August 2018
RG-263c

Case Study for the TCEQ's Ecological Risk Assessment Process

Remediation Division
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Case Study for the TCEQ's Ecological Risk Assessment Process

Prepared by
Remediation Division

RG-263c
August 2018
www.tceq.texas.gov/assets/public/comm_exec/pubs/rg/rg-263c.pdf

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Published and distributed
by the
Texas Commission on Environmental Quality
P.O. Box 13087
Austin TX 78711-3087

How is our customer service? tceq.texas.gov/customersurvey

Overview

Objective: To provide case study examples of a Tier 1 Exclusion Criteria Checklist, a Tier 2 Screening Level Ecological Risk Assessment, and an Ecological Services Analysis. This document is to be used in conjunction with TCEQ's Conducting Ecological Risk Assessments at Remediation Sites in Texas (RG-263), the Benchmark Tables and Supporting Documentation for the TCEQ's Ecological Risk Assessment Process (RG-263b), and the Ecological Protective Concentration Level Database. RG-263 is the parent document, the Excel file containing the benchmarks and supporting documentation comprise RG-263b. This case study document is RG-263c.

Audience: the regulated community and environmental professionals.

References:

- The regulatory citation for the Texas Risk Reduction Program (TRRP) rule is Title 30, Texas Administrative Code, Chapter 350 [30 TAC 350].
- The TRRP rule, together with conforming changes to related rules, is contained in 30 TAC 350 and was published in the September 17, 1999 Texas Register (24 Tex. Reg. 7436–766). The rule was amended in 2003 (effective September 1, 2003; 28 Tex. Reg. 6935–37), in 2007 (effective March 19, 2007; 32 Tex. Reg. 1526–79), and in 2009 (effective March 19, 2009, 34 Tex. Reg. 1866–72).
- Find links for the TRRP rule and preamble, Tier 1 PCL tables, and other TRRP information at: <www.tceq.texas.gov/remediation/trrp/>.
- TRRP guidance documents undergo periodic revision and are subject to change. Referenced TRRP documents may be in development. Links to current versions appear at: <www.tceq.texas.gov/goto/trrp-guidance>.
- The TCEQ is committed to accessibility. If you are unable to access the information in any portion of this document, please contact the Technical Program Support Team at the phone number or e-mail address below.

Contacts: TCEQ Remediation Division, 512-239-2200, or <techsup@tceq.texas.gov>. For mailing addresses, refer to <www.tceq.texas.gov/about/directory/>.

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Supporting Information

Resources available on the TCEQ's Ecological Risk Assessments webpage at <www.tceq.texas.gov/remediation/eco/eco.html>.

- Data Tables by Media (Excel file).
- Dioxin and Furan TEQ Calculations (EPA document – provided as Excel file).
- ProUCL Output – Upper Prediction Limits, Upper Confidence Limits, and Outlier Tests (EPA document - provided as Excel file).

Abbreviations

APAR - affected property assessment report

AUF – area use factor

AWTC - Apollo Wood Treating Company

BAF - bioaccumulation factor

bgs - below ground surface

bkgd - background

CCA - chromated copper arsenate

COC - chemical of concern

CSM - conceptual site model

DF - dilution factor

dSAYs - discounted service-acre-years

EPC - exposure point concentration

EMF - exposure modifying factor

ERA - ecological risk assessment

ERAG – Ecological Risk Assessment Guidance [Conducting Ecological Risk Assessments at Remediation Sites in Texas (TCEQ publication RG-263)]

ESA - ecological services analysis

FIR - food ingestion rate

ft - feet

GWBU – groundwater-bearing unit

HEA – habitat equivalency analysis

HQ - hazard quotient

J – data qualifier/flag indicating that analyte detected between the method detection limit and the method quantitation limit and

KM - Kaplan-Meier

LOAEL - lowest observed adverse effect level

MQL - method quantitation limit

NA – not applicable

NOAEL - no observed adverse effect level

PAH - polycyclic aromatic hydrocarbon

PCDD - polychlorinated dibenzo-*p*-dioxins

PCDF - polychlorinated dibenzofurans

PCL - protective concentration level

PCP - pentachlorophenol

RAP - response action plan

RBEL - risk-based exposure limit

SAB – EPA's Science Advisory Board

SDL - sample detection limit

SSIR - soil or sediment ingestion rate

SLERA - screening level ecological risk assessment (Tier 2)

SVOC - semi-volatile organic compound

TAC - Texas Administrative Code

TCDD - tetrachlorodibenzo-*p*-dioxin

TCEQ - Texas Commission on Environmental Quality

TPAH - total polycyclic aromatic hydrocarbons

TEQ - toxic equivalency

TPWD - Texas Parks and Wildlife Department

TRRP - Texas Risk Reduction Program

TRV - toxicity reference value

U – data qualifier/flag indicating that analyte not detected above sample detection limit

UCL - upper confidence limit

UPL - upper prediction limit

U.S. EPA - United States Environmental Protection Agency

USGS - United States Geological Survey

VCP - Voluntary Cleanup Program

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1.0 Introduction and Purpose

This publication is a case study that presents a hypothetical affected property, the releases of chemicals of concern (COCs) from the associated facility and how they can be evaluated through the Tier 1 Exclusion Criteria Checklist (Checklist), the Tier 2 screening level ecological risk assessment (SLERA) and the ecological service analysis (ESA).

This case study is fictional, but highlights circumstances commonly found during the development of the checklist (e.g., disturbed ground), the SLERA (e.g., the groundwater-to-surface water pathway, identification and evaluation of hot spots) and the ESA (e.g., compensatory restoration). Much of the background information for the hypothetical site is repeated in all three of the ecological assessments. This allows the person to review only the relevant example assessment needed for their site.

This publication is a companion to the TCEQ's ecological risk assessment (ERA) guidance Conducting Ecological Risk Assessments at Remediation Sites in Texas (RG-263; also referred to as *"ERAG"*) the Supporting Documentation for the TCEQ's Ecological Benchmark Tables (RG-263b), and the Ecological Protective Concentration Level (PCL) Database or "PCL Database[1]."

This case study incorporates the exposure input information and PCL output from the PCL Database – the only source of wildlife exposure information used.

Although the use of the PCL Database is encouraged for developing Tier 2 and 3 ERAs, the TCEQ recognizes that there will be instances when a site COC or receptor is not included in the PCL Database. In these cases, the person will have to rely on other sources, with adequate justification. Additionally, the person may use alternative wildlife exposure inputs—with appropriate justification—for receptors included in the PCL Database.

Where applicable, the person is encouraged to reference the PCL Database as a source of exposure inputs and outputs and to include screenshots, printouts, and exported files as part of the ERA.

This document does not provide a standardized format for the inclusion of PCL Database outputs; rather, it is left to the person to present these items when and where appropriate. However, the use of the PCL Database does not change the obligation for the completion of the 10 Required Elements (30 TAC 350.77(c)). For example, the appropriate communities and representative species must be chosen (Required Element #2), and a detailed conceptual site model (CSM) must be developed and presented (Required Element #3).

[1] The ERA guide, Benchmark Tables, this document and its supporting documentation, and a link to the PCL Database can be found on TCEQ's ERA web page at: <www.tceq.texas.gov/remediation/eco/eco.html>.

This document provides examples of ecological assessments described in the Texas Risk Reduction Program (TRRP) rule; therefore, terminology specific to the TRRP rule (30 TAC 350) and the science of ERAs is used throughout.

Terms in this publication are defined in the ERAG (RG-263) glossary. **Specifically note the use of "the person," which has a special meaning under the TRRP rule.** Also note these terms, used throughout this case study:

- "Affected property" [30 TAC 350.4(a)(1)] and "site" denote the entire area of contamination. These terms are used interchangeably in this publication and often in ERAs received by the TCEQ.
- "On-site" refers to all environmental media within the legal boundaries of property owned or leased by the person.
- "Off-site" refers to all environmental media outside of the legal boundaries of the property.

Throughout this document, references to the numbered chapters, sections, subsections, etc., of ERAG (RG-263) are shown in **bold** type. For example, "see **3.1**" means "see subsection **3.1** in ERAG." These bolded ERAG references are located throughout the text and within some of the guidance boxes.

> To assist the person, detailed information and recommended actions appear in these guidance boxes. However, additional guidance appears in the content paragraphs.

2.0 Site Background

From 1950 until 2004, the Apollo Wood Treating Company (AWTC) manufactured treated utility poles, foundation pilings, and lumber with creosote and pentachlorophenol (PCP) on a 15-acre tract near Orion, Texas in Sunny County (Figure 1).

Wood was treated under pressure with creosote or PCP in a heated oil-based solution. After treatment, the wood was removed and allowed to dry outside on drip tracks, resulting in large volumes of contaminated soil. Other treatment wastes included wastewater and sludge. Wastewater was generated as a condensate in the treatment process, and by rinsing tanks and equipment.

After separation of recoverable chemicals, wastewater was spread on-site or stored in an evaporation pond. An oily sludge gradually accumulated in the wastewater evaporation pond. This sludge was dumped into unlined pits on-site. It is believed that chromated copper arsenate (CCA) was also used at the site.

The on-site property is adjacent to a large, permanently inundated wetland that receives surface runoff from upstream (north). Surface water in the wetland flows south and enters Moon Creek. Although surface water runoff from the site is primarily to the south, the proximity of the wetland (and its riparian area) to the former sludge pits made it susceptible to runoff from the facility during significant rain events. In addition, past disposal practices at the former facility could also have contributed to releases to the wetland.

Moon Creek is located south of the on-site property and is a perennial, second order stream that flows from east to west (see Figure 1). Moon Creek is not a classified stream segment, but two miles downstream, it empties into Lake Jupiter, which is classified but not shown on any figures.

There are two transitional riparian areas: (1) between the site and Moon Creek to the south and (2) between the site and the wetland to the west.

Based on depth of the uppermost groundwater-bearing unit (8 feet below ground surface (bgs)) and the depth of Moon Creek, impacted groundwater is believed to discharge to Moon Creek south of the site.

The sludge pits and evaporation pond were known to overflow, resulting in releases to soil and groundwater on-site, and to surface water and sediment in the off-site creek and wetland. On-site soil received drippings from treated wood and spills of wood-treating chemicals.

In 2004 AWTC stopped wood-treating operations. Then, in 2006:

- All above-ground structures associated with wood treatment (e.g., drip tracks) were demolished and removed.
- Any wastes remaining in the evaporation pond and sludge pits were removed and disposed of off-site.

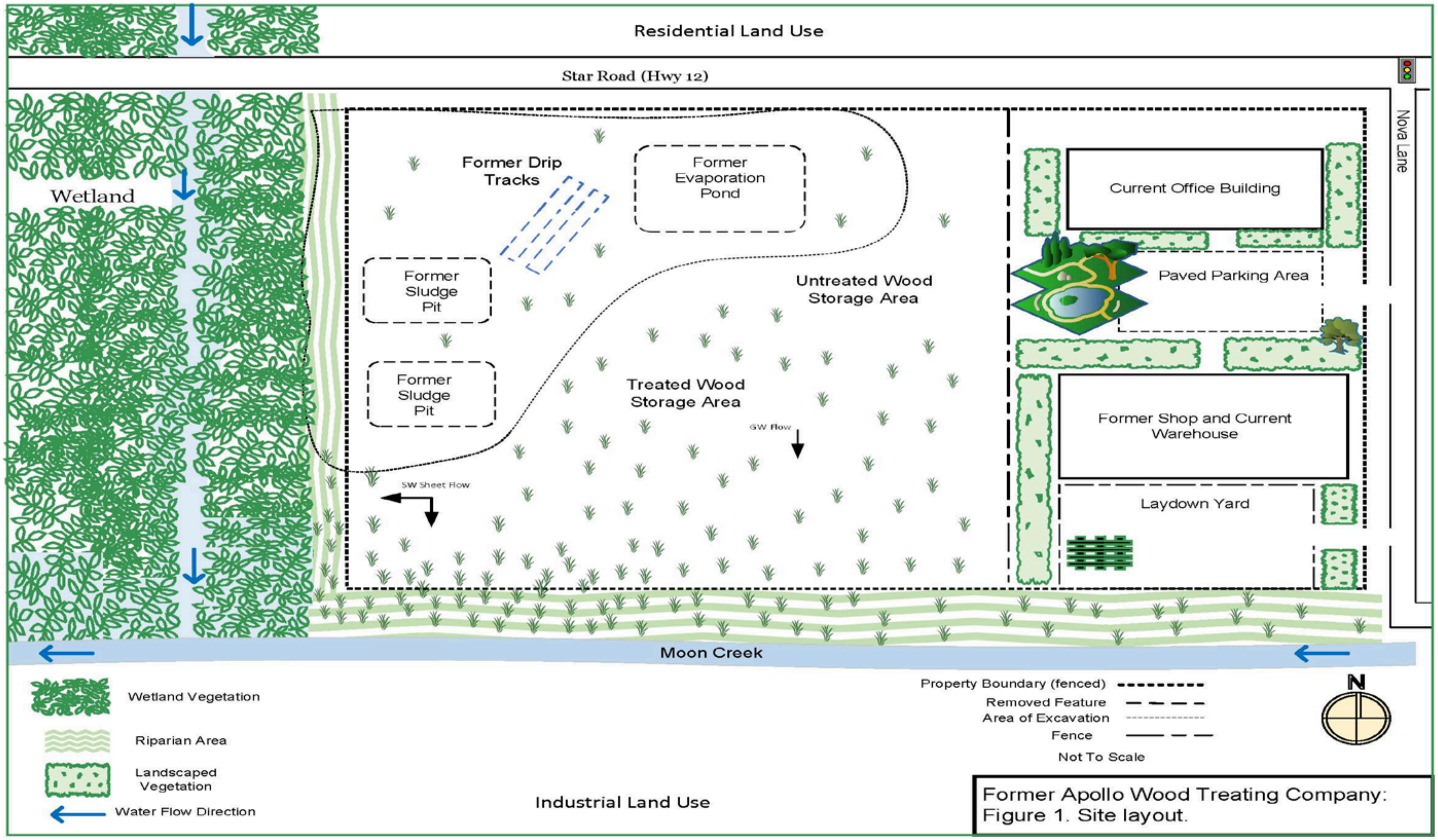

Figure 1. Site layout.

- Soil from the former wood treating area was excavated to a depth of approximately 5 feet bgs, and the area returned to grade.

- Soil was also excavated directly to the west of the former wood treating area into the riparian area. This area received overflow from the former sludge pits based on previous investigation data and visual observations.

Figure 1 shows the outline of the 2006 excavation area and the former wood treating area.

Today, the on-site area is not maintained, and the excavated riparian area has recovered to its former status and function. The on-site area is overgrown with grass, weeds, and shrubs. Birds, mammals, and reptiles have been observed on the affected property. They have also been observed on the off-site creek and wetland (and their riparian areas). Additionally, burrows— 6-inches to 8-inches wide and 3-feet to 4-feet deep, likely from an armadillo— have been found on the site.

AWTC leases the office building, warehouse (former shop), and laydown yard on the eastern part of the site to an oilfield-support business that refurbishes equipment. The laydown yard is covered by gravel and is used to store industrial equipment. An employee recreation area is adjacent to the parking lot. This area includes picnic tables, walking trails and a decorative pond.

In 2006, AWTC was contacted by another party who was interested in buying the property, pending an environmental site assessment and other requirements of the TCEQ's Voluntary Cleanup Program (VCP). AWTC hired Eclipse Consulting who developed: (1) a Phase I assessment report (Eclipse Consulting, 2007) presenting the site's history, and (2) a Phase II assessment with site analytical data (Eclipse Consulting, 2008). The results of the Phase II Environmental Site Assessment include the following:

- In the unexcavated central portion of the former facility, on-site surface and subsurface soils were contaminated with wood-treating chemicals and waste products, primarily where the treated wood was stored.

- The shallow groundwater (8-10 feet bgs) may be in contact with affected subsurface soils. Chemicals from the affected soils could move into the groundwater and then discharge into Moon Creek. Sampling indicated that the deeper groundwater has not been affected by historical operations at the site. Additionally, groundwater samples collected from a temporary well near the eastern third of the site (currently commercial use) did not indicate any contamination.

- Surface water and sediment samples collected from the creek and wetland indicated the presence of facility-related chemicals.

The Phase I and Phase II assessments were presented to the TCEQ and the site was admitted into the VCP.

AWTC developed an affected property assessment report (APAR), including a Tier 1 Checklist and a Tier 2 SLERA. The APAR also included a determination of the nature and extent of the affected property, which required sampling for surface soil, subsurface soil, groundwater (shallow and deep), surface water, and sediment.

Sampling for the APAR was designed to address both human health and ecological exposures. However, only those samples collected from potentially-impacted ecological habitat were used to support the ecological evaluations. Since burrows of sufficient width and depth were noted on-site, and contamination is known to be in the subsurface, an evaluation of subsurface soil exposure to burrowing receptors is required in the SLERA (see **6.6.4** in ERAG).

COCs found on the affected property include metals, PCP, polycyclic aromatic hydrocarbons (PAHs), and dioxins/furans.

The person should see ERAG **2.3** for more information on collection of data to support ecological evaluations.

3.0 Tier 1 Exclusion Criteria Checklist Case Study

As described in **3.1** in ERAG, the purposes of the Tier 1 Exclusion Criteria Checklist [(30 TAC 350.77(b)] are to characterize the ecological setting of the affected property and to determine the existence of complete and potentially significant ecological exposure pathways using exclusion criteria. If a complete ecological exposure pathway is already known or suspected, the person may elect to proceed directly to Tier 2 (or Tier 3). However, since the completion of the Tier 1 Checklist may eliminate some ecological exposure pathways, it is advisable to begin all ecological evaluations at Tier 1 to better focus the assessment.

In this case study, the Tier 1 Exclusion Criteria Checklist as shown in 30 TAC 350.77(b) is shown in the solid-lined boxes. Helpful instructions and guidance are presented in the dashed boxes.

