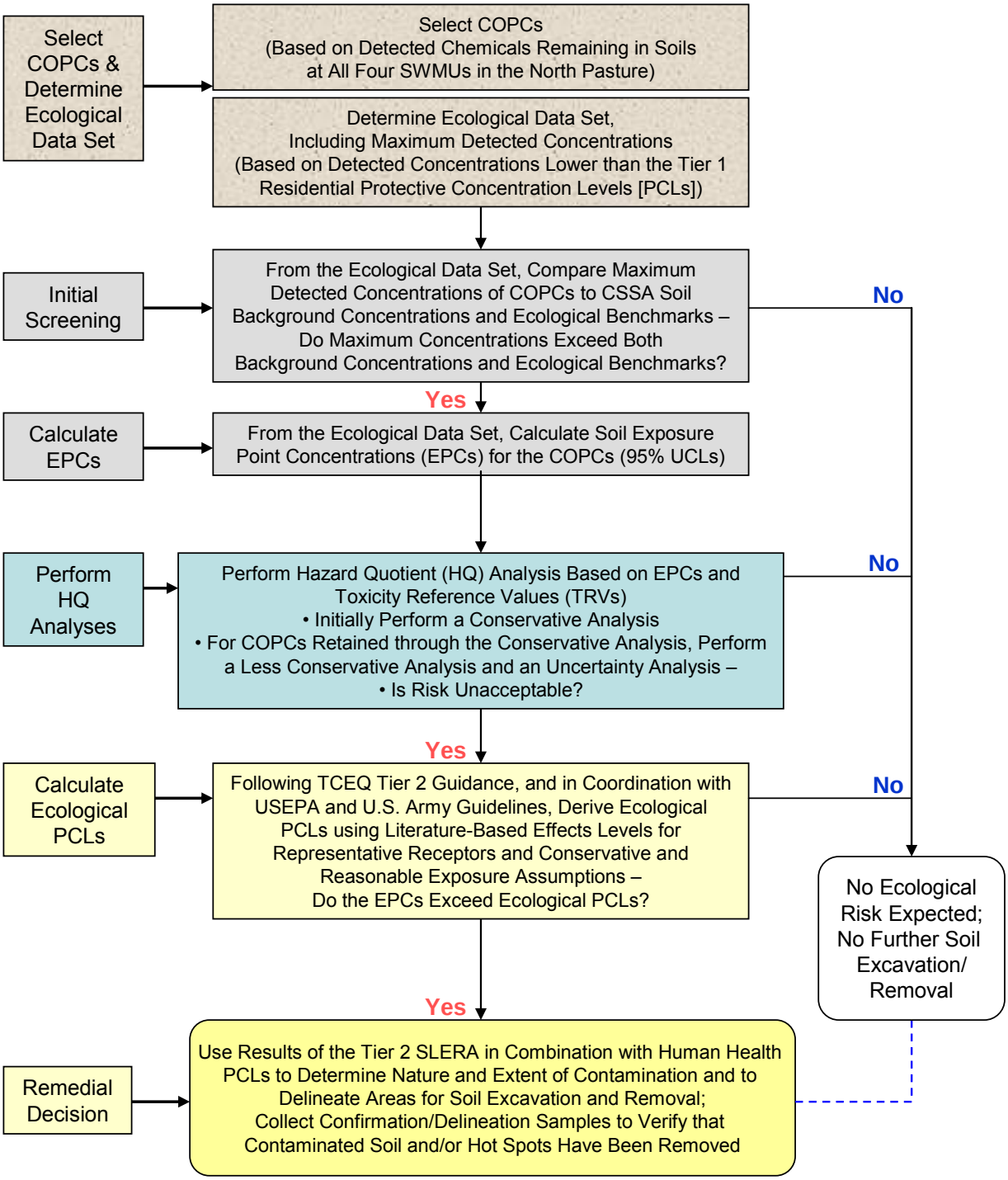
5.1 ESTIMATION OF ENVIRONMENTAL EXPOSURE

The information presented in this section is also shown in the following flowchart. All soils at the sites that have COPCs that exceed Tier 1 residential PCLs are being used to determine nature and extent of contamination and for planning excavation and removal activities. As funding allows, results from this ERA are also planned for use in determining nature and extent of contamination and for delineating soils for excavation and removal. Thus, to the extent funding allows, the ERA will be used in conjunction with the human health risk assessment to determine areas of soils that should be excavated and removed. Confirmation sampling will be used as part of this process to verify that contaminated soils and/or hot spots have been appropriately removed.