Part I: Affected Property Identification and Background Information

The person should see **3.3.2** in ERAG for assistance in filling out this part of the Checklist. If a more detailed description of the site and surroundings is available in a different location (as provided in 2.0 of this case study), then the person may reference that location.

Part I, Requirement 1: Site Description

1) Provide a description of the specific area of the response action and the nature of the release. Include estimated acreage of the affected property and the facility property, and a description of the type of facility and/or operation associated with the affected property. Also describe the location of the affected property with respect to the facility property boundaries and public roadways.

Part I, Requirement 1: Site Description Response

The former facility is located on a 15-acre tract of land three miles south of Orion, Texas in Sunny County at the intersection of Highway 12 (Star Road) and Nova Lane. The affected property consists of approximately 16 acres and includes 10 on-site acres and 6 acres of off-site portions of the adjacent wetland and creek and their riparian areas.

From 1950 until 2004, the Apollo Wood Treating Company (AWTC) manufactured treated utility poles, foundation pilings, and lumber with creosote and pentachlorophenol. It is believed that CCA was also used at the site.

Operations generated wastewater that was stored on-site in an unlined evaporation pond. The sludge pits and evaporation pond were known to overflow onto the surrounding soils and into the adjacent creek and wetland. Wood treating chemicals migrated from the on-site soils into the groundwater.

On-site soil was also contaminated by drippings from treated wood, or from spills of wood-treating chemicals. Figure 1 provides a conceptual layout of the affected property.

Part I, Requirement 1 Continued: – Site Maps, Figures, or Photos

Attach available USGS topographic maps and/or aerial or other affected property photographs to this form to depict the affected property and surrounding area. Indicate attachments:

☐ Topo map ☐ Aerial photo ☒ Other

Part I, Requirement 1 Continued: – Site Maps, Figures, or Photos Response

Figure 1 in the SLERA depicts the site, surrounding land uses, and current and historical site features.

> The person should attach topographic maps, aerial photos, site photos or other visual representations. The person can also refer to these maps or photos located in another part of the APAR. These figures should show surrounding land use as well as site features (current and historical).

Part I, Requirement 2: Identification of Contaminated Media

2) Identify environmental media known or suspected to contain chemicals of concern (COCs) at the present time. Check all that apply:

Known/Suspected COC Location	Based on sampling data?	
☒ Soil ≤ 5 ft below ground surface	☒ Yes	☐ No
☒ Soil >5 ft below ground surface	☒ Yes	☐ No
☒ Groundwater	☒ Yes	☐ No
☒ Surface Water/Sediments	☒ Yes	☐ No

Explain (previously submitted information may be referenced):

Part I, Requirement 2: Identification of Contaminated Media Response

Data from the Phase II assessment (Eclipse Consulting, 2008) and the APAR show that the media indicated above contain or are suspected of containing organic or inorganic constituents. COCs have been detected in surface and subsurface soil and groundwater on the facility property and in the sediments and surface waters in the wetland and creek.

> The person may refer to data in the APAR or present data summary tables from other sources, if data are available at the time the Checklist is completed.

Part I, Requirement 3: Nearest Surface Water Body Information

3) Provide the information below for the nearest surface water body which has become or has the potential to become impacted from migrating COCs via surface water runoff, air deposition, groundwater seepage, etc. Exclude wastewater treatment facilities and stormwater conveyances/impoundments authorized by permit. Also exclude conveyances, decorative ponds, and those portions of process facilities which are:

a. Not in contact with surface waters in the State or other surface waters which are ultimately in contact with surface waters in the State; and

b. Not consistently or routinely utilized as valuable habitat for natural communities including birds, mammals, reptiles, etc.

The nearest surface water body is *50 feet to the south* from the affected property and is named *Moon Creek*. The water body is best described as a:

☒ freshwater stream: _X__ perennial (has water all year)
______ intermittent (dries up completely for at least 1 week a year)
______ intermittent with perennial pools

☒ freshwater swamp/marsh/wetland
☐ saltwater or brackish marsh/swamp/wetland
☐ reservoir, lake, or pond; approximate surface acres:
☐ drainage ditch
☐ tidal stream ☐ bay ☐ estuary
☐ other; specify

The nearest surface water body is 50 feet to the south from the affected property and is named Moon Creek. The water body is best described as a freshwater, perennial stream. A freshwater wetland is located directly west of the site.

Part I, Requirement 3: Nearest Surface Water Body Response

Moon Creek is located approximately 50 feet to the south of the affected property and is a perennial creek. The freshwater wetland is located to the west of the affected property.

Part I, Requirement 3 Continued: Nearest Surface Water Body Classification

Is the water body listed as a State classified segment in Appendix C of the current Texas Surface Water Quality Standards; "307.1 - 307.10?

☐ Yes Segment # __________ Use Classification:

☒ No

If the water body is not a State classified segment, identify the first downstream classified segment.

Name: *Lake Jupiter*

Segment #: *9999*

Use Classification: *Primary Contact Recreation, High Aquatic Life Use*

As necessary, provide further description of surface waters in the vicinity of the affected property:

Part I, Requirement 3 Continued: Nearest Surface Water Body Classification Response

Moon Creek is a perennial second order stream that flows east to west adjacent to the former facility. The creek discharges to Lake Jupiter two miles downstream. Jupiter Lake is within Segment 9999 and has a use classification of primary contact recreation and high aquatic life use. A large freshwater wetland is located west of the former facility. The wetland receives surface runoff from upstream (north). The wetland flows into Moon Creek just east of the site.

The person should use the most current version of the Texas Surface Water Quality Standards [30 TAC 307] and stream segment maps to determine the closest classified segment in the watershed and its use classification. See **3.3.2** in ERAG for more information.

Part II: Exclusion Criteria and Supportive Information

Subpart A. Surface Water and Sediment Exposure

The person should see **3.3.3.1** in ERAG for assistance in filling out this part of the Checklist. Subpart A of the Checklist deals with the surface water and sediment exposure pathways and asks if there has been a release or a potential release to surface water or sediment.

Part II, Subpart A, Surface Water/Sediment Exposures

1) Regarding the affected property where a response action is being pursued under the TRRP, have COCs migrated and resulted in a release or imminent threat of release to either surface waters or to their associated sediments via surface water runoff, air deposition, groundwater seepage, etc.? Exclude wastewater treatment facilities and stormwater conveyances/impoundments authorized by permit. Also exclude conveyances, decorative ponds, and those portions of process facilities which are:

a. Not in contact with surface waters in the State or other surface waters which are ultimately in contact with surface waters in the State; and

b. Not consistently or routinely utilized as valuable habitat for natural communities including birds, mammals, reptiles, etc.

☒ Yes ☐ No

Explain:

If the answer is Yes to Subpart A above, the affected property does not meet the exclusion criteria. However, complete the remainder of Part II to determine if there is a complete and/or significant soil exposure pathway, then complete PART III - Qualitative Summary and Certification. If the answer is No, go to Subpart B.

Part II, Subpart A, Surface Water/Sediment Exposures Response

Moon Creek is a perennial stream located south of the site that receives on-site surface runoff and impacted shallow groundwater discharges. In addition, past releases of COCs into the adjacent wetland occurred.

Because pathways to these surface water bodies via these sources are complete, the Tier 1 Checklist is failed for this exclusion criterion and further evaluation is needed for the surface water and sediment pathways.

Subpart B. Affected Property Setting

The person should see **3.3.3.2** in ERAG for assistance in filling out this part of the Checklist. Subpart B deals with the affected property setting and the concept of "disturbed ground."

For the exclusion criterion to be accepted the affected property cannot serve as valuable habitat, as foraging area, or refuge for wildlife, livestock, or protected species.

Although this criterion is constructed as a "yes or no" question, the TCEQ acknowledges that a portion(s) of the site may qualify for exclusion.

Part II, Subpart B. Affected Property Setting

In answering "Yes" to the following question, it is understood that the affected property is not attractive to wildlife or livestock, including threatened or endangered species (i.e., the affected property does not serve as valuable habitat, foraging area, or refuge for ecological communities). (May require consultation with wildlife management agencies.)

1) Is the affected property wholly contained within contiguous land characterized by: pavement, buildings, landscaped area, functioning cap, roadways, equipment storage area, manufacturing or process area, other surface cover or structure, or otherwise disturbed ground?

☐ Yes ☒ No

Explain:

If the answer to Subpart B above is Yes, the affected property meets the exclusion criteria, assuming the answer to Subpart A was No. Skip Subparts C and D and complete PART III - Qualitative Summary and Certification. If the answer to Subpart B above is No, go to Subpart C.

Part II, Subpart B. Affected Property Setting Response

The eastern third (5 acres) of the terrestrial area is removed from further ecological evaluation because this portion is an active commercial area with buildings, parking lot, laydown yard, maintained landscape, walking trails, a decorative pond, and impervious cover, and therefore meets the definition of disturbed ground. However, this 10-acre portion does not have impervious cover, is attractive to wildlife, possibly including protected species, and may be a stopover for wildlife that forage in the nearby wetland and creeks; therefore, this exclusion criterion does not apply here. The evaluation moves to the next criterion.

Subpart C. Soil Exposure

The person should see **3.3.3.3** in ERAG for assistance in filling out this part of the Checklist. Subpart C deals with the soil exposure at the affected property. It asks whether the COCs in the soil are only below 5 feet or if there is a physical barrier present to prevent exposure to COCs in surface soil.

Part II, Subpart C, Soil Exposure

1) Are COCs which are in the soil of the affected property solely below the first 5 feet beneath ground surface **or** does the affected property have a physical barrier present to prevent exposure of receptors to COCs in surface soil?

☐ Yes ☒ No

Explain:

If the answer to Subpart C above is Yes, the affected property meets the exclusion criteria, assuming the answer to Subpart A was No. Skip Subpart D and complete PART III - Qualitative Summary and Certification. If the answer to Subpart C above is No, proceed to Subpart D.

Part II, Subpart C, Soil Exposure Response

Previously submitted information states that surface soils are contaminated.

Subpart D. *De Minimus* Land Area

The person should see **3.3.3.4** in ERAG for assistance in filling out this part of the Checklist. Subpart D is the final soil exclusion criterion and deals with the concept of a *de minimus* land area of 1 acre or less. Additionally, all conditions as described in Subpart D (*de minimus* land area) must be met before the *de minimus* question can be applied.

Regarding the potential presence of protected species, the person could request a formal consultation with a resource agency [e.g., the Texas Parks and Wildlife Department (TPWD)] or conduct a habitat survey led by a qualified ecologist in conjunction with records of protected species occurrence research obtained from the TPWD. However, if neither of these two efforts are made and if the affected property supports wildlife, the person should assume that protected species could also be present.

Part II, Subpart D De Minimus Land Area Evaluation

In answering "Yes" to the question below, it is understood that all of the following conditions apply:

The affected property is not known to serve as habitat, foraging area, or refuge to threatened/endangered or otherwise protected species. (Will likely require consultation with wildlife management agencies.)

Similar but unimpacted habitat exists within a half-mile radius.

The affected property is not known to be located within one-quarter mile of sensitive environmental areas (e.g., rookeries, wildlife management areas, preserves). (Will likely require consultation with wildlife management agencies.)

There is no reason to suspect that the COCs associated with the affected property will migrate such that the affected property will become larger than one acre.

1) Using human health protective concentration levels as a basis to determine the extent of the COCs, does the affected property consist of one acre or less <u>and</u> does it meet all of the conditions above?

☐ Yes ☒ No

Explain how conditions are met/not met:

If the answer to Subpart D above is Yes, then no further ecological evaluation is needed at this affected property, assuming the answer to Subpart A was No. Complete PART III - Qualitative Summary and Certification. If the answer to Subpart D above is No, proceed to Tier 2 or 3 or comparable ERA.

Part II, Subpart D De Minimus Land Area Response

As birds, mammals, and reptiles have been observed on-site, the site could serve as habitat, foraging area, or refuge to protected species.

Similar but unimpacted habitat does not exist within a half-mile radius.

The affected property is located within one-quarter mile of sensitive environmental areas (i.e., wetland).

The facility was in operation for over 50 years and some source materials were not removed until 2006. COCs have migrated off-site through various media during this time. Ongoing migration is likely still occurring via contaminated groundwater and soil runoff.

Based on the data collected to support the APAR, the affected property has been defined and is greater than one acre.

Part III: Qualitative Summary and Certification

As discussed in **3.3.4**, the person would provide a summary of the information in the Checklist: (1) emphasizing why the exclusion criteria were or were not met, and (2) recommending the next ecological evaluation action, if appropriate.

If the person decides to use a reasoned justification (or an expedited stream evaluation) to attempt to conclude the ERA process, it may be referenced here as the next action, but it must be a separate document (see **3.5** in ERAG).

Part III. Qualitative Summary and Certification

Attach a brief statement (not to exceed 1 page) summarizing the information you have provided in this form. This summary should include sufficient information to verify that the affected property meets or does not meet the exclusion criteria. The person should make the initial decision regarding the need for further ecological evaluation (i.e., Tier 2 or 3) based upon the results of this checklist. After review, TCEQ will make a final determination on the need for further assessment. **Note that the person has the continuing obligation to re-enter the ERA process if changing circumstances result in the affected property not meeting the Tier 1 exclusion criteria.**

Completed by: *Otto Jetson* *(Typed/Printed Name)*

Environmental Scientist *(Title)*

March 3, 2014 *(Date)*

I believe that the information submitted is true, accurate, and complete, to the best of my knowledge.

Stacey Spacely *(Typed/Printed Name of Person)*

Project Manager, Apollo Wood Treating Company *(Title of Person)*

Stacey Spacely *(Signature of Person)*

March 10, 2014 *(Date Signed)*

Part III. Qualitative Summary and Certification Response

This site is 15 acres of previously industrial property. Currently, one-third of the property is used for industrial purposes, and two-thirds is inactive and potentially attractive to wildlife. There is some tall grass on the southern portion of the property. Moon Creek, a perennial creek borders the property to the south. A permanently inundated wetland is located adjacent to the property, to the west.

COCs in shallow groundwater likely discharge to Moon Creek. Impacted surface water runoff enters the wetland and the creek. COCs used for wood treatment are present in the surface soils.

The site does not meet the Tier 1 Exclusion Criteria Checklist, and further ecological evaluation (e.g., Tier 2 SLERA) is required to address:

- COCs in the on-site surface and subsurface soils.
- Off-site surface soils.
- Groundwater.
- Sediments and surface waters (in both Moon Creek and the adjacent wetland).

It is very important that the person complete Part III. Failure to do so will render the Checklist incomplete.

3.1 Application of Reasoned Justification

The Checklist was completed using existing information. Multiple ecological exposure pathways are identified for this affected property and none of these are planned to be removed by an immediate response action. Therefore, a reasoned justification is not likely for this case study, and all ecological exposure pathways are retained for further assessment.

However, if an imminent response action for an affected property addresses specific ecological exposure pathways (e.g., by installing a cap, or removing soil and backfilling to eliminate the pathway), then the person could submit a reasoned justification allowing the ERA to be concluded for that specific pathway without the need for a Tier 2 or 3 ERA. However, additional evaluation would still be needed for the remaining ecological exposure pathways (e.g., surface water and sediment). See **3.5.1** in ERAG for more information on reasoned justification.

3.2 Application of Expedited Stream Evaluation

Based on the existing information from the Checklist, Moon Creek is perennial, and the wetland is permanently inundated, so the expedited stream evaluation does not apply.

However, if Moon Creek was the only surface water body and was an intermittent creek that met the seven qualifying conditions (e.g., no appreciable habitat, meets acute water quality criteria), the surface water assessment could be moved downstream to more robust aquatic habitat. See **3.5.2** in ERAG for more information on the use of an expedited stream evaluation, including the seven qualifying conditions.

4.0 Tier 2 SLERA Case Study

As discussed in **4** of ERAG, the purposes of the Tier 2 SLERA are to scientifically eliminate COCs that do not pose an ecological risk, and to develop PCLs for those COCs that do pose an unacceptable risk to selected ecological receptors.

The Tier 2 SLERA serves to identify COCs, exposure pathways, and ecological receptors of concern based on application of default exposure assumptions and literature-based effect levels. If a SLERA is to be conducted, it is advisable to prepare a work plan for TCEQ review or discussion (see **4.3** in ERAG for more information on developing a SLERA work plan).

The TRRP rule at 30 TAC 350.77(c) establishes 10 minimum required elements to be satisfied when completing a Tier 2 SLERA; however, before implementation, it is important that adequate data (quality and quantity) be collected from ecological habitat within the affected property.

This case study shows how the required elements are implemented and highlights some key technical issues commonly found in Tier 2 SLERAs reviewed by the TCEQ.

This example SLERA also incorporates input information and PCL output from the PCL Database – it is the only source of ecological exposure information used. However, the TCEQ recognizes that there will be instances when a site COC, or receptor, is not included in the PCL Database. In these cases, the person will have to rely on other sources.

Additionally, the person may use alternative, but well-justified, wildlife exposure inputs and toxicity reference values (TRVs) for receptors, or uptake factors, for COCs in the PCL Database.

Although the use of the PCL Database is encouraged for developing Tier 2 and 3 ERAs, not all the required elements can be met via the PCL Database. The person is encouraged to reference the PCL Database as a source of exposure inputs and to include screenshots, printouts, and exported files as part of the ERA.

See **2** of ERAG for additional information on determining the data set to represent the site. The person should ensure that the Method Quantitation Limits (MQLs) are below the assessment level to ensure adequate data quality. The assessment level is equal to the lower of the media-based benchmarks, the most conservative wildlife PCL from the appropriate habitat listed in the PCL Database, or approved background (if higher). See ERAG **2.1** for more information on assessment levels and **6.2** for a discussion on habitats.

4.1 Problem Formulation

> Problem formulation is the first phase of the ecological risk process. It identifies the major factors such as affected property size and ecology, COCs and their distribution in relevant media, potential ecological receptors, and complete exposure pathways to be considered in the assessment. Under the TCEQ's ERA process, problem formulation encompasses the first four required elements. See **4.1.1** and Figure 4.1 in ERAG.

4.1.1 Environmental Setting

The former Apollo Wood Treating Company (AWTC) site is in north eastern Texas at 1234 Star Road (Highway 12) in Orion, Texas in Sunny County. (LAT: 30.392816, LONG: -97.672713). The on-site property encompasses approximately 15 acres of land. Figure 1 shows a general layout of the site.

> The person should include site location map(s), a photographic log, and any habitat observations.

From 1950 until 2004, the AWTC manufactured treated utility poles, foundation pilings, and lumber with creosote and PCP. Wood was treated under pressure with creosote or PCP in a heated oil-based solution. After treatment, the wood was removed from the pressure chamber and allowed to drip dry outside, resulting in large volumes of contaminated soil. Other treatment wastes include wastewater and sludge. Wastewater was generated as a condensate in the treatment process and by rinsing tanks and equipment. After separation of recoverable chemicals, wastewater was spread on-site or stored in an evaporation pond. An oily sludge gradually accumulated in the wastewater evaporation pond. This sludge was dumped into unlined pits on-site.

In 2004 the company ceased wood-treating operations. Currently, AWTC leases the office building, warehouse, and laydown yard on the eastern portion of the site to an oilfield-support business that refurbishes equipment. The eastern one third of the site is paved, and has only landscaped vegetation; therefore, these soil exposure areas have been removed from further ecological analysis using the Tier 1 Exclusion Criteria Checklist (see 3.0 of this publication).

Surface drainage across the site generally flows to the west and south. A wetland is located directly west of the site and a perennial creek (Moon Creek) is located to the south. Both aquatic areas have transitional riparian habitat. The surrounding land use is mixed industrial and residential, with industrial properties located on the south side of the site and residential properties to the north.

In addition to the COCs associated with the processes on site, the person should consider the possibility of contributions of COCs from off-site sources. In this example, the property to the south has been identified as commercial and industrial land use. The nature of these nearby businesses and chemicals used on these properties should be considered in designing the risk assessment and sampling strategy.

Based on depth of the uppermost groundwater bearing unit, and the depth of Moon Creek, impacted groundwater is believed to discharge to Moon Creek south of the site. The uppermost groundwater-bearing unit was determined to be 8 feet bgs. Metals and PAHs have been detected in interface wells adjacent to the creek.

Groundwater classification (1, 2 or 3), or use of a Municipal Setting Designation, does not preclude the evaluation of the groundwater-to-surface water and sediment pathways for ecological exposures.

4.1.2 Ecological Resources

Ecological resources are limited to urban terrestrial wildlife (e.g. American robin) and freshwater aquatic life in the stream. The wetland to the west of the site provides sufficient cover and forage for a variety of species, both terrestrial and aquatic. The former wood-treating and wood-storage areas have patches of grasses and weeds, shrubs, and a few small trees. Birds, mammals, and reptiles have been observed on the affected property. Additionally, suspected armadillo burrows have been observed on the site.

Refer to **6.6.4** in ERAG for information on when to assess burrowing receptors.

A description of ecological resources should include a summary of site visit observations with photos, habitat surveys, plant or tree surveys, or any other relevant documentation developed for the site.

Moon Creek receives groundwater discharge and surface water runoff from the site. This perennial stream provides habitat for small fish, aquatic invertebrates, amphibians, reptiles, birds, and mammals. There is riparian habitat associated with Moon Creek, and to a lesser extent, with the wetland.

A more detailed discussion on habitats and receptors, including protected species, is provided in 4.3.2 of this publication.

4.2 COCs and Benchmark Screening (Required Element 1)

Comparison of affected property concentrations to ecological benchmarks is the first required element in a Tier 2 SLERA, as specified in the TRRP rule [30 TAC 350.77 (c)(1)]. This text provides the data set for all relevant media evaluated in this SLERA, presents the benchmark screening, and analyzes the data for hot spots in all relevant media.

> See **5** in ERAG for a discussion on required element 1. The analytical tables presented for screening should include all the analyzed constituents.
>
> For example, all the metals analyzed by EPA Method 6010B (or 6020B) should be listed and if not detected then the sample detection limit should be listed. The person should present a figure showing the sample locations and describe where quality assurance information on the data can be found. The person should also clarify the sampling depths of the soil and sediment samples. All soil and sediment data are presented in dry weight.
>
> The example data set discussed here is an abbreviated list of a few metals from an EPA Method 6010B analysis, PCP and PAHs from EPA Method 8270C and, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDs and PCDFs) from EPA Method 8290.
>
> If the TCEQ has accepted a refined COC list, or site-specific background concentrations, these should be documented here.

4.2.1 Data Set

All appropriate media (soil, surface water, sediment, and groundwater) were sampled, and data from each individual medium are discussed below. To ensure that only ecological habitat was evaluated for soil exposure pathways, a subset of the entire APAR data set was used in this SLERA. For example, soil samples from the active commercial area that were removed from the SLERA using the Tier 1 Exclusion Criteria Checklist (i.e., the eastern 5 acres) were not incorporated into the data set for the SLERA.

> The TCEQ does not specify the format for data presentation (e.g., the use of scientific notation vs. standard arithmetic format). Present data in whatever format provides the most clarity. In this case study, the water data, water screening benchmarks, all dioxin/furan data (presented as 2,3,7,8-TCDD TEQ), and TEQ PCLs are presented in scientific notation at two significant figures (e.g., 5.0E-05 vs 0.00005). In general, the sediment and soil data and their PCLs are displayed in standard arithmetic numbers to two decimal places.

The analytical results for metals, PCP, PAHs, and dioxin/furan data are presented by media in a separate Excel file found on the TCEQ ERA website at: <www.tceq.texas.gov/remediation/eco/eco.html>.

- Dioxins/furans are presented as avian or mammal 2,3,7,8-TCDD TEQs – see **10.5.2** in ERAG. PAHs are assessed as total PAHs (TPAHs) for soil and sediment– see **10.5.3** in ERAG. TPAHs summations were calculated using the entire sample detection limit (SDL) for those PAHs detected below the MQL.

All analytical data were reviewed using the methods described in TRRP-13 (Review and Reporting of COC Concentration Data under TRRP, May 2010). Data usability qualifiers (also known as flags) commonly found in this case study data are:

- J - Analyte detected between the method detection limit and the method quantitation limit and
- U - Analyte not detected above sample detection limit

The 2,3,7,8-TCDD TEQ were calculated for PCDDs and PCDFs using the EPA Advanced Kaplan-Meier (KM) TEQ Calculator (U.S. EPA, 2014). This tool calculates TEQs from congener results and takes into consideration non-detect and rejected data. The TEQ calculations are shown in the EPA's calculator, which is an Excel file posted on the TCEQ ERA website at: <www.tceq.texas.gov/remediation/eco/eco.html>.

> When the sum of individual compounds, isomers, or groups of congeners are used to represent a data point, and the chemical analysis indicates an undetected value, the proxy value specified at 350.51(n) shall be used for calculating the sum of the respective compounds, isomers, or congeners. This assumes that the COC has not been eliminated in accordance with the criteria at 350.71(k).

Soil: Data are available from on-site surface soil (30 locations) within the property boundary and off-site surface soil from the riparian areas associated with Moon Creek (four samples) and the transitional riparian area of the wetland on the west side of the site (six samples). Figure 2 shows the soil sample locations, Table A-1 in the Excel file posted on the TCEQ ERA website shows the surface soil sample data and Table A-2 shows the subsurface sample data. Additionally, 10 subsurface soil samples were collected from a subset of the on-site locations.

All surface soil samples evaluated in the SLERA were collected from 0-0.5 feet bgs and subsurface samples were collected from 0.5-5 feet bgs. Surface soil sampling locations were chosen to represent the contamination in the unexcavated areas (e.g., former treated wood storage area), verify that the excavated area is not contaminated, and to address the potential for surface water runoff pathways to the creek and wetland. Locations for subsurface soil samples were biased because the samples were collected from areas of known contamination (i.e., treated wood storage area) or excavation (see Figure 2). These samples are included in this SLERA to address potential exposures to burrowing receptors.

Soil samples were analyzed for metals, SVOCs, and dioxins/furans. No site-specific soil background samples were obtained, but Texas-specific median background concentrations for the metals in soil were used as appropriate. The maximum detected concentration for each COC from the 40 surface soil samples (combination of on-site and off-site) and 10 on-site subsurface samples was screened using the plant and soil invertebrate benchmarks from RG-263b.

Surface Water and Sediment (Moon Creek): A total of 20 co-located surface water and sediment samples were collected from Moon Creek in the summer, during low flow conditions. Figure 3 shows the surface water and co-located sediment sampling locations. Surface water and sediment samples were collected to address surface water runoff from the site in depositional areas adjacent to the site. Table A-3 in the Excel file on the TCEQ ERA website presents the surface water data and Table A-4 presents the sediment data. Upstream samples (10) and downstream samples (10) were collected. The upstream locations are not considered to be affected by site operations, or by any other potential industrial activities, and therefore represent background [see 30 TAC 350.4(a)(6)] samples of surface water and sediment. The downstream locations are generally adjacent to the site. Sediment samples were collected in the top four inches of sediment.

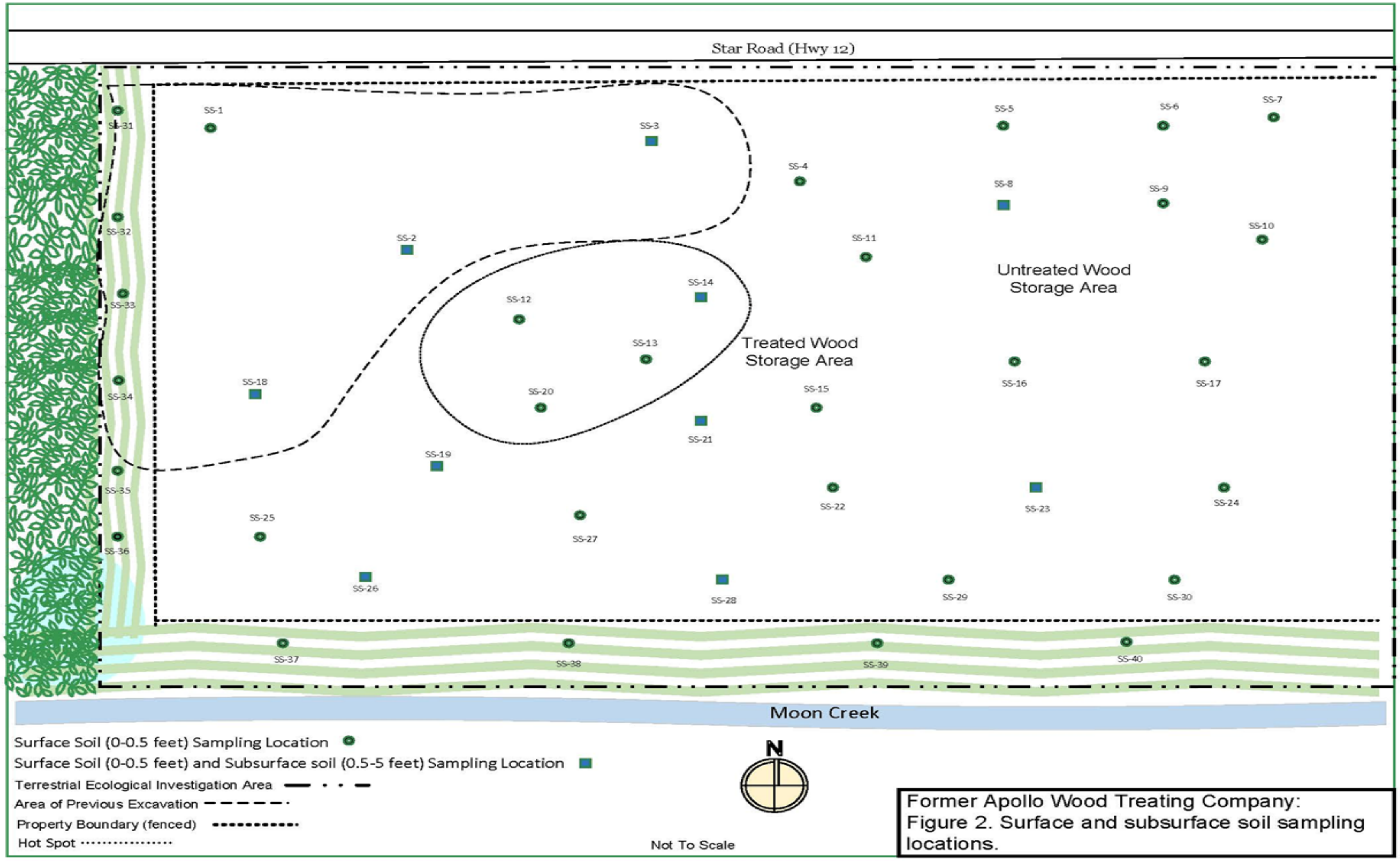

Figure 2. Surface and subsurface soil sampling locations.

> The person should provide rationales for background sample locations. Maps showing all sample locations should be provided. Include an analysis of land use and identification of potential sources of site COCs, such as another wood-treating site or another potential source of elevated metals and SVOCs. A description of the sampling technique should also be included. Any statistical analysis of the background data should be provided.

Surface water samples were analyzed for metals and SVOCs. Sediment samples were analyzed for metals, SVOCs, and dioxins/furans consistent with the soil medium. Filtered surface water samples – representing the dissolved fraction – were analyzed for metals for direct comparison to the benchmarks as appropriate. Surface water samples were not analyzed for dioxins/furans because the conceptual site model indicated that contamination would likely be from overland flow. Moon Creek is perennial and if dioxins/furans are present in the creek they are likely associated with the sediment.

Some response actions have already taken place at the site to remove most of the potential sources of dioxins/furans; however, there are detections of dioxins/furans in the surface soil. The lack of dioxin and furan data in the surface water is further discussed in the Uncertainty Analysis (4.9.1 in this publication).

Groundwater: Groundwater samples were collected from three monitoring wells located adjacent to Moon Creek (Figure 3). The wells are interface wells screened at the depth where it is believed that groundwater intercepts Moon Creek. Only two rounds of groundwater data (six samples) were available, so the maximum detected concentrations were used in this SLERA for benchmark screening. Table A-5 in the Excel data file on the TCEQ ERA website presents the groundwater data.

Groundwater data obtained to support the Phase II investigation (Eclipse Consulting, 2008) were not used because the samples were collected more than nine years ago from a temporary well. These data are useful in planning the APAR investigation, but not as samples on which remediation decisions will be made. For example, the Phase II groundwater samples were analyzed for dioxins/furans and none were detected above SDLs, therefore, groundwater was not analyzed for dioxins/furans in the APAR groundwater samples.

Groundwater samples from the three monitoring wells were analyzed for metals and SVOCs. Filtered groundwater samples – representing the dissolved fraction – were analyzed for metals for direct comparison to the benchmarks as appropriate.

Surface Water and Sediment (Wetland): Twenty sediment samples were collected from an 8-acre area of the wetland found to the west property boundary. Ten of these samples are co-located with surface water samples (Figure 3).

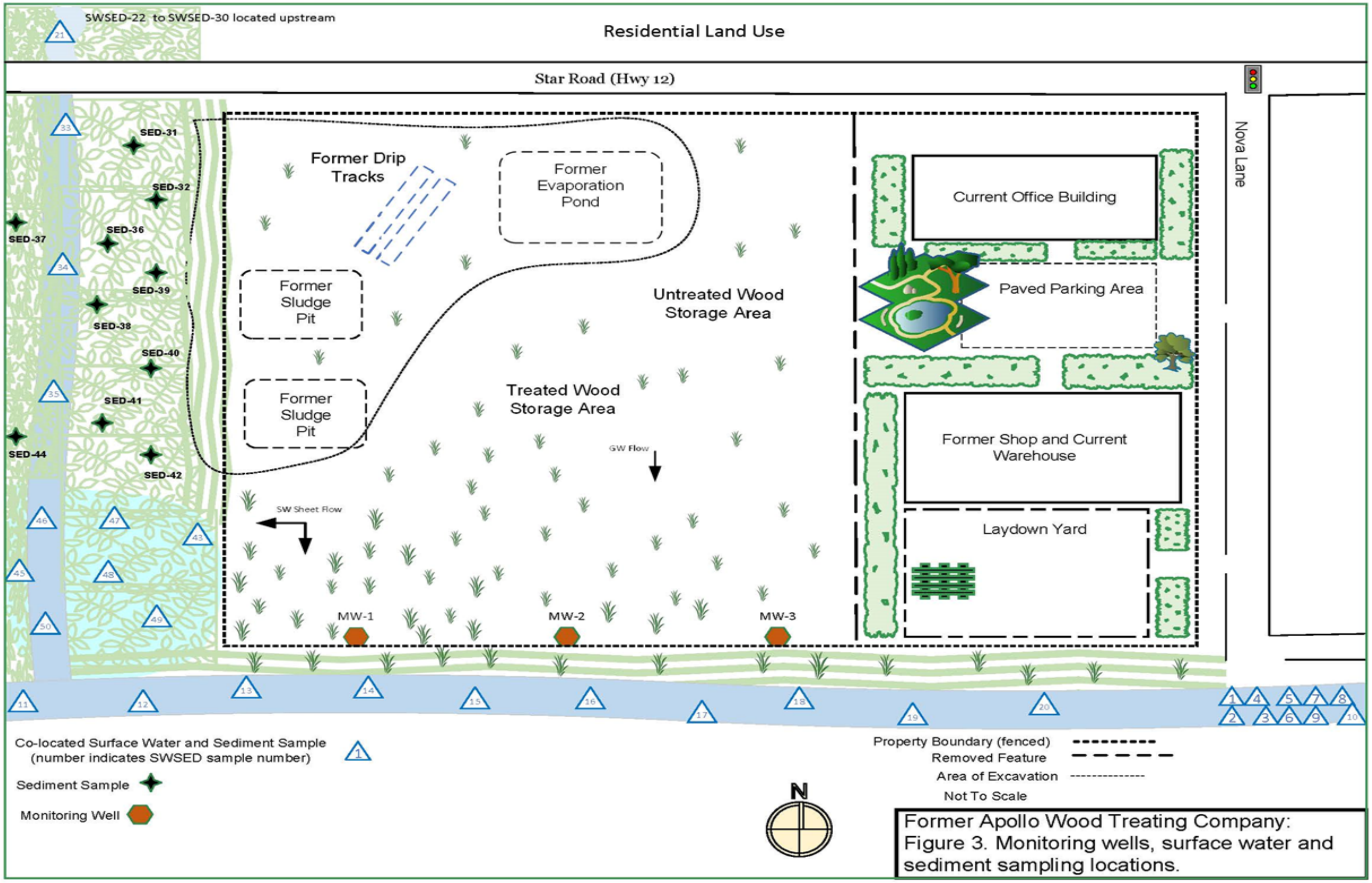

Figure 3. Monitoring wells, surface water, and sediment sampling locations.