During the November 29, 2007 meeting discussing this ERA, it was agreed that the human health criteria can be used as the upper limit of the contamination remaining at the sites. Thus, the PCL values for residential criteria would be considered the maximum concentration remaining at the site and all analytical results lower than the human health criteria will be used for the ERA. This would be the defined ERA data set. Thus, based on this approach, sample results below the human health criteria will be used to determine maximum detected concentrations and 95% UCLs. The screening comparisons will initially compare the maximum detected concentration that is below the human health PCL to the ecological benchmark. If a COPC is retained through this initial screening, then the 95% UCL concentration will be calculated as the EPC (only using the data below the human health PCL).

The maximum concentrations of the COPCs detected for the North Pasture sites are summarized in Table 6. This table shows the maximum concentration detected, the CSSA background concentration, the ecological benchmark for soil, and the Tier 1 residential soil PCLs. The table shows both the combined Tier 1 soil PCL ($^{Tot}Soil_{Comb}$) for a 30-acre source area, and the groundwater soil ingestion PCL ($^{GW}Soil_{Ing}$) for a 30-acre source area. The concentrations below the $^{Tot}Soil_{Comb}$ PCL (or the background concentration if the background value is higher) will be considered the upper limit of contamination remaining at the site and the data set for the SLERA will include analytical results below those PCLs.

Tier 2 Data Evaluation for North Pasture ERA



5.1.1 Soil

The calculated EPCs will represent the COPC concentration in the soil that a receptor species would be exposed to through typical foraging activities. As stated above, the maximum reported concentration of a COPC from the ERA data set will be used in the initial screening to select COPCs. If COPCs are selected in the initial screening, EPCs for surface soil samples will be calculated based on the 95% UCL concentration of the arithmetic mean of the data from the ERA data set. USEPA's ProUCL Version 4.0 software will be used to calculate the appropriate distribution of the data, and the associated UCL (USEPA, 2004). Non-detects will be included in the UCL calculation at one-half the sample quantitation limit (SQL). If the calculated 95% UCL concentration is greater than the maximum detected concentration for a chemical, the maximum detected concentration will be used as the EPC.

5.1.2 Tissue

Target receptors associated with the North Pasture are primarily exposed through the ingestion of COPC present in their food. Contaminant loads in plant and animal food consumed by selected indicator species will be calculated using empirical uptake factors. Two separate sets of factors will be used, one for the BCVI and GCWA (whose diets are composed mainly of non-soil dwelling invertebrates) and a second one for the remaining indicator species (whose dietary intakes are primarily associated with plant and animal species directly exposed to soils).

In the case of the BCVI and GCWA, tissue concentrations will be calculated using bioaccumulation factors (BAF) applicable to non-soil dwelling invertebrates. The diet of both endangered birds is made up primarily of leaf and branch dwelling invertebrates that feed on the leaf material, such as spiders, caterpillars, and beetles rather that soil dwelling invertebrates. BAFs for non-soil dwelling invertebrates will be obtained from the Bioaccumulation Factors Database developed by the Health Effects Research Program of the Army Center for Health Promotion and Preventive Medicine (CHPPM).

For the remaining indicator species, soil to tissue transfer will be calculated using empirical uptake factors identified as biotransfer factors (BTFs). These factors will be obtained from reported 90th percentile BTF values for soil to plants (BJC, 1998), soil to invertebrates (Sample *et al.*, 1998a) and soil to animal tissue (Sample *et al.*, 1998b), as applicable to the diet composition for any given indicator species.