Because of the density of the vegetation and the shallow depth of overlying water, surface water samples could only be collected from the narrow channel and a flat and wet area in the southern part of the wetland near Moon Creek.

Ten more co-located surface water and sediment samples were taken upstream of the wetland, across Star Road in the drainage that feeds into the wetland.

Three surface water samples were collected in November 2015 at locations SW-34, SW-45 and SW-49 and analyzed for naphthalene and lead only. These samples were collected to verify or dispute chronic surface water exceedances for these two COCs.

Like Moon Creek sampling, filtered surface water samples were analyzed for metals and SVOCs. Sediment samples were analyzed for metals, SVOCs, and dioxins/furans. See the Uncertainty Analysis (4.9.1 in this publication) for a discussion of the lack of data for dioxins/furans in surface water.

4.2.2 Benchmark Screening

For simplicity, this SLERA case study combined the surface soil data from on-site and off-site riparian soil into one data set for the benchmark screening. As per required element 1, the maximum detected concentration from each environmental media (soil, surface water, sediment, and groundwater) is compared to benchmarks as shown in Tables 1-6.

> The benchmarks for all media are presented in RG-263b (Benchmark Tables and Supporting Documentation for the TCEQ's Ecological Risk Assessment Process). This case study reflects the use of a revised soil benchmark for TPAHs of 2.8 mg/kg. See **5.2** and **10.5.3** for detailed information on the derivation and use of this benchmark.

4.2.2.1 Soil

The maximum detected concentration for each COC from the 40 surface-soil samples (combination of on-site and off-site riparian) was screened against the plant and soil invertebrate benchmarks described below (and shown on Table 1).

Ten subsurface-soil samples were collected from a subset of the on-site locations (Figure 2). Table 1 also provides: a summary of the justification for retaining or removing a COC from further evaluation, whether a COC is bioaccumulative in soil; sample depth; maximum detection; number of detections; number of samples; soil benchmarks; soil background; number of exceedances; and justification and outcome of the screening process. Cadmium, chromium, copper, lead, zinc, PCP, and dioxins/furans are considered bioaccumulative in soil and must be carried forward as COCs for evaluation of risks to wildlife if detected above their detection limits or background.

The bioaccumulative designation is listed on Table 5.1 in ERAG and indicated by bold lettering on the Benchmark Tables (RG-263b).

Benchmarks and background soil concentrations are obtained from the Benchmark Tables found on the TCEQ ERA website at: <www.tceq.texas.gov/remediation/eco/eco.html>.

For the combination of on-site and off-site surface soil (0-0.5 feet bgs) samples:

- Arsenic is removed as a COC in soil because the maximum detected concentration is below the benchmark and arsenic is not considered bioaccumulative.
- Cadmium is removed as a COC because the maximum detection is below the Texas-specific median background concentration.

Because cadmium is a bioaccumulative COC in soil, if it had been detected at a concentration greater than background, it would have been retained as a COC even if the maximum detection was below the benchmark.

- Chromium, lead, and zinc in soil move forward to the food web analysis. The maximum detected concentrations of these metals are greater than their respective benchmarks and background values, as well as being bioaccumulative in soil.
- Copper moves forward to the food web analysis because (1) it is detected at a maximum concentration greater than background and (2) is considered bioaccumulative, although the maximum detected concentration is less than the soil benchmark.
- For the organics, PCP, TPAHs, and 2,3,7,8-TCDD TEQs move forward for further analysis because PCP, dioxins/furans are bioaccumulative and because the TPAHs are detected above the benchmark.

For the on-site subsurface soil (0.5–5 feet bgs) samples:

- Arsenic and cadmium are not retained as COCs for further analysis (like the surface soil evaluation).
- Arsenic in subsurface soil is detected at concentrations less than the benchmark and is not bioaccumulative.
- Cadmium's maximum concentration is below background.
- Chromium is a subsurface soil COC and is detected at a maximum concentration above the benchmark and background concentrations and is considered bioaccumulative.

- Copper, lead, PCP, and 2,3,7,8-TCDD TEQs are subsurface soil COCs. These COCs are detected at maximum concentrations less than benchmarks (when available) but are considered bioaccumulative.

- Zinc is a subsurface soil COC. It is detected at a concentration greater than the benchmark and background. It is also bioaccumulative in soil.

- TPAHs are retained because the maximum detected concentration of 15.1 mg/kg is greater than the benchmark of 2.8 mg/kg.

Figure 4 shows the surface and subsurface soil concentrations of chromium, copper, lead, and zinc. Figure 5 shows the surface and subsurface soil concentrations of PCP and TPAHs. Figure 6 shows the surface and subsurface soil concentrations of dioxins/furans, such as 2,3,7,8-TCDD TEQs for birds and mammals.

Table 1. Surface and subsurface soil data summary and benchmark screening

COC	Depth Interval[2]	Max Detect (mg/kg)	Detections	Soil Benchmark (mg/kg)	TX-Specific Median Background (mg/kg)	Benchmark Exceedance Count	Retain COC?
Arsenic	Surface Soil	17.2	33/40	18	5.9	0	No - max < benchmark and not bioaccumulative
Cadmium	Surface Soil	0.9	14/40	32	1	0	No - max < benchmark, bioaccumulative, but < background (bkgd)
Chromium	Surface Soil	207	39/40	0.4	30	38	Yes - max > benchmark and bkgd, bioaccumulative
Copper	Surface Soil	31.2	40/40	70	15	0	Yes - max < benchmark but > bkgd and bioaccumulative
Lead	Surface Soil	231	40/40	120	15	1	Yes - max > benchmark and bkgd, bioaccumulative
Zinc	Surface Soil	375	40/40	120	30	4	Yes - max > benchmark and bkgd, bioaccumulative
PCP	Surface Soil	12.3	23/40	5	No bkgd value	4	Yes - max > benchmark, bioaccumulative
TPAHs	Surface Soil	41.1	40/40	2.8	No bkgd value	21	Yes - max > benchmark
TCDD TEQ (Avian)	Surface Soil	1.2E-04	13/13	No benchmark	No bkgd value	NA	Yes - detected bioaccumulative
TCDD TEQ (Mammal)	Surface Soil	1.2E-04	13/13	No benchmark	No bkgd value	NA	Yes - detected bioaccumulative
Arsenic	Subsurface Soil	11.89	10/10	18	5.9	0	No - max < benchmark and not bioaccumulative
Cadmium	Subsurface Soil	0.63	4/10	32	1	0	No - max < benchmark, bioaccumulative, but < bkgd
Chromium	Subsurface Soil	34.8	10/10	0.4	30	10	Yes - max > benchmark and bkgd, bioaccumulative

[2] Surface soil is defined as 0 – 0.5 ft bgs and subsurface soil is defined as 0.5 – 5 ft bgs. A clear indication of sample depths should be provided.

COC	Depth Interval[2]	Max Detect (mg/kg)	Detections	Soil Benchmark (mg/kg)	TX-Specific Median Background (mg/kg)	Benchmark Exceedance Count	Retain COC?
Copper	Subsurface Soil	29.0	10/10	70	15	0	Yes - max > bkgd and bioaccumulative
Lead	Subsurface Soil	26	10/10	120	15	0	Yes - max > bkgd and bioaccumulative
Zinc	Subsurface Soil	132	10/10	120	30	1	Yes - max > bkgd and bioaccumulative
PCP	Subsurface Soil	0.0069	2/10	5	No bkgd value	0	Yes - detected bioaccumulative
TPAHs	Subsurface Soil	15.1	10/10	2.8	No bkgd value	6	Yes - max > benchmark
TCDD TEQ (Avian)	Subsurface Soil	1.5E-06	4/4	No benchmark	No bkgd value	NA	Yes - detected bioaccumulative
TCDD TEQ (Mammal)	Subsurface Soil	1.0E-06	4/4	No benchmark	No bkgd value	NA	Yes - detected bioaccumulative

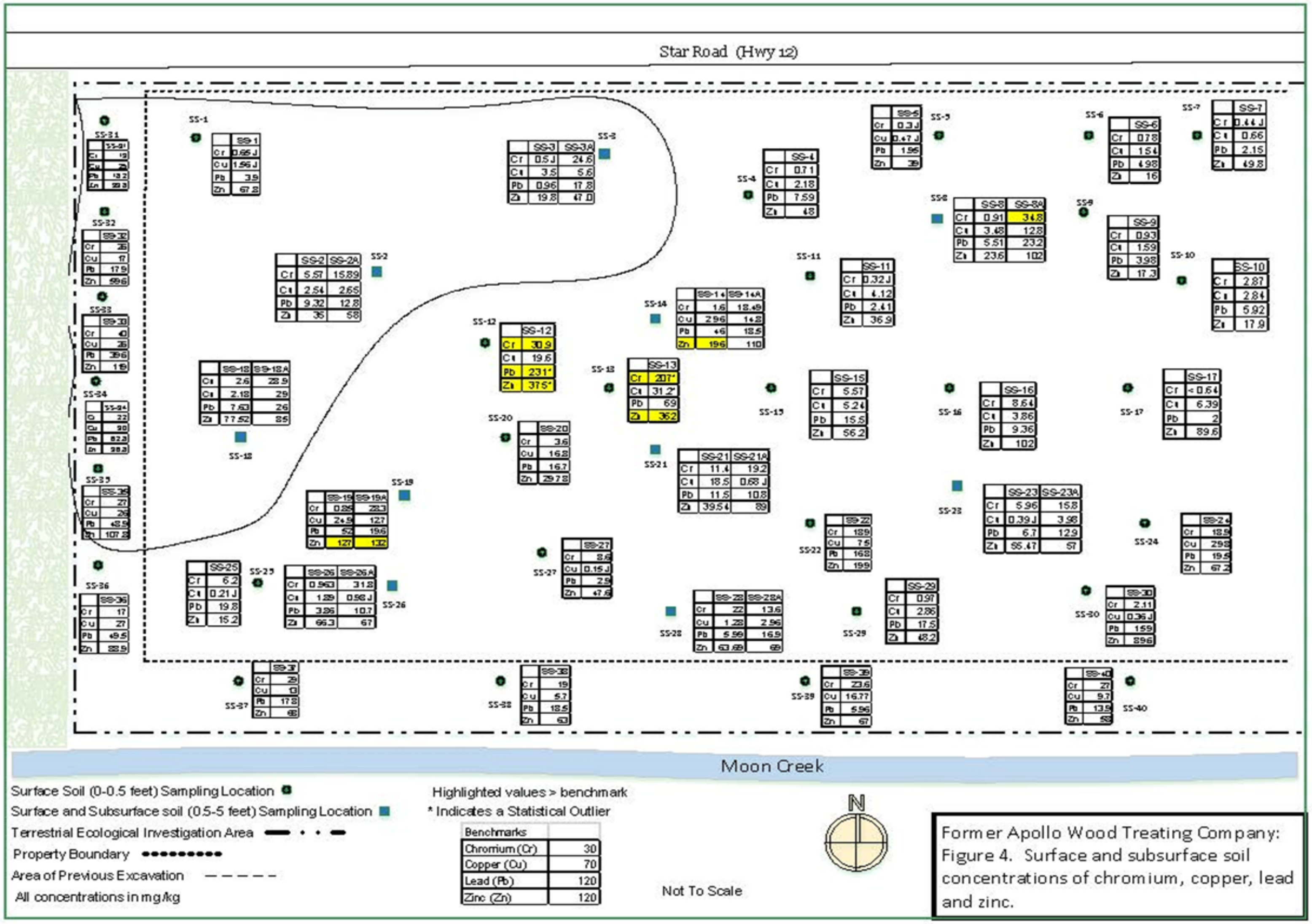

Figure 4. Surface and subsurface soil concentrations of chromium, copper, lead, and zinc.

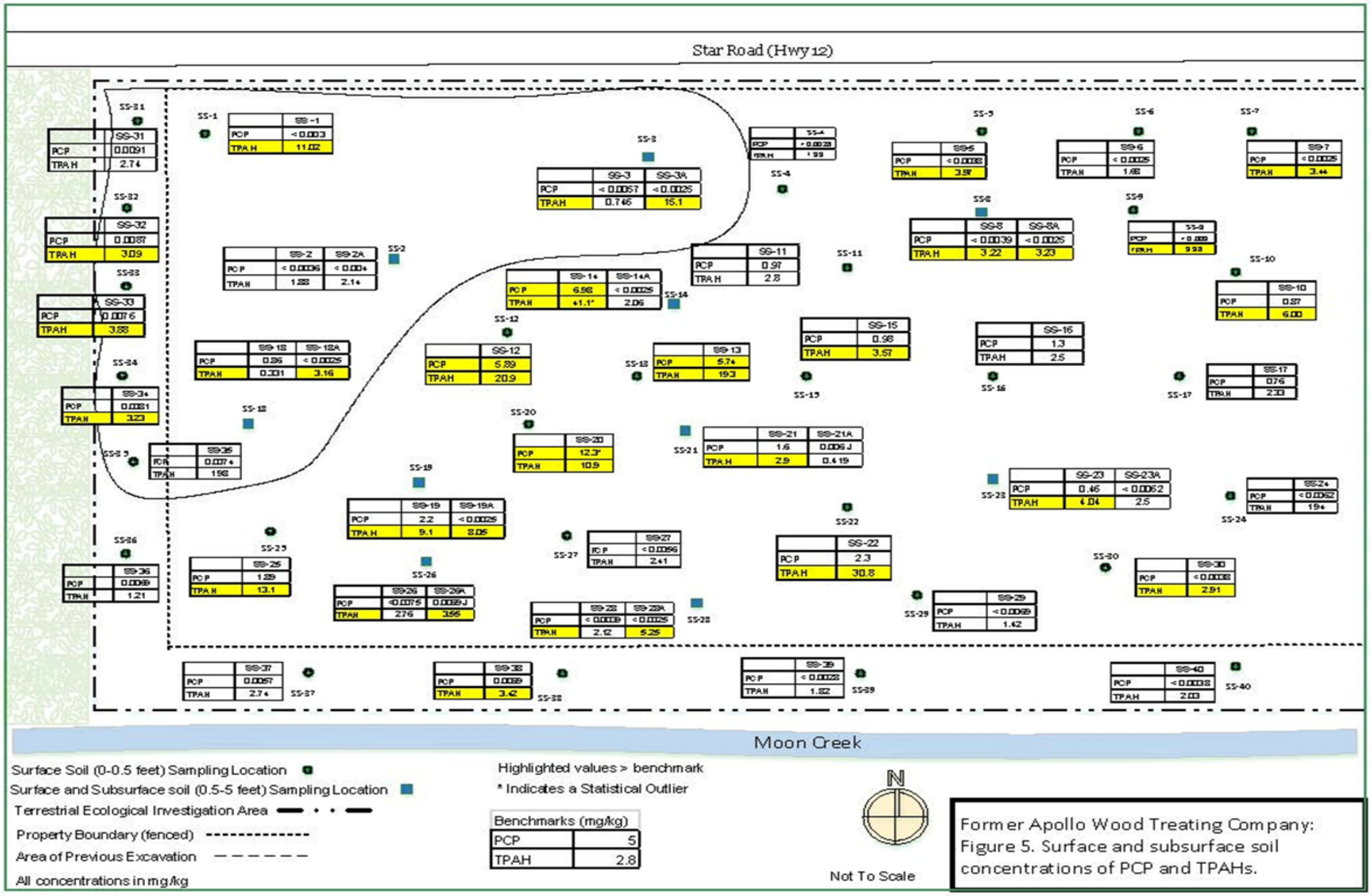

Figure 5. Surface and subsurface soil concentrations of PCP and TPAHs.

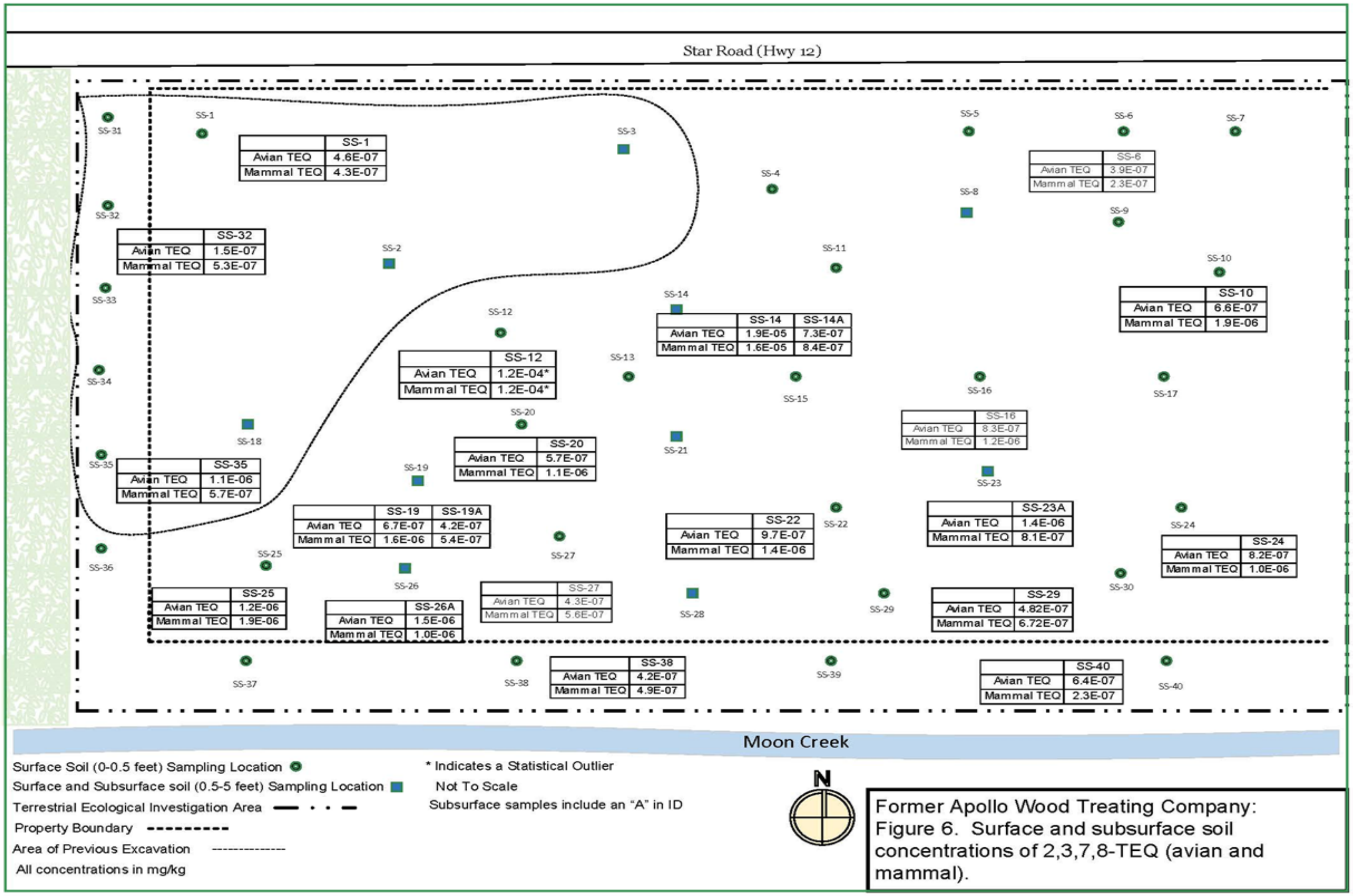

Figure 6. Surface and subsurface soil concentrations of 2,3,7,8-TEQ (avian and mammal).

4.2.2.2 Moon Creek Surface Water and Sediment

Table 2 shows the ecological benchmark comparisons for the surface water in Moon Creek; Table 3 and Figures 7 and 8 show the comparisons for sediment.

Surface water concentrations and benchmarks for metals in Table 2 are for the dissolved fraction. Freshwater chronic values for aquatic life are used as benchmarks because Moon Creek is perennial. Chronic values for metals (except arsenic) were adjusted for hardness using the segment-specific hardness of 68 mg/L. The value for PCP was adjusted using a pH of 7.1 for Segment 9999, Jupiter Lake. None of the detected COCs are considered bioaccumulative in water.

> The equations used for hardness adjustment and the PCP pH adjustment can be found in the Benchmark Tables (RG-263b).

No COC concentrations in surface water exceeded the chronic benchmarks except for arsenic. Dioxins/furans were not analyzed in the surface water samples because, as hydrophobic compounds, they are more likely to be found in the sediment. The lack of surface water dioxin/furan data is discussed in the Uncertainty Analysis (4.9.1 in this publication).

There were more PAHs detected in the downstream (adjacent to the site) locations (only naphthalene upstream). PAHs were not detected at concentrations greater than their respective benchmarks. Note that the detection limit for benzo(a)pyrene in surface water was 0.00003 mg/L and the chronic benchmark is 0.000014 mg/L. It is unlikely that benzo(a)pyrene is present at a concentration greater than the chronic criteria, but below the detection limit, because there were so few detections of PAHs in the surface water in general. See 4.9 in this publication (Uncertainty Analysis) for additional discussion.

Arsenic is detected in the upstream (background) samples (maximum = 0.34 mg/L) at a greater concentration than the downstream samples (maximum = 0.27 mg/L), but comparison of maximum detected values is not sufficient to remove arsenic as a surface water COC. An upper prediction limit (UPL) for arsenic was calculated using the 10 surface water arsenic samples collected upstream of the site[3]. The upstream arsenic surface water UPL is 0.305 mg/L. The maximum detected arsenic concentration from the downstream samples is 0.27 mg/L, and because this value is less than the UPL, arsenic is removed as a COC in surface water.

[3] The output from EPA's ProUCL program is provided as a separate excel file on the TCEQ ERA website. All statistical calculations were completed with ProUCL.

The UPL is the TCEQ's preferred background statistic. EPA's ProUCL program can be used to calculate the UPLs. The person should provide justification for which UPL is chosen from those calculated by the program. All ProUCL outputs should be submitted as part of the SLERA documentation. The person should work with the TCEQ to determine the location for background sampling and then should clearly explain all statistical evaluations of the data set. This includes determination and removal of any significant outliers.

Table 3 presents the maximum sediment concentrations from the upstream and the downstream (site-adjacent) locations. In the upstream samples, chromium, zinc, and TPAHs have maximum detected concentrations greater than their sediment benchmarks. All maximum downstream (adjacent to the site) concentrations exceed benchmarks except arsenic, cadmium, and PCP. All sediment samples were taken from the top four inches of sediment.

Figure 3 shows the locations of the sediment samples. Sample SWSED-1 represents the most downstream location of the background or reference samples and the samples are numbered sequentially moving upstream to SWSED-10. It is assumed that this portion of Moon Creek was not impacted by site operations and it is not expected to receive any groundwater discharge from the site. Location SWSED-11 is the most downstream of the samples and SWSED-20 is located at the property boundary upstream.

Arsenic is the only downstream analyte that can be eliminated at this point in the SLERA because the maximum detected concentration is less than the benchmark and arsenic is not considered bioaccumulative. Cadmium, copper zinc, PCP, and 2,3,7,8-TCDD TEQs are considered bioaccumulative in sediment and are therefore retained. Thus, in the downstream samples, cadmium, chromium, copper, lead, zinc, PCP, TPAHs, and 2,3,7,8-TCDD TEQ are considered COCs requiring further evaluation.

Since all maximum concentrations from downstream (adjacent) samples exceed those from the upstream samples, it is unlikely that the development of UPLs will result in removal of any of these COCs.

Table 2. Moon Creek surface water data summary and benchmark screening

COC	Upstream or Adjacent to Site	Max Detect (mg/L)	Data Flag	Detections	Freshwater Chronic Benchmark (mg/L)	Benchmark Exceedance Count
Arsenic	Upstream	3.4E-01		10/10	1.5E-01	2
Cadmium	Upstream	2.7E-04	U	0/10	1.9E-04	All ND
Chromium	Upstream	4.3E-04	J	5/10	5.4E-02	0
Copper	Upstream	9.7E-04	J	2/10	6.8E-03	0
Lead	Upstream	4.8E-04	U	0/10	1.7E-03	All ND
Zinc	Upstream	5.2E-02		10/10	8.5E-02	0
Pentachlorophenol	Upstream	4.6E-05	U	0/10	7.4E-03	All ND
1-Methylnaphthalene	Upstream	3.4E-05	U	0/10	2.1E-03	All ND
2-Methylnaphthalene	Upstream	3.4E-05	U	0/10	6.3E-02	All ND
Acenaphthene	Upstream	3.0E-05	U	0/10	2.3E-02	All ND
Acenaphthylene	Upstream	2.1E-05	U	0/10	No benchmark	All ND
Anthracene	Upstream	2.0E-05	U	0/10	3.0E-04	All ND
Fluorene	Upstream	2.1E-05	U	0/10	1.1E-02	All ND
Naphthalene	Upstream	5.3E-04	J	1/10	2.5E-01	0
Phenanthrene	Upstream	2.0E-05	U	0/10	3.0E-02	All ND
Benz(a)anthracene	Upstream	2.5E-05	U	0/10	3.5E-02	All ND
Benzo(a)pyrene	Upstream	3.0E-05	U	0/10	1.4E-05	All ND
Benzo(b)fluoranthene	Upstream	2.8E-05	U	0/10	No benchmark	All ND
Benzo(g,h,i)perylene	Upstream	2.6E-05	U	0/10	No benchmark	All ND
Benzo(k)fluoranthene	Upstream	2.8E-05	U	0/10	No benchmark	All ND
Chrysene	Upstream	4.6E-05	U	0/10	7.0E-03	All ND
Dibenz(a,h)anthracene	Upstream	2.6E-05	U	0/10	5.0E-03	All ND
Fluoranthene	Upstream	2.0E-05	U	0/10	6.2E-03	All ND
Indeno(1,2,3-cd)pyrene	Upstream	5.1E-05	U	0/10	No benchmark	All ND
Pyrene	Upstream	2.2E-05	U	0/10	7.0E-03	All ND
Arsenic	Adjacent	2.7E-01	J	10/10	1.5E-01	2
Cadmium	Adjacent	2.7E-04	U	0/10	1.9E-04	All ND
Chromium	Adjacent	5.3E-03		10/10	5.4E-02	0
Copper	Adjacent	1.7E-03	J	6/10	6.8E-03	0
Lead	Adjacent	1.4E-03	J	6/10	1.7E-03	0
Zinc	Adjacent	7.6E-03		10/10	8.5E-02	0
Pentachlorophenol	Adjacent	4.6E-05	U	0/10	7.4E-03	All ND
1-Methylnaphthalene	Adjacent	3.4E-05	U	0/10	2.1E-03	All ND
2-Methylnaphthalene	Adjacent	3.4E-05	U	0/10	6.3E-02	All ND
Acenaphthene	Adjacent	3.0E-05	U	0/10	2.3E-02	All ND
Acenaphthylene	Adjacent	2.1E-05	U	0/10	No benchmark	All ND
Anthracene	Adjacent	2.0E-05	U	0/10	3.0E-04	All ND
Fluorene	Adjacent	5.3E-05		1/10	1.1E-02	0
Naphthalene	Adjacent	6.3E-04		1/10	2.5E-01	0
Phenanthrene	Adjacent	9.0E-05		1/10	3.0E-02	0
Benz(a)anthracene	Adjacent	7.0E-05		1/10	3.5E-02	0
Benzo(a)pyrene	Adjacent	3.0E-05	U	0/10	1.4E-05	All ND
Benzo(b)fluoranthene	Adjacent	2.8E-05	U	0/10	No benchmark	All ND

COC	Upstream or Adjacent to Site	Max Detect (mg/L)	Data Flag	Detections	Freshwater Chronic Benchmark (mg/L)	Benchmark Exceedance Count
Benzo(g,h,i)perylene	Adjacent	2.6E-05	U	0/10	No benchmark	All ND
Benzo(k)fluoranthene	Adjacent	2.8E-05	U	0/10	No benchmark	All ND
Chrysene	Adjacent	4.6E-05	U	0/10	7.0E-03	All ND
Dibenz(a,h)anthracene	Adjacent	2.6E-05	U	0/10	5.0E-03	All ND
Fluoranthene	Adjacent	8.1E-05		1/10	6.2E-03	0
Indeno(1,2,3-cd)pyrene	Adjacent	5.1E-05	U	0/10	No benchmark	All ND
Pyrene	Adjacent	5.5E-05		1/10	7.0E-03	NA

Table 3. Moon Creek sediment data summary and benchmark screening.

COC	Upstream or Adjacent to Site	Max Detect (mg/kg)	Data Flag	Detections	Sediment Freshwater Benchmark (mg/kg)	Benchmark Exceedance Count	Retain COC?
Arsenic	Upstream	7		8/10	9.79	0	NA - upstream of site
Cadmium	Upstream	0.49		5/10	0.99	0	NA - upstream of site
Chromium	Upstream	47		10/10	43.4	2	NA - upstream of site, note max > benchmark
Copper	Upstream	27		10/10	31.6	0	NA - upstream of site
Lead	Upstream	15		10/10	35.8	0	NA - upstream of site
Zinc	Upstream	130		10/10	121	3	NA - upstream of site, note max > benchmark
PCP	Upstream	0.0039	U	0/10	1.2	0	NA - upstream of site
TPAHs	Upstream	5.38		10/10	1.61	6	NA - upstream of site, note max > benchmark
TCDD TEQ (Avian)	Upstream	9.7E-07		3/3	No benchmark	NA	NA - upstream of site
TCDD TEQ (Mammal)	Upstream	1.2E-06		3/3	No benchmark	NA	NA - upstream of site
Arsenic	Adjacent	9.2		10/10	9.79	0	No - max < benchmark
Cadmium	Adjacent	0.94		4/10	0.99	0	Yes - detected bioaccumulative, > upstream
Chromium	Adjacent	45.6		10/10	43.4	1	Yes - max > benchmark
Copper	Adjacent	58		10/10	31.6	3	Yes - max > benchmark and upstream, detected bioaccumulative
Lead	Adjacent	72.8		10/10	35.8	7	Yes - max > benchmark and upstream

COC	Upstream or Adjacent to Site	Max Detect (mg/kg)	Data Flag	Detections	Sediment Freshwater Benchmark (mg/kg)	Benchmark Exceedance Count	Retain COC?
Zinc	Adjacent	250		10/10	121	8	Yes - max > benchmark and upstream, detected bioaccumulative
PCP	Adjacent	0.56		4/10	1.2	0	Yes - detected bioaccumulative, > upstream
TPAHs	Adjacent	9.8		10/10	1.61	9	Yes - max > benchmark and upstream
TCDD TEQ (Avian)	Adjacent	2.1E-06		5/5	No benchmark	NA	Yes - detected bioaccumulative
TCDD TEQ (Mammal)	Adjacent	2.2E-06		5/5	No benchmark	NA	Yes - detected bioaccumulative

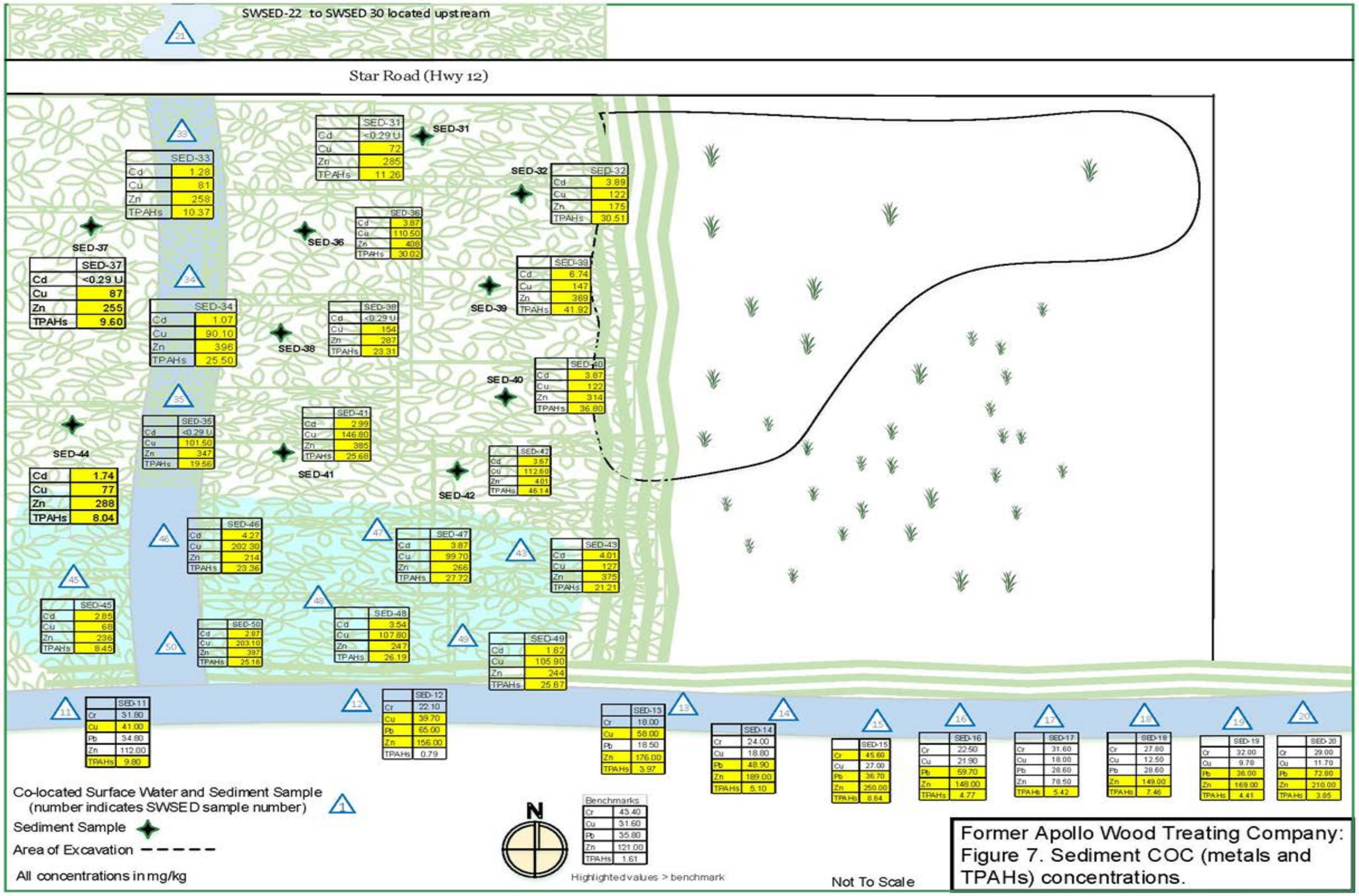

Figure 7. Sediment COC (metals and TPAHs) concentrations.