5.2 ESTIMATION OF RECEPTOR UPTAKE

For indicator receptor species, exposed primarily through the ingestion pathway, dietary intake will be expressed as a dose based on measured COPC concentrations in the media in which they reside, the ingestion rate of medium by the receptor, and factors that are likely to modify the extent of the exposure. A dose is expressed in terms of intake in milligrams per kilogram of body weight per day (mg/kg-day). The exposure algorithm for estimating daily intake through the ingestion exposure route can be described as follows:

$$Dose = C_{medium} \times IR \times EMFs$$

where:

Dose	=	Estimated daily intake of constituent through an exposure route (mg/kg/day)
C_{medium}	=	Concentration of constituent in a particular medium (mg/kg)
IR	=	Ingestion rate of medium by receptor, normalized for body weight (kg-bw/day)
EMF	=	Expose modifying factors (unitless).

C_{medium} is the concentration of constituent in a particular medium (mg/kg) to be represented in the SLERA as the maximum detected concentration or the 95% UCL concentration data set. Small range receptors will be evaluated separately for each SWMU using the site-specific EPCs, while maximum detected concentrations or combined 95% UCL concentration data from the four SWMUs under consideration will apply to the larger range receptors.

The IR is the ingestion rate of medium by a receptor, normalized for body weight. Specific intake values, as well as other parameters for the indicator species selected in this SLERA, are presented individually for each species in the sections below. Much of this information was taken from the SLERA recently performed at Camp Bullis (Weston, 2006). The ecological habitat is similar and thus the same indicator species and exposure factors will be used for CSSA as were used for Camp Bullis.

EMFs represent factors that are likely to modify the extent of the exposure fraction of media ingested from a contaminated source. In the SLERA, these factors will be calculated as the product of three EMFs: exposure frequency (EF), bioavailability, and area use factor (AUF).

The EF accounts for migration or other seasonal activity patterns that determine species-specific annual use of the affected area. EF values for receptor species selected for the SLERA will be conservatively set at a 100% exposure value. The overall evaluation for endangered birds will be protective of reproduction during the exposure period. NOAEL's used in the SLERA are based on reproductive effects TRVs.

Bioavailability is the ratio of COPC that reaches a site of toxic action in an organism to the total load of that COPC in the environment. For the SLERA, bioavailability values will be conservatively set at a 100% value for all indicator species.

The AUF is defined as the ratio of home range, or feeding/foraging range, to the area of the site under investigation. AUF will be set in the SLERA at 100% for indicator species selected, other than the red-tailed hawk and gray fox, because those species have small foraging ranges. Individual AUF values will be used for the hawk and the fox because their foraging ranges exceed the size of any of the four SWMUs under evaluation. As a conservative approach, all SWMUs in the North Pasture will be used in the exposure calculation based on their surface area and individual maximum concentration values. Maximum background concentrations will be used as representative for the remaining foraging range, outside of the SWMUs, for the red-tailed hawk and gray fox.

5.2.1 White-Footed Mouse

The white-footed mouse was selected as a target receptor for assessment of potential food-chain bioaccumulation from soil into species of herbivore mammals. The ingestion of invertebrates and plant tissue, and incidental ingestion of soil, represent the primary routes of exposure for the mouse. The mouse was assessed only as an herbivore for this SLERA to represent the most conservative risk associated with herbivorous mammals in the North Pasture. The following table summarizes the specific parameters and references that will be used.

Table 7 Parameters Used in White-Footed Mouse Exposure Calculations

Parameter	Average Adult	Units	Reference/Notes
Intake Rate$_{tissue}$	0.0025	kg/day (dry weight)	Based on the allometric equation (Nagy, 1987) for mammals – IR (g/day) = 0.577 x Wt0.727. See Eq. 3-3 in USEPA (1993).
Intake Rate$_{soil}$	0.00025	kg/day (dry weight)	Ingestion of soil assumed to equal 10% of the prey ingestion rate based on data for the mouse from Beyer *et al*. (1994). Refer to Table 4-4 in USEPA, 1993.
Foraging Territory	0.15	hectare	Based on a conservative foraging territory.
Area Use Factor	100	percent	Based on a conservative assumption that the species derives its entire diet from the site.
Body Weight	0.0014	kilogram	Most conservative value presented in Wildlife Exposure Factors Handbook (USEPA, 1993).
Dietary Composition	100	percent	Based on a conservative assumption of 100% dietary intake of site vegetation.