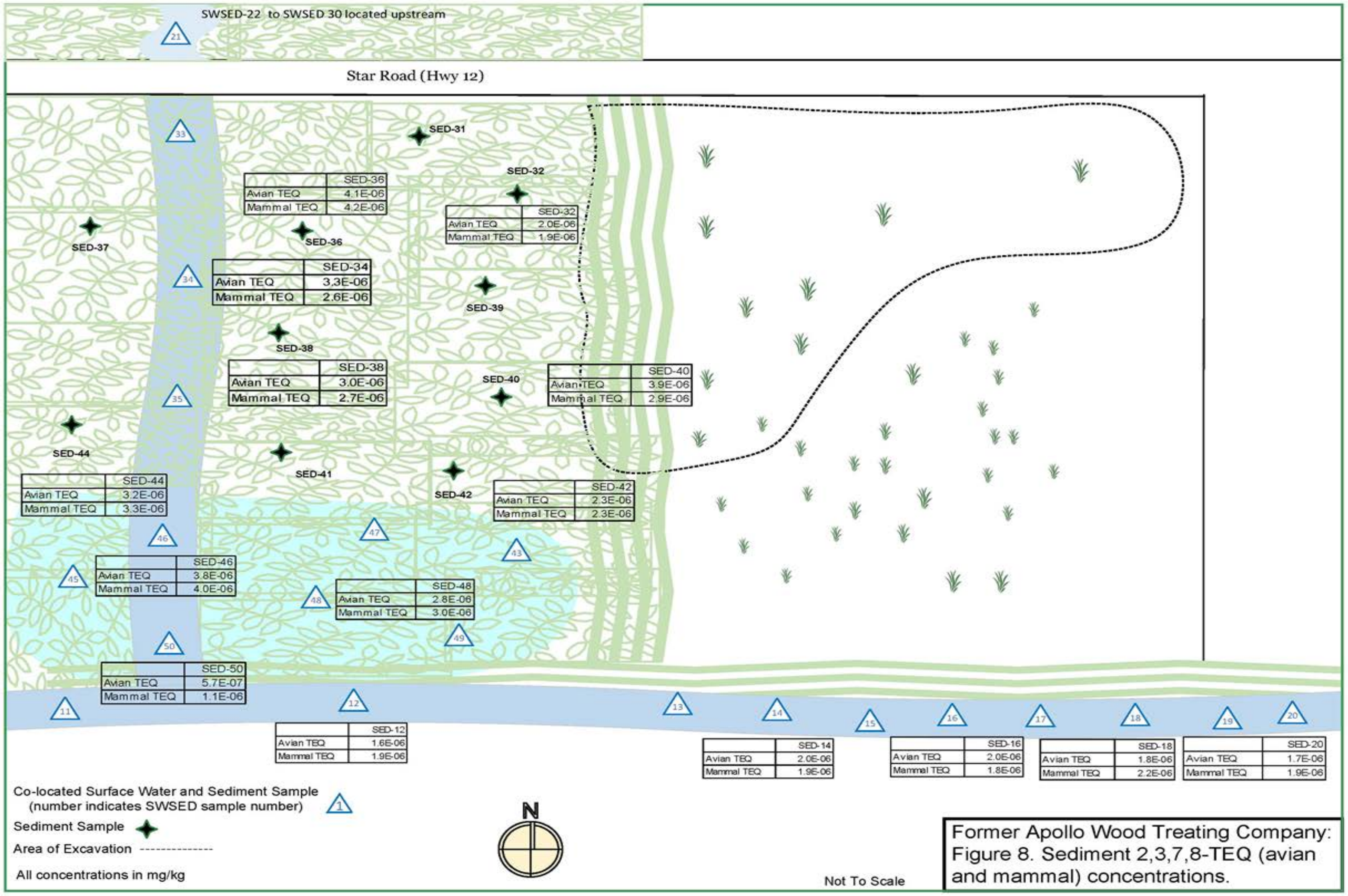

Figure 8. Sediment 2,3,7,8-TEQ (avian and mammal) concentrations.

4.2.2.3 Groundwater-to-Surface Water and Groundwater-to-Sediment

The comparisons of ecological benchmarks to the concentrations of groundwater that are discharging to surface water in Moon Creek are shown in Table 4.

There is limited groundwater data available from the Phase II investigation (i.e., one year and two sampling events). The maximum detected concentration for each COC from the two sampling events and three monitoring wells is used as the exposure point concentration (EPC) in this SLERA. See Figure 3 for locations of the monitoring wells near Moon Creek.

> The person should use the maximum detected concentration from the interface wells for the benchmark screening. For any COC that exceed a benchmark, an EPC can be used. See TRRP-15eco for additional information on EPCs for groundwater, including development of a discharge-weighted groundwater concentration. For simplicity in this case study, the maximum detected groundwater concentrations were used as this is the default approach discussed in TRRP-15eco. One output of the discharge-weighted groundwater exercise is the Q_{gw} (groundwater discharge rate). Q_{gw}, along with surface water flow rate (Q_{sw}), can be used in justification of the groundwater-to-surface water dilution factor.

As described in TRRP-24 (2007), a default dilution factor of 0.15 can be applied for groundwater releases to freshwater streams and rivers where the groundwater discharge is less than 15 percent of the seven-day, two-year low-flow (7Q2). For this site, the contributing groundwater is the shallow groundwater zone and not the more productive deeper groundwater unit, thereby limiting the groundwater discharge into the creek. Moon Creek receives multiple contributions of surface water upstream of the site from urban runoff (e.g., irrigation runoff from lawn care). Further justification of the default dilution factor should normally be presented in the APAR (e.g., groundwater flow and stream flow).

As shown on Table 4, arsenic, copper, chromium, lead, zinc, and several PAHs have maximum detected concentrations greater than their surface water benchmarks, but when the default dilution factor is applied, the values are less than the revised benchmarks. Following this analysis, no COCs for the groundwater-to-surface water pathway are carried forward.

Table 4. Moon Creek groundwater-to-surface water benchmarks screening.

COC	Max Detect (mg/L)	Data Flag	Detections	Freshwater Chronic Benchmark (mg/L)	Benchmark Exceedance Count	Benchmark Adjusted for Dilution (mg/L)	Adjusted Benchmark Exceedance Count
Arsenic	1.7E-01		3/6	1.5E-01	1	1.0E+00	0
Cadmium	1.2E-04	J	2/6	1.9E-04	0	NA	NA
Chromium	8.7E-03		2/6	5.4E-02	0	NA	NA
Copper	4.1E-02		4/6	6.8E-03	4	4.5E-02	0
Lead	4.0E-03		6/6	1.7E-03	4	1.1E-02	0
Zinc	1.6E-01		6/6	8.5E-02	1	5.7E-01	0
Pentachlorophenol	2.1E-04	J	1/6	7.4E-03	0	NA	NA
1-Methynaphthalene	3.9E-03		4/6	2.1E-03	3	1.4E-02	0
2-Methylnaphthalene	7.2E-02		6/6	6.3E-02	1	4.2E-01	0
Acenaphthene	3.8E-02		6/6	2.3E-02	2	1.5E-01	0
Acenaphthylene	1.8E-03		3/6	No benchmark	NA	NA	NA
Anthracene	1.9E-03		6/6	3.0E-04	1	2.0E-03	0
Benz(a)anthracene	5.1E-05	U	0/6	3.5E-02	All ND	NA	All ND
Benzo(a)pyrene	7.9E-05	J	2/6	1.4E-05	6	9.3E-05	0
Benzo(b)fluoranthene	5.0E-05	U	0/6	No benchmark	All ND	NA	All ND
Benzo(g,h,i)perylene	5.9E-05	U	0/6	No benchmark	All ND	NA	All ND
Benzo(k)fluoranthene	6.3E-05	J	1/6	No benchmark	NA	NA	NA
Chrysene	1.1E-03		3/6	7.0E-03	0	NA	NA
Dibenz(a,h)anthracene	5.6E-05	J	1/6	5.0E-03	0	NA	NA
Fluoranthene	4.9E-03		4/6	6.2E-03	0	NA	NA
Fluorene	7.9E-03		5/6	1.1E-02	3	7.3E-02	0
Indeno(1,2,3-cd)pyrene	5.0E-05	U	0/6	No benchmark	All ND	NA	All ND
Naphthalene	1.0E-01		6/6	2.5E-01	0	NA	NA
Phenanthrene	2.1E-02		6/6	3.0E-02	0	NA	NA
Pyrene	6.1E-03		6/6	7.0E-03	0	NA	NA

> See TRRP-24 for additional discussion on the use of dilution factors, including the required justification. The TRRP rule [30 TAC 350.75(i)(4)] states that the person is required to establish PCLs for COCs in groundwater that discharge to surface water. The rule also states that this surface water PCL (^{SW}SW) is the lesser of the human health and ecological surface water risk-based exposure limits (RBELs). The person may establish a surface water dilution factor (*DF*) when the concentration of a COC in groundwater at the zone of discharge to surface water exceeds the ^{SW}SW for any COC at the time the affected property assessment is conducted (with some limitations). The TRRP rule and TRRP-24 provide the equation below to establish the groundwater-to-surface water PCL (^{SW}GW). This equation should be used to adjust the aquatic life RBEL (or surface water PCL) for dilution as the groundwater mixes with the surface water. $^{SW}GW = {}^{SW}SW \div DF$

There is sufficient knowledge about the groundwater-to-surface water pathway to justify no further analysis of the groundwater-to-surface water or groundwater-to-sediment pathways (i.e., ^{SED}GW PCLs are not warranted). The site conceptual model indicates that the groundwater potentially seeps into the sides of Moon Creek and does not up-well into Moon Creek sediments. Additionally, the evaluation of the groundwater showed limited detections of SVOCs and metals, with none above the surface water benchmarks.

> As discussed in TRRP-24, some COCs may persist at acutely toxic concentrations at the groundwater-to-surface water interface and in sediment pore water. Groundwater-to-sediment PCLs (^{Sed}GW) should be developed if conditions indicate that: (1) persistent COCs are present in the groundwater and (2) site conditions indicate that these COCs originating in groundwater could accumulate in the sediment pore water or bulk sediment. TRRP-24 provides the equation to establish the groundwater-to-sediment PCL (^{SED}GW). The person may also choose to sample sediment pore water and bulk sediment in locations that best represent the groundwater as it enters the surface water body in lieu of developing ^{SED}GW PCLs.

4.2.2.4 Wetland Surface Water and Sediment

Table 5 shows the ecological benchmark comparisons for the surface water in the adjacent wetland; Table 6 shows the comparisons for sediment concentrations.

Co-located sediment and surface water samples (SWSED-21 – SWSED-30) were collected from the unnamed creek that flows into the wetland from the north. This upstream area is not associated with site operations. These 10 samples represent upstream contributions of COCs into the wetland.

Five co-located surface water and sediment samples were collected from the unnamed creek within the wetland and another 5 samples were taken from the southern portion of the wetland that was inundated during sampling. An additional 10 sediment samples were taken in the wetland, but inadequate depth (less than two inches at the time of sampling) prevented the collection of acceptable surface water samples from these locations. Figure 3 shows the locations of the wetland samples.

Surface water concentrations and benchmarks for the metals are for the dissolved fraction. Freshwater chronic values are used as benchmarks because the wetland is permanently inundated. As was done for the Moon Creek evaluation, chronic values were adjusted for hardness and pH using the segment-specific hardness of 68 mg/L and pH of 7.1 for Segment 9999, Jupiter Lake.

Table 5 shows the maximum detections from the surface water samples taken upstream and within the wetland compared to freshwater chronic benchmarks. Lead in the upstream samples exceeded the chronic benchmark in two of the samples. The surface water samples collected from the wetland have concentrations exceeding the benchmarks for arsenic, copper, lead, and naphthalene. Surface water benchmarks are not available for several of the PAHs [acenaphthalene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, and indeno(c,d-123)pyrene] and this is discussed further in the Uncertainty Analysis (4.9.2 in this publication).

Table 6 shows additional analysis of the surface water exceedances for arsenic, copper, lead, and naphthalene. An upstream UPL was calculated for arsenic and copper and although there are exceedances of the benchmarks for these two metals, their maximum detected concentrations were below the upstream UPLs. Arsenic and copper are removed as surface water COCs in the wetland.

In November 2015, the three surface water locations with exceedances for lead (SW-34, SW-45 and SW-49) and the one location with an exceedance for naphthalene (SW-49) were resampled. As shown on Table 6, all the detections of these two COCs were below benchmarks. Lead and naphthalene are removed as surface water COCs in the wetland. Following this analysis, there are no surface water COCs in the wetland.

Table 7 shows the maximum sediment concentrations from samples collected in the wetland and upstream. Arsenic and chromium are removed as COCs. Cadmium, copper, zinc, PCP, TPAHs, and 2,3,7,8-TCDD TEQs are retained as COCs for further assessment.

Table 5. Wetland surface water data summary and benchmark screening.

COC	General Location	Maximum Detection (mg/L)	Data Flag	Detections	Freshwater Chronic Benchmark (mg/L)	Benchmark Exceedance Count
Arsenic	Upstream of Wetland	1.86E-01		10/10	1.5E-01	2
Cadmium	Upstream of Wetland	2.7E-04	U	0/10	1.9E-04	All ND
Chromium	Upstream of Wetland	6.3E-04	J	6/10	5.4E-02	0
Copper	Upstream of Wetland	9.7E-02		6/10	6.8E-03	7
Lead	Upstream of Wetland	4.5E-02	J	2/10	1.7E-03	2
Zinc	Upstream of Wetland	5.1E-02		10/10	8.5E-02	0
Pentachlorophenol	Upstream of Wetland	4.6E-05	U	0/10	7.4E-03	All ND
1-Methylnaphthalene	Upstream of Wetland	3.4E-05	U	0/10	2.1E-03	All ND
2-Methylnaphthalene	Upstream of Wetland	3.4E-05	U	0/10	6.3E-02	All ND
Acenaphthene	Upstream of Wetland	4.8E-03	J	2/10	2.3E-02	0
Acenaphthylene	Upstream of Wetland	2.8E-04	J	1/10	No benchmark	NA
Anthracene	Upstream of Wetland	2.0E-05	U	0/10	3.0E-04	All ND
Fluorene	Upstream of Wetland	2.1E-05	U	0/10	1.1E-02	All ND
Naphthalene	Upstream of Wetland	1.7E-01		4/10	2.5E-01	0
Phenanthrene	Upstream of Wetland	6.0E-03	J	4/10	3.0E-02	0
Benz(a)anthracene	Upstream of Wetland	5.9E-03	J	2/10	3.5E-02	0
Benzo(a)pyrene	Upstream of Wetland	3.0E-05	U	0/10	1.4E-05	NA
Benzo(b)fluoranthene	Upstream of Wetland	2.8E-05	U	0/10	No benchmark	All ND
Benzo(g,h,i)perylene	Upstream of Wetland	2.6E-05	U	0/10	No benchmark	All ND
Benzo(k)fluoranthene	Upstream of Wetland	6.9E-04	J	1/10	No benchmark	NA
Chrysene	Upstream of Wetland	4.5E-03		3/10	7.0E-03	0
Dibenz(a,h)anthracene	Upstream of Wetland	2.6E-05	U	0/10	5.0E-03	NA
Fluoranthene	Upstream of Wetland	2.8E-02		4/10	6.2E-03	1
Indeno(1,2,3-cd)pyrene	Upstream of Wetland	5.1E-05	U	0/10	No benchmark	All ND
Pyrene	Upstream of Wetland	2.5E-03		3/10	7.0E-03	0
Arsenic	Within Wetland	1.7E-01		10/10	1.5E-01	2
Cadmium	Within Wetland	2.7E-04	U	0/10	1.9E-04	All ND
Chromium	Within Wetland	8.6E-03		10/10	5.4E-02	0
Copper	Within Wetland	7.3E-02		9/10	6.8E-03	6

COC	General Location	Maximum Detection (mg/L)	Data Flag	Detections	Freshwater Chronic Benchmark (mg/L)	Benchmark Exceedance Count
Lead	Within Wetland	9.6E-03		9/10	1.7E-03	3
Zinc	Within Wetland	6.7E-02		10/10	8.5E-02	0
PCP	Within Wetland	2.4E-04		3/10	7.8E-03	0
1-Methylnaphthalene	Within Wetland	3.4E-05	U	0/10	2.1E-03	All ND
2-Methylnaphthalene	Within Wetland	3.4E-05	U	0/10	6.3E-02	All ND
Acenaphthene	Within Wetland	4.8E-03	J	2/10	2.3E-02	0
Acenaphthylene	Within Wetland	2.1E-05	U	0/10	No benchmark	NA
Anthracene	Within Wetland	2.3E-04	J	3/10	3.0E-04	0
Fluorene	Within Wetland	6.3E-03	J	4/10	1.1E-02	0
Naphthalene	Within Wetland	3.4E-01		6/10	2.5E-01	1
Phenanthrene	Within Wetland	1.0E-02		5/10	3.0E-02	0
Benz(a)anthracene	Within Wetland	6.0E-04	J	2/10	3.5E-02	0
Benzo(a)pyrene	Within Wetland	3.0E-05	U	0/10	1.4E-05	All ND
Benzo(b)fluoranthene	Within Wetland	2.8E-05	U	0/10	No benchmark	All ND
Benzo(g,h,i)perylene	Within Wetland	2.6E-05	U	0/10	No benchmark	All ND
Benzo(k)fluoranthene	Within Wetland	2.8E-05	U	0/10	No benchmark	All ND
Chrysene	Within Wetland	1.7E-03		4/10	7.0E-03	0
Dibenz(a,h)anthracene	Within Wetland	2.6E-05	U	0/10	5.0E-03	All ND
Fluoranthene	Within Wetland	5.8E-03		6/10	6.2E-03	0
Indeno(1,2,3-cd)pyrene	Within Wetland	5.1E-05	U	0/10	No benchmark	All ND
Pyrene	Within Wetland	2.1E-03		3/10	7.0E-03	0

Table 6. Wetland surface water data UPL screening and resampled data.

COC (Sample Date)	Max Detect (mg/L)	Detections	Upstream UPL (mg/L)	Freshwater Chronic Benchmark (mg/L)	Final COC?
Arsenic (8/2015)	1.7E-01	10/10	1.87E-01	1.5E-01	No, max > benchmark, < upstream UPL
Copper (8/2015)	7.3E-02	9/10	9.7E-02	6.8E-03	No, max > benchmark, < upstream UPL
Lead (8/2015)	9.5E-03	9/10	Not Calculated	1.7E-03	See note for 11/2015 lead results.
Lead (11/2015)	1.1E-03	3/3	Not Calculated	1.7E-03	No, following resample, max < benchmark
Naphthalene (8/2015)	3.4E-01	6/10	Not Calculated	2.5E-01	See note for 11/2015 naphthalene results.
Naphthalene (11/2015)	7.4E-02	2/3	Not Calculated	2.5E-01	No, following resample, max < benchmark

Table 7. Wetland sediment data summary and benchmark screening.

COC	General Area	Max Detect (mg/kg)	Data Flags	Detections	Sediment Freshwater Benchmark (mg/kg)	Benchmark Exceedance Count	Retain COC?
Arsenic	Upstream of Wetland	7.54		10/10	9.79	0	NA - upstream of wetland
Cadmium	Upstream of Wetland	0.63		4/10	0.99	0	NA - upstream of wetland
Chromium	Upstream of Wetland	40.8		10/10	43.4	0	NA - upstream of wetland
Copper	Upstream of Wetland	30.3		10/10	31.6	0	NA - upstream of wetland
Lead	Upstream of Wetland	30.8		10/10	35.8	0	NA - upstream of wetland
Zinc	Upstream of Wetland	109		10/10	121	0	NA - upstream of wetland
PCP	Upstream of Wetland	0.0039	U	0/10	1.2	0	NA - upstream of wetland
TPAHs	Upstream of Wetland	3.22		10/10	1.61	7	NA - upstream of wetland
TCDD TEQ (Avian)	Upstream of Wetland	9.0E-07		2/2	NA	NA	NA - upstream of wetland

COC	General Area	Max Detect (mg/kg)	Data Flags	Detections	Sediment Freshwater Benchmark (mg/kg)	Benchmark Exceedance Count	Retain COC?
TCDD TEQ (Mammal)	Upstream of Wetland	9.4E-07		2/2	NA	NA	NA - upstream of wetland
Arsenic	Within Wetland	9.2		20/20	9.79	0	No - max < benchmark
Cadmium	Within Wetland	6.74		16/20	0.99	16	Yes - max > benchmark and upstream, detected bioaccumulative
Chromium	Within Wetland	42.1		20/20	43.4	0	No - max < benchmark
Copper	Within Wetland	203		20/20	31.6	20	Yes - max > benchmark and upstream, detected bioaccumulative
Lead	Within Wetland	33.7		20/20	35.8	0	No - max < benchmark, not bioaccumulative
Zinc	Within Wetland	408		20/20	121	20	Yes - max > benchmark and upstream, detected bioaccumulative
PCP	Within Wetland	1.04		18/20	1.2	0	Yes - detected bioaccumulative, > upstream
TPAHs	Within Wetland	46.14		20/20	1.61	20	Yes - max > benchmark and upstream
TCDD TEQ (Avian)	Within Wetland	4.1E-06		10/10	NA	NA	Yes - detected bioaccumulative, > upstream
TCDD TEQ (Mammal)	Within Wetland	4.2E-06		10/10	NA	NA	Yes - detected bioaccumulative, > upstream

4.2.2.5 Benchmark Screening Summary

Following the conservative benchmark screening, Table 8 shows a summary of the COCs to be carried forward for further analysis.

There were no COCs retained for surface water in the wetlands, Moon Creek, or in the groundwater that discharges to the creek.

Dioxins/furans were not analyzed in the groundwater or surface water samples. This may constitute a data gap, but dioxins/furans are hydrophobic and are expected to partition to sediments.

Table 8. Benchmark screening summary.

COC	On-Site Surface Soil and Off-Site Riparian Surface Soil	On-Site Subsurface Soil	Moon Creek Surface Water	Moon Creek Sediment	Groundwater	Wetland Surface Water	Wetland Sediment
Arsenic	Not retained	Not retained	Not retained	Not retained	Not retained	Retained	Not retained
Cadmium	Not retained	Not retained	Not retained	Retained	Not retained	Retained	Retained
Chromium	Retained	Retained	Not retained	Retained	Not retained	Not retained	Not retained
Copper	Retained	Retained	Not retained	Retained	Not retained	Retained	Retained
Lead	Retained	Retained	Not retained	Retained	Not retained	Retained	Not retained
Zinc	Retained	Retained	Not retained	Retained	Not retained	Not retained	Retained
PCP	Retained	Retained	Not retained	Retained	Not retained	Retained	Retained
Naphthalene	Evaluated as TPAH	Evaluated as TPAH	Not retained	Evaluated as TPAH	Not retained	Retained	Evaluated as TPAH
Chrysene	Evaluated as TPAH	Evaluated as TPAH	Not retained	Evaluated as TPAH	Not retained	Retained	Evaluated as TPAH
Fluoranthene	Evaluated as TPAH	Evaluated as TPAH	Not retained	Evaluated as TPAH	Not retained	Retained	Evaluated as TPAH
Pyrene	Evaluated as TPAH	Evaluated as TPAH	Not retained	Evaluated as TPAH	Not retained	Retained	Evaluated as TPAH
TPAHs	Retained	Retained	Evaluated as individual PAHs	Retained	Evaluated as individual PAHs	Evaluated as individual PAHs	Retained
TCDD TEQ (Avian)	Retained	Retained	Not Analyzed	Retained	Not Analyzed	Not Analyzed	Retained
TCDD TEQ (Mammal)	Retained	Retained	Not Analyzed	Retained	Not Analyzed	Not Analyzed	Retained

4.2.3 Hot Spot Analysis

As described in TRRP-15eco and ERAG, the determination and evaluation of hot spots in ecological habitat should be conducted in a Tier 2 or Tier 3 ERA.

The presence of hot spots at an affected property can be important in the assessment and management of wildlife risks. The purpose of a hot-spot evaluation is to identify any risks to wildlife receptors that would not be determined and mitigated through the standard risk evaluation, which is based on averaging COC concentrations across larger areas (i.e., using a 95 percent UCL as the EPC). Section 2.4.4 in TRRP-15eco provides guidance on procedures for identifying hot spots in soil.

> The person should consider the possibility of hot spots in all site media and present documentation in the SLERA if it is determined that a hot spot analysis would not be relevant for a medium.
>
> Hot spots will differ from site to site. There is no clear process to define hot spots, although numerous strategies and approaches are presented in TRRP-15eco.
>
> It is up to the person to develop a justification for the presence or absence of hot spots.
>
> Because there is a commitment to remove or otherwise negate the complete exposure pathway for those locations defined in the hot spot, identification of a hot spot and subsequent removal (from further risk calculations) of those data within a hot spot should be discussed in the risk management portion of the SLERA
>
> Below are the example hot spot analyses developed for this case study. Note that the tools used to define a hot spot at another site may or may not be like what is presented in this example.

4.2.3.1 Hot Spot Analysis for On-Site Surface Soil

Visual and Spatial Relationships of Sample Locations with Elevated Concentrations - Following an initial review of the surface soil data, it appears that several sample locations near the former treated wood storage area are elevated for one or more COCs. This area was not previously excavated.

Figures 4, 5 and 6 show the spatial distribution of the soil data. Locations SS-12 and SS-13 have the maximum detected results for all the metals and 2,3,7,8-TCDD TEQs. Location SS-20, just south of SS-12, has the maximum detected concentration for PCP. Location SS-19 also has elevated concentrations for copper, lead and zinc and is located south of the area where the maximum detected values are located.

A visual assessment and presentation of the COC concentrations on a map is paramount to a hot spot evaluation (2.4.4.3 in TRRP-15eco).

Visualization of sample locations exhibiting elevated concentrations of COCs can be helpful in determining if these data points are spatially discrete and distinct from surrounding areas, or if the elevated concentrations are grouped together.

Keep in mind that there could be more than one hot spot area at a site, or different hot spots for different COCs.

Statistical Outlier Testing – EPA's ProUCL program was used to evaluate the data set for outliers using all the on-site surface soil data. Table 9 presents the summary of the outlier testing.

The outlier tests indicated that SS-12, SS-13, SS-14, and SS-20 were sample locations with at least one COC outlier.

The TCEQ suggests (but does not require) a statistical outlier test to identify potential hot spots, particularly where there are abundant data.

If statistical outliers are identified and the elevated concentrations can be attributed to an error (e.g., lab or sample collection error, data-entry error, transcription error), the erroneous data should be removed from the data set for determination of the EPC and identification of hot spots.

All statistical outputs (e.g., ProUCL) should be provided as an appendix or attachment to the Tier 2 SLERA.

More guidance regarding the evaluation of outliers appears in Appendix B of TRRP-15eco.

95 Percent UCL and Individual Sample Points Exceeding Default PCLs for Shrew or Robin – Based on the previous two lines of evidence, the clustered sample locations could be a hot spot.

Because the intent of the hot spot analysis is to identify areas of increased exposures to small-ranging receptors, these sample locations were further evaluated against the PCL Database's Average TRV PCLs for the American robin and least shrew. Exceedances of shrew and robin PCLs are considered good indicators of ecological risk because of the sensitivity of these receptors, owing to their small body weights, high ingestion rates, small home ranges, and diets consisting mostly of soil invertebrates.

Table 9 shows the 95 percent UCLs for the remaining COCs for the on-site surface soil data set. None of the UCLs exceeds the lower of the shrew or robin PCLs. However, as indicated by the shaded values in Table 9, there are individual exceedances of the PCLs.

Table 9. Hot spot analysis for on-site surface soil.

COC	95% UCL (mg/kg) - All Surface Soil On-Site Data	Outliers (mg/kg) and Location	Species	Lower of Robin or Shrew Avg TRV PCL (mg/kg)	SS-12	SS-13	SS-14	SS-20
Chromium	80.61	207 (SS-13)	American Robin	289.25	30.90	207.00	1.60	3.60
Copper	13.92	31.2 (SS-13)	American Robin	295.31	19.62	31.20	2.96	16.80
Lead	32.95	231 (SS-12)	American Robin	125.61	231.00	69.00	46.00	16.70
Zinc	104.70	375 (SS-12)	American Robin	163.78	375.00	362.00	196.00	29.78
PCP	2.97	12.3 (SS-20)	Least Shrew	5.80	5.89	5.74	6.98	12.30
TPAHs	11.76	41.1 (SS-14)	American Robin	15.29	20.88	19.33	41.11	10.93
TCDD TEQ (Avian)	9.8E-05	1.2E-04 (SS-12)	American Robin	5.8E-04	1.2E-04	N/A	1.9E-05	5.7E-07
TCDD TEQ (Mammal)	1.0E-04	1.2E-04 (SS-12)	Least Shrew	4.4E-04	1.2E-04	N/A	1.6E-05	1.1E-06

Since all four of the outlier locations are clustered together, thereby potentially increasing the likelihood of risk to small-ranging receptors, it was decided that individual COC concentrations from these locations should also be evaluated against the robin and shrew PCLs, as shown in Table 9.

Sample locations SS-12, SS-13 and SS-14 had concentrations of multiple COCs that exceeded the lower of the Average TRV PCLs; whereas, SS-20 had only PCP that exceeded. This analysis indicates that a small ranging receptor could receive increased exposure in this clustered area that could be masked by use of the 95 percent UCL for the entire site.

Although SS-19 was identified as a potential hot spot location in the visual and spatial analysis, none of the concentrations at SS-19 exceed the Average TRV PCLs for the robin and shrew and therefore SS-19 was removed from the hot spot analysis.

The on-site hot spot is defined by locations SS-12, SS-13, SS-14 and SS-20.

Conclusions of Hot Spot Surface Soil On-Site Analysis – Several types of analyses were performed to identify potential hot spots. These included visual and spatial analyses of elevated concentrations, statistical outlier testing, an analysis of COCs 95 percent UCLs compared to least shrew and robin PCLs, and a comparison of individual sample concentrations to the PCLs.

Based on the weight-of-evidence, locations SS-12, SS-13, SS-14 and SS-20 represent an area of a potential hot spot. Figure 2 shows the outline of the on-site surface soil hot spot.

> Once the hot spot is identified and there is a commitment to remediate the soil, (1) the data from the hot spot can be removed from the surface soil data set from this point forward and (2) revised UCLs can be calculated. See 4.9.3 in this document for additional discussion on the use of proxy concentrations in the data set following removal of the hot spot data.
>
> The remediation of the hot spot is discussed further in section 4.11.1 of this publication (Ecological Risk Management).

4.2.3.2 Hot Spot Analysis for Riparian Surface Soil

There were 10 surface soil samples collected in the riparian areas located along the western side of the site by the wetland (i.e., SS-31 through SS-36) and along the southern side of the site by Moon Creek (i.e., SS-37 through SS-40). Figure 4 shows a spatial distribution of the soil data.

Following an initial review of the surface soil data, it appears that one sample (SS-33) has a chromium concentration (40 mg/kg) that is elevated in relation to the surrounding samples; however, the spatial analysis of the riparian data does not suggest that a hot spot is present. The location of the elevated concentration had previously been excavated and the adjacent sample locations to the north and south are not elevated (i.e., there is not an area of multiple samples clumped together with elevated concentrations).

An evaluation of protected species is presented in 4.3.2.4 and the timber rattlesnake is identified as being potentially present in the riparian area. However, the COC concentrations and their distribution do not indicate an area of concentrated exposure to the snake. Additionally, the riparian habitat does not contain any unique or special habitats that would be specifically attractive to the timber rattlesnake. Further analysis to determine if a hot spot is present in the riparian soils is not needed.

4.2.3.3 Hot Spot Analysis for Moon Creek Sediment

There were 8 sediment samples collected in Moon Creek adjacent to the site and 2 samples collected just downstream of the site (Figure 3). Following an initial review of the sediment data, none of the maximum detected concentrations exceed the default benthic PCLs (see Table 19). Based on a spatial analysis (Figures 7 and 8), no areas of elevated concentrations are identified.

An evaluation of protected species is presented in 4.3.2.4 and the white-faced ibis is identified as potentially present in the creek. Like the riparian habitat, there are no unique features in Moon Creek that would attract the ibis over other areas. Additionally, the home range of the white-faced ibis is almost 3,000 acres, and with no special habitat attractions in the creek adjacent to the site, the white-ibis would be a transient forager.

Further analysis to determine if a hot spot is present in the Moon Creek sediment is not needed.

4.2.3.4 Hot Spot Analysis for Wetland Sediment

There were 20 sediment samples collected in the wetland located west of the site. Following an initial review of the sediment data, cadmium, copper, lead, zinc, PCP, TPAHs, and dioxins/furans are considered COCs in the wetland – either because they are bioaccumulative or are detected at concentrations greater than their benchmarks. Figures 7 and 8 show the data for each sample location and present the spatial distribution of the concentrations.

Like Moon Creek, the white-faced ibis is a protected species that could be found foraging in the wetland. However, there are no indications that the areas with benchmark exceedances would be particularly attractive to the ibis, which would result in concentrated exposure.

Based on the visual evaluation of the data, there are no areas of multiple samples clumped together with elevated concentrations; however, there appears to be a general area of exceedances that is further evaluated through the SLERA process.

Further analysis to determine if a hot spot is present in the wetland sediment is not needed.

4.3 Exposure Pathway Analysis (Required Element 2)

The second required element of the Tier 2 SLERA is the identification of communities, feeding guilds, and representative species that might be supported by habitats on the affected property (30 TAC 350.77(c)(2)).

4.3.1 Communities

For this site, communities consist of soil invertebrates, terrestrial vegetation, benthic invertebrates, and aquatic life. COCs that exceed ecological (community-level) benchmarks but do not subsequently prove to be a risk to higher-trophic-level receptors may still harm these community-level receptors. Tables 1-6 show the COCs that exceed community benchmarks and Table 9 summarizes the COCs by media.

> Ecological communities are collections of plant and animal populations occupying the same habitat in which the various species interact with one another (see **6.1** in ERAG). Communities refer to those groups whose exposure to COCs can be evaluated in terms of the media in which they reside.
>
> Communities are not included in the wildlife-oriented PCL Database.
>
> To address this required element under TRRP, an evaluation of relevant communities must be completed for the benthic and aquatic life communities within the SLERA. See 2.3 in TRRP-15eco for a discussion on plant and soil invertebrate communities.

4.3.2 Feeding Guilds, Food Webs, and Representative Species

The affected property contains several habitats and a variety of associated species. The terrestrial habitat on-site is primarily upland, characterized by scattered grasses, weeds, and shrubs. A riparian habitat exists in the buffer area between the terrestrial habitat and Moon Creek—a perennial freshwater creek. The wetland represents a different type of aquatic habitat from Moon Creek.

Using the PCL Database, two primary habitats can be accessed to represent these varied habitats: Minor Habitat-Terrestrial and Freshwater Systems.

As described in ERAG **6.2**, the term *feeding guilds* refers to broad groups of related ecological receptors (e.g., piscivorous birds) that represent the variety of species potentially exposed to COCs at the affected property. Feeding guilds are based on a shared feeding strategy, similar potential for exposure, and physiological or taxonomic similarity.