5.2.2 Short-Tailed Shrew

The short-tailed shrew was selected as a target receptor for assessment of potential food-chain bioaccumulation from soil into species of insectivorous mammals. The ingestion of invertebrates and incidental ingestion of soil represent the primary routes of exposure for the shrew. The following table summarizes the specific parameters and references that will be used.

Table 8 Parameters Used in Short-Tailed Shrew Exposure Calculations

Parameter	Average Adult	Units	Reference/Notes
Intake Rate$_{tissue}$	0.002	kg/day (dry weight)	Based on the allometric equation (Nagy, 1987) for mammals – IR (g/day) = 0.577 x Wt0.727. See Eq. 3-3 in USEPA (1993).
Intake Rate$_{soil}$	0.0002	kg/day (dry weight)	Ingestion of soil assumed to equal 10% of the prey ingestion rate based on data for the shrew from Beyer *et al.* (1994). Refer to Table 4-4 in USEPA, 1993.
Foraging Territory	0.39	hectare	Based on a conservative foraging territory.
Area Use Factor	100	percent	Based on the conservative assumption that the species derives its entire diet from the site.
Body Weight	0.0015	kilogram	Most conservative value presented in Wildlife Exposure Factors Handbook (USEPA, 1993).
Dietary Composition	100	percent	Based on a conservative assumption of 100% dietary intake from site invertebrates.

5.2.3 Gray Fox

The gray fox was selected as a target receptor for assessment of potential food-chain bioaccumulation from soil into species of omnivorous mammals. The ingestion of small mammals and birds represent the primary routes of exposure for the fox. The following table summarizes the specific parameters and references that will be used.

Table 9 Parameters Used in Gray Fox Exposure Calculations

Parameter	Average Adult	Units	Reference/Notes
Intake Rate$_{tissue}$	0.2204	kg/day (dry weight)	Based on the allometric equation (Nagy, 1987) for mammals – IR (g/day) = 0.577 x Wt0.727. See Eq. 3-3 in USEPA (1993).
Intake Rate$_{soil}$	0.0022	kg/day (dry weight)	Ingestion of soil assumed to equal 1% of the prey ingestion rate based from Beyer *et al.* (1994). Refer to Table 4-4 in USEPA (1993).
Foraging Territory	700	hectare	Based on a conservative foraging territory.
Area Use Factor	--	--	Percent is calculated as the ratio of combined SWMU size to the foraging territory size.
Body Weight	4.1	kilogram	Mammals of Texas Online (2005) http://www.nsrl.ttu.edu/tmot1/Default.htm.
Dietary Composition	100	percent	Based on an assumption of 100% intake of omnivore prey.

5.2.4 American Robin

The American robin was selected as a target receptor for assessment of potential food-chain bioaccumulation from site soil into species of predominantly insectivorous birds. The ingestion of plants, invertebrates, and incidental ingestion of soil represent the primary routes of exposure for the robin. The robin is a potential year-round resident of the site, and, therefore, it is a conservative receptor because of the frequency of exposure. The following table summarizes the specific parameters and references that will be used.

Table 10 Parameters Used in American Robin Exposure Calculations

Parameter	Average Adult	Units	Reference/Notes
Intake Rate$_{tissue}$	0.011	kg/day (dry weight)	Based on the allometric equation (Nagy, 1987) for birds – IR (kg/day) = 0.0582 x Wt0.651. See Eq. 3-3 in USEPA (1993).
Intake Rate$_{soil}$	0.0011	kg/day (dry weight)	Ingestion of soil assumed to equal 10% of the prey ingestion rate based on data for species of birds from Beyer *et al*. (1994). Refer to Table 4-4 in USEPA (1993).
Area Use Factor	100	percent	Based on the conservative assumption that the species derives its entire diet from the site.
Foraging Territory	0.15	hectare	Based on conservative foraging territory.
Body Weight	0.077	kilogram	Most conservative value presented in Wildlife Exposure Factors Handbook (USEPA, 1993).
Dietary Composition	100	percent	Based on an assumption of 50% intake of site vegetation and 50% of site invertebrates.

5.2.5 Bobwhite Quail

The bobwhite quail was selected as a target receptor for assessment of potential food-chain bioaccumulation from site soil into species of herbivorous birds. The ingestion of plants/seeds and incidental ingestion of soil represent the primary routes of exposure for the quail. The following table summarizes the specific parameters and references that will be used.

Table 11 Parameters Used in Bobwhite Quail Exposure Calculations

Parameter	Average Adult	Units	Reference/Notes
Intake Rate$_{tissue}$	0.017	kg/day (dry weight)	Based on the allometric equation (Nagy, 1987) for birds – IR (kg/day) = 0.0582 x Wt$^{0.651}$. See Eq. 3-3 in USEPA (1993).
Intake Rate$_{soil}$	0.0017	kg/day (dry weight)	Ingestion of soil assumed to equal 10% of the prey ingestion rate based on data from Beyer *et al*. (1994). Refer to Table 4-4 in USEPA (1993).
Foraging Territory	3.6	mile	Based on a 3.6 mile foraging range.
Area Use Factor	100	percent	Based on the conservative assumption that the species derives its entire diet from the site.
Body Weight	0.154	kilogram	Most conservative value presented in Wildlife Exposure Factors Handbook (USEPA, 1993).
Dietary Composition	100	percent	Based on an assumption of 100% intake of site vegetation.

5.2.6 Black-Capped Vireo

The BCVI was selected to represent the effects of COPCs on an insectivorous bird and because it is an endangered species. Ingestion of invertebrate tissue represents the primary route of exposure for the vireo. Because it consumes invertebrates from the leaves and branches of trees, incidental ingestion of soil is not considered to be a pathway of exposure for the vireo. The following table summarizes the specific parameters and references that will be used.

Table 12 Parameters Used in Black-Capped Vireo Exposure Calculations

Parameter	Average Adult	Units	Reference/Notes
Intake Rate$_{tissue}$	0.003	kg/day (dry weight)	Based on the allometric equation (Nagy, 1987) for birds – IR (kg/day) = 0.0582 x Wt0.651. See Eq. 3-3 in USEPA (1993).
Intake Rate$_{soil}$	0.00003	kg/day (dry weight)	Assumed 1%. As an insectivore consuming its food from the leaves and branches of trees, incidental soil ingestion for the vireo is considered to be negligible (Sample and Sutter, 1994).
Foraging Territory	5	hectare	Based on a conservative foraging territory of 5 ha.
Area Use Factor	100	percent	Based on the conservative assumption that the species derives its entire diet from the site.
Exposure Frequency	50	percent	Based on a 6-month presence at the site due to migration (March-August).
Body Weight	0.009	kilogram	Cornell Birds of North America Online http://bna.birds.cornell.edu/BNA.
Dietary Composition	100	percent	Based on an assumption of 100% intake of site invertebrates.

5.2.7 Golden-Cheeked Warbler

The GCWA was selected to represent the effects of COPCs on a tree-dwelling insectivore and because it is an endangered species. The ingestion of leaf- and tree-dwelling invertebrate tissue represents the primary routes of exposure for the GCWA. Incidental ingestion of soil is not attributed to exposure based on the consumption of insects from branches and leaves of trees and minimal contact with the soil. The following table summarizes the specific parameters and references that will be used.

Table 13 Parameters Used in Golden-Cheeked Warbler Exposure Calculations

Parameter	Average Adult	Units	Reference/Notes
Intake Rate$_{tissue}$	0.003	kg/day (dry weight)	Based on the allometric equation (Nagy, 1987) for birds – IR (kg/day) = 0.0582 x Wt0.651. See Eq. 3-3 in USEPA (1993).
Intake Rate$_{soil}$	0.00003	kg/day (dry weight)	Assumed 1%. As an insectivore consuming its food from the leaves and branches of trees, incidental soil ingestion for the warbler is considered to be negligible (Sample and Sutter, 1994).
Area Use Factor	100	percent	Based on the conservative assumption that the species derives its entire diet from the site.
Foraging Territory	5	hectare	Based on a conservative foraging territory of 5 hectares.
Exposure Frequency	50	percent	Based on a 6-month presence at the site due to migration (March-August).
Body Weight	0.01	kilogram	Cornell Birds of North America Online (http://bna.birds.cornell.edu/BNA).
Dietary Composition	100	percent	Based on an assumption of 100% intake of site invertebrates.

5.2.8 Red-tailed Hawk

The red-tailed hawk was selected as a target receptor for assessment of potential food-chain bioaccumulation from soil into species of carnivorous birds. The ingestion of prey species (*i.e.*, small mammals, birds), and incidental ingestion of soil represent the primary routes of exposure for the hawk. The following table summarizes the specific parameters and references that will be used.

Table 14 Parameters Used in Red-tailed Hawk Exposure Calculations

Parameter	Average Adult	Units	Reference/Notes
Intake Rate$_{tissue}$	0.057	kg/day (dry weight)	Based on the allometric equation (Nagy, 1987) for birds – IR (kg/day) = 0.0582 x Wt0.651. See Eq. 3-3 in USEPA (1993).
Intake Rate$_{soil}$	0.0033	kg/day (dry weight)	Ingestion of soil conservatively assumed to equal 1% of the prey ingestion rate based on data for carnivorous bird species from Beyer *et al.* (1994). Refer to Table 4-4 in USEPA (1993).
Foraging Territory	60	hectare	Based on a conservative foraging territory. Hawk's territory is typically 60-160 hectares (Wildlife Exposure Factors Handbook, USEPA, 1993).
Area Use Factor	--	--	Percent is calculated as the ratio of combined SWMU size to the foraging territory size.
Body Weight	0.957	kilogram	Most conservative value presented in Wildlife Exposure Factors Handbook (USEPA, 1993).
Dietary Composition	100	percent	Based on an assumption of 100% intake of omnivore prey.

6.0 CHARACTERIZATION OF ECOLOGICAL EFFECTS

The ecological effects characterization presents more detailed information on the toxicity of the COPCs to ecological species. Toxicity information has been specifically used to develop toxicity reference values (TRV) for selected target receptors or communities. The TRV is the daily dose for a species that is likely to cause no adverse effects from chronic exposure. Two types of values can be used to evaluate effects of a COPC on wildlife species: a no-observable adverse effect level (NOAEL)-based TRV and a lowest-observable adverse effect level (LOAEL)-based TRV. The NOAEL endpoint reflects the highest exposure level that causes no statistically significant difference in effect compared to the test control organisms. The LOAEL endpoint reflects the lowest exposure level shown to cause some adverse effect in a potential receptor species. TRVs are developed using available toxicity information and extrapolation factors.

6.1 LITERATURE REVIEW OF TOXICITY DATA

The toxicity of COPCs will be assessed for terrestrial wildlife in both the hardwood and the grassland ecosystems. Scientific literature will be reviewed for media-specific and species-specific toxicity data. Criteria and toxicity data will be obtained from the sources listed below:

- Oak Ridge National Laboratory (ORNL) (Sample, *et al.*, 1996).
- USEPA Region 9 Biological Technical Assessment Group (BTAG) (CH2M Hill, 2002).
- ECO – SSLs Ecological Soil Screening Levels (USEPA, 2005).

6.2 DERIVATION OF TRVs FOR BIRDS AND MAMMALS

The derivation of TRVs for birds and mammals will be based on the *Toxicological Benchmarks for Wildlife: 1996 Revision* guidance document from ORNL (Sample, *et al.*, 1996). The ORNL guidance document will be used as the primary source because it typically provides the most conservative TRVs.

Allometric modeling from Sample and Arenal (1999) will be used for all interspecies extrapolations (*i.e.*, when the test species is different from the wildlife or target receptor species). Body weights for test organisms will be based on those from the actual test study whenever possible. When body weights are not available for the actual test species, then the weight of the same species from another study will be used. The equation presented below will be used to estimate the NOAEL for target bird and mammal species.

$$NOAEL_W = NOAEL_t \left[\frac{bw_t}{bw_w} \right]^{(1-b)}$$

where:

$NOAEL_w$ = NOAEL for target avian or mammalian wildlife species

$NOAEL_t$ = NOAEL for avian or mammalian test species

bw_t = Body weight of avian or mammalian test species

bw_w = Body weight of avian or mammalian wildlife species

b = Allometric scaling factor that is specific to either birds or mammals.

In the absence of chemical-specific parameters, allometric scaling factors of 1.2 for birds and 0.94 for mammals will be used (Sample and Arenal, 1999).

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