Identification of these feeding guilds collectively defines the food webs specific to potentially affected habitats for evaluation in the risk assessment. Both ERAG and the PCL Database contain food webs for the seven major habitats identified in Texas. These food webs depict the feeding guilds that comprise them and the trophic levels they occupy.

As described in Section 4.3.2.1, not every species listed in a PCL Database habitat is present at every site or needs to be evaluated. For example, there are three shrews listed in the Minor Habitat-Terrestrial: least shrew, desert shrew, and southern short-tailed shrew, but only the least shrew is appropriate for this SLERA based on the location of the site in the state. Site-specific modifications to the species listed in the Minor Habitat-Terrestrial and Freshwater Systems Habitat are discussed in Sections 4.3.2.1 and 4.3.2.2.

If a species is removed from a specific habitat assessment, particularly if it has been known to be a risk driver (e.g., robin, shrew), justification needs to be provided in the SLERA.

4.3.2.1 Minor Habitat–Terrestrial

The site is in an industrial area, next to an active commercial property. The terrestrial portion of the site is sizable (10 acres), but its scattered grasses, weeds, and shrubs cannot be easily categorized among the five major terrestrial habitats. Therefore, application of Minor Habitat - Terrestrial is appropriate for characterizing this area.

Minor Habitat-Terrestrial is discussed in **6.2.3** in ERAG and is also presented in the PCL Database. The individual species in the PCL Database that are supported by this habitat can be found by clicking on the "Habitat" tab and then clicking on the relevant arrow under the "Associated Species" column.

Exhibit 1 is a screenshot from the PCL Database that identifies the species in the Minor Habitat-Terrestrial. If, for example, the site included a small stock tank that became impacted, it would be appropriate to use the Minor Habitat-Aquatic species for the tank.

All the species listed in Minor Habitat-Terrestrial were evaluated in this SLERA except for the desert shrew, the southern short-tailed shrew, and the white-footed mouse. Based on the location of the site in the state, only the least shrew is applicable. Both the white-footed mouse and the deer mouse are present at the site and have the same dietary composition (60 percent vegetation, 40 percent arthropods). However, the white-footed mouse was removed as a receptor because of its greater body weight.

The feeding guilds represented are: herbivorous birds and mammals (e.g., mourning dove and eastern cottontail), omnivorous birds and mammals (e.g., American robin and least shrew), and carnivorous birds, mammals, and reptiles (e.g., red-tailed hawk, red fox, and Texas rat snake). Thirty on-site surface soil samples were used to assess these feeding guilds.

Because armadillo burrows were found on-site, and contaminated subsurface soil is present, the nine-banded armadillo is evaluated for exposure to surface and subsurface soil in this SLERA. Ten subsurface (0.5–5 feet bgs) soil samples (a subset of the 30 on-site surface soil samples) were collected and used to generate a 95 percent UCL. This 95 percent was compared to the 95 percent UCL generated from surface soil data and the higher of the two was used as the EPC for the armadillo's exposure.

> See **6.6.4** in ERAG for additional information on burrowing receptors and collection of subsurface soil samples.

Assoc. Species	Habitat Name	Habitat ID	Description
▶	DESERT-ARID	DESERT-ARID	Vegetative cover is predominantly semi-desert grassland and arid shrubland, except for high elevation islands of oak, juniper, and pinyon pine woodland. Example: Trans Pecos area.
▶	ESTUARINE SYSTEMS	ESTUARINE SYSTEMS	Saline and brackish wetlands are complex and highly productive ecosystems, containing a variety of plant and animal species that are specially adapted to fluctuations in salinity, water levels, and seasonal temperatures and can include saltwater marshes, sand flats, sandy sea shores, mangrove swamps, and barrier islands. Example: Gulf Coast region.
▶	FRESHWATER SYSTEMS	FRESHWATER SYSTEMS	Encompasses a wide variety of aquatic habitats including rivers, creeks, swamps, marshes, bogs, and flood plains. Many protected species utilize wetland habitat, and most species of amphibians are dependent on sources of water (such as wetlands) for reproductive success. Example: Riparian areas throughout the State.
▶	MINOR	MINOR	Fragmented ecological habitat or isolated island-like areas that cannot easily be categorized among the seven major habitats (e.g., an unmaintained grassy area adjacent to a laydown yard or a small, man-made stock pond). Included species are representative of a variety of feeding guilds and are useful for generalized PCL analysis.
▶	MINOR HABITAT - AQUATIC	MINOR AQUATIC	A subset of the MINOR habitat containing only aquatic organisms.
▼	MINOR HABITAT - TERRESTRIAL	MINOR TERRESTRIAL	A subset of the MINOR habitat containing only terrestrial organisms.

AMERICAN ROBIN (TR)	AMERICAN WOODCOCK (TR)	BOBWHITE QUAIL (TR)	DEER MOUSE (TR)	DESERT SHREW (TR)	EASTERN COTTONTAIL (TR)
LEAST SHREW (TR)	MOURNING DOVE (TR)	NINE-BANDED ARMADILLO (TR)	NORTHERN CARDINAL (TR)	RACCOON TERRESTRIAL (TR)	RED FOX (TR)
RED-TAILED HAWK (TR)	SOUTHERN SHORT-TAILED SHREW (TR)	TEXAS RAT SNAKE (TR)	VIRGINIA OPOSSUM (TR)	WHITE FOOTED MOUSE (TR)	

Assoc. Species	Habitat Name	Habitat ID	Description
▶	SHORTGRASS PRAIRIE	SHORTGRASS PRAIRIE	Native shortgrass prairie features blue grama, buffalograss, and fringed sage, and mixed grass areas; also includes sandsage prairies and Shinnery sands areas. One of the most remarkable ecological features in this habitat is playas - ephemeral freshwater shallow circular-shaped wetlands, most more than 15 acres in size that are primarily filled by rainfall. Example: Texas High Plains.
▶	SHRUB/SCRUB	SHRUB/SCRUB	Characterized by individual woody plants generally less than 9ft tall scattered throughout semi-arid regions with less than 30 percent woody canopy cover. The expansion of Ashe juniper (cedar) has had a tremendous impact on the ecosystem, causing a decrease in plant species diversity and an increase in soil erosion. Example: Texas Hill Country.

Exhibit 1. PCL Database screenshot - Minor Habitat Terrestrial.

4.3.2.2 Freshwater Systems Habitat

Because of the diversity of species and the perennial nature of both Moon Creek and the wetland, it is appropriate to apply the Freshwater Systems Habitat from the PCL Database. The riparian area of this habitat is assessed using the terrestrial species associated with Freshwater Systems.

> As described in **6.2.1** in ERAG, the Freshwater Systems Habitat encompasses wetlands, rivers, creeks, swamps, bogs, and floodplains and therefore this habitat and its receptors are applicable to Moon Creek, the adjacent wetland, and riparian areas.
>
> The Freshwater Systems Habitat contains species that are found in aquatic settings, but also species that occupy the riparian or fringe area and are considered terrestrial (e.g., least shrew).
>
> The PCL Database differentiates between these receptors based on their primary sources of food and ingested media. As shown by the screenshot in Exhibit 2, receptors that derive their food (and any incidental medium ingestion) from soil are identified with the two-character field "TR" (terrestrial) that appears at the end of the receptor's name [e.g., American Robin (TR)]. Similarly, if the receptor's food (and medium ingestion) is based on sediment, "AQ" (aquatic) appears at the end of its name [e.g., Spotted Sandpiper (AQ)]. Therefore, COC concentrations in sediment collected from Moon Creek and the wetland would be evaluated for potential risk to the aquatic-based receptors and soil samples collected from the riparian areas would be evaluated for risk to the terrestrial-based receptors. Also see **2.9** and **6.2.3** in ERAG.

Moon Creek and Wetland – Moon Creek and the wetland area are aquatic freshwater habitats and their sediments are appropriately evaluated using the Freshwater Systems Habitat in the PCL Database. The feeding guilds represented are: herbivorous birds and mammals (e.g., red-winged blackbird and swamp rabbit), omnivorous birds and mammals (e.g., American wigeon and raccoon-aquatic), and carnivorous birds, mammals, and reptiles (e.g., kestrel, mink, and plain-bellied water snake).

For Moon Creek, all but eight of the aquatic species listed in the Freshwater Systems Habitat were evaluated in this SLERA. The American alligator, bald eagle and osprey were not included as they require large fish as prey which are not present in Moon Creek. The snow goose and Canada goose were eliminated and the American wigeon was used to represent an herbivorous bird. The snow goose and Canada goose are larger birds with larger home ranges than the wigeon. The eastern least tern was removed because it prefers coastal habitats. The great blue heron was eliminated because the snowy egret has the same dietary composition (100 percent fish) and a much lower body weight. Also, there are several other heron species included (green heron, yellow-crowned night heron, and black-crowned night heron). Protected species including the bald eagle, whooping crane and interior least tern were eliminated as potentially present because the available habitat does not meet species requirements. See section 4.3.2.4 in this publication for additional discussion on protected species in Sunny County.

For the wetland, all the species eliminated in the Moon Creek assessment were eliminated from the wetland for the same reasons (described in the preceding paragraph). In addition, because the wetland did not provide water at a sufficient depth for foraging (less than two inches at the time of sampling), the belted kingfisher was removed as a receptor. All other aquatic species listed in Freshwater Systems Habitat were evaluated in this SLERA.

Riparian Areas – The riparian areas are transitional areas between the terrestrial uplands and the freshwater habitats in the wetland and Moon Creek. This habitat was evaluated using the Freshwater Systems Habitat in the PCL Database but focused on the soil-based exposure.

The feeding guilds represented are: herbivorous mammals (e.g., eastern cottontail), omnivorous birds and mammals (e.g., American robin and least shrew), and carnivorous birds, mammals, and reptiles (e.g., American kestrel, red fox, and timber rattlesnake).

All the terrestrial-based species listed in the Freshwater Systems Habitat were evaluated in this SLERA except for the bobcat, coyote, southern short-tailed shrew, common yellow throat, and northern harrier. The American kestrel has a smaller body weight, and smaller home range than the northern harrier, and therefore the American kestrel is retained as a carnivorous bird. Carnivorous mammals are represented by the red fox and evaluation of the bobcat and coyote would be redundant. Based on the location of the site in the state, of the two shrews listed in the Freshwater Systems Habitat-aquatic, only the least shrew is applicable.

Assoc. Species	Habitat Name	Habitat ID	Description
	DESERT-ARID	DESERT-ARID	Vegetative cover is predominantly semi-desert grassland and arid shrubland, except for high elevation islands of oak, juniper, and pinyon pine woodland. Example: Trans Pecos area.
	ESTUARINE SYSTEMS	ESTUARINE SYSTEMS	Saline and brackish wetlands are complex and highly productive ecosystems, containing a variety of plant and animal species that are specially adapted to fluctuations in salinity, water levels, and seasonal temperatures and can include saltwater marshes, sand flats, sandy sea shores, mangrove swamps, and barrier islands. Example: Gulf Coast region.
	FRESHWATER SYSTEMS	FRESHWATER SYSTEMS	Encompasses a wide variety of aquatic habitats including rivers, creeks, swamps, marshes, bogs, and flood plains. Many protected species utilize wetland habitat, and most species of amphibians are dependent on sources of water (such as wetlands) for reproductive success. Example: Riparian areas throughout the State.

AMERICAN ALLIGATOR (AQ)	AMERICAN KESTREL (TR)	AMERICAN MINK (AQ)	AMERICAN ROBIN (TR)	AMERICAN WIGEON (AQ)	AMERICAN WOODCOCK (TR)
BALD EAGLE (AQ)	BELTED KINGFISHER (AQ)	BLACK CROWNED NIGHT HERON (AQ)	BOBCAT (TR)	CANADA GOOSE (AQ)	COMMON YELLOW THROAT (TR)
COTTON MOUSE (TR)	COTTONMOUTH WATER MOCASSIN (AQ)	COYOTE (TR)	EASTERN COTTONTAIL (TR)	EASTERN LEAST TERN (AQ)	GREAT BLUE HERON (AQ)
GREEN HERON (AQ)	INTERIOR LEAST TERN (AQ)	LEAST SHREW (TR)	MALLARD (AQ)	MARSH RICE RAT (AQ)	MARSH WREN (AQ)
MUSKRAT (AQ)	NORTHERN HARRIER (TR)	OSPREY (AQ)	PLAIN-BELLIED WATER SNAKE (AQ)	RACCOON SEMI-AQUATIC (AQ)	RED FOX (TR)
RED WINGED BLACKBIRD (AQ)	SNAPPING TURTLE (AQ)	SNOW GOOSE (AQ)	SNOWY EGRET (AQ)	SOUTHERN SHORT-TAILED SHREW (TR)	SPINY SOFT SHELL TURTLE (AQ)
SPOTTED SANDPIPER (AQ)	SWAMP RABBIT (AQ)	TIMBER RATTLESNAKE (TR)	VIRGINIA OPOSSUM (TR)	WHITE FACED IBIS (AQ)	WHOOPING CRANE (AQ)
YELLOW CROWNED NIGHT HERON (AQ)	YELLOW MUD TURTLE (AQ)				

	MINOR	MINOR	Fragmented ecological habitat or isolated island-like areas that cannot easily be categorized among the seven major habitats (e.g., an unmaintained grassy area adjacent to a laydown yard or a small, man-made stock pond). Included species are representative of a variety of feeding guilds and are useful for generalized PCL analysis.
	MINOR HABITAT - AQUATIC	MINOR AQUATIC	A subset of the MINOR habitat containing only aquatic organisms.
	MINOR HABITAT - TERRESTRIAL	MINOR TERRESTRIAL	A subset of the MINOR habitat containing only terrestrial organisms.
	SHORTGRASS PRAIRIE	SHORTGRASS PRAIRIE	Native shortgrass prairie features blue grama, buffalograss, and fringed sage, and mixed grass areas; also includes sandsage prairies and Shinnery sands areas. One of the most remarkable ecological features in this habitat is playas - ephemeral freshwater shallow circular-shaped wetlands, most more than 15 acres in size that are primarily filled by rainfall. Example: Texas High Plains.

Exhibit 2. PCL Database screenshot - Freshwater Systems Habitat.

4.3.2.3 Reptiles and Amphibians

The site could provide habitat for reptiles such as snakes, lizards, and turtles, including special status species such as the timber rattlesnake (see Section 4.3.2.4 of this publication).

The assessment of risk to reptiles from exposure to COCs in sediment, surface water, and soil is highly uncertain. Note that the:

- Minor Habitat- Terrestrial includes the Texas rat snake.
- Freshwater Systems Habitat includes the snapping turtle, cottonmouth water moccasin, timber rattlesnake, plain-bellied water snake, spiny softshell turtle, and the yellow mud turtle as aquatic receptors; it includes the timber rattlesnake as a terrestrial receptor potentially present in the riparian area.

Amphibians could travel between the aquatic and terrestrial habitats at the site. The life-history requirements of amphibians potentially expose this group to contaminants in surface water, sediments, and soils at various intensities, depending on developmental stage and the life history unique to each species.

In addition to their unique life history, the physiological properties of amphibians heighten their exposure to contaminants in the environment. Amphibians are exposed to contaminants through the direct uptake from water and substrate as well as the ingestion of sediments, soils, and food items. The skin of amphibians is thin and highly permeable serving as part of the respiratory system. This permeability maintains the organisms balance in nature, but also creates a route for the potential for uptake and intensifies the risk of contaminant exposure to amphibians by permitting chemical transport across membranes.

> Typically, birds and mammals dominate risk assessments for aquatic-based wildlife receptors.
>
> A qualitative or quantitative evaluation of risks to amphibians and reptiles, depending on available toxicological and life-history information, should also be included in the ERA if they are expected to occur at the affected property.
>
> Amphibians and reptiles that are commonly found in Texas may include sensitive and representative species that may frequent areas where they may be exposed to COCs in sediments.
>
> A more rigorous evaluation is required where a protected reptile or amphibian species may occur at the affected property.

4.3.2.4 Protected Species

The federal and state-listed species for Sunny County are presented in the table below. The TPWD maintains a database of species potentially present in all the counties in Texas at <tpwd.texas.gov/gis/rtest/>. Table 10 presents the habitat requirements of the protected species and includes a determination of the potential presence of that species at the site. This evaluation concludes that the timber (canebrake) rattlesnake and white-faced ibis could be present at or around the site and therefore are included as potential receptors in the SLERA.

Table 10. Federal and state-listed species within Sunny County.

Species[4]	**Species Category**	**Listing Status**[5]	**Associated Habitat**	**Potentially on Affected Property?**
American Peregrine falcon (*Falco peregrinus anatum*)	Bird	ST	Nests in tall cliff eyries; winters along coast and farther south; occupies wide range of habitats during migration including urban and lake shores.	No – site habitat does not correspond to species requirements
Bald Eagle (*Haliaeetus leucocephalus*)	Bird	ST	In Texas, preferred nesting habitat is along river systems, or within 1-2 miles of some other large water body. Fish is the primary food, but also prey on waterfowl, turtles, small mammals, and carrion (TPWD, 2018a).	No – Moon Creek does not represent a body of water of suitable size.
Interior Least Tern (*Sterna antillarum athalassos*)	Bird	FE, SE	Prefers open habitat and avoids thick vegetation and narrow beaches. Sand and gravel bars within a wide unobstructed river channel or open flats along lake shorelines provide favorable nesting habitat (TPWD, 2018b).	No – habitat does not correspond to species requirements
White-faced Ibis (*Plegadis chihi*)	Bird	ST	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will visit brackish and saltwater habitats, nests in marshes in low trees on the ground in bulrushes or reeds or on floating mats.	Yes – freshwater wetland and edges of Moon Creek could be attractive to this species
White-tailed Hawk (*Buteo albicaudatus*)	Bird	ST	Found near coast on prairies, cordgrass flats and scrub-live oak. Further inland it is found on prairies, mesquite, and oak savannahs.	No – fragmented habitat, industrial area. No prairies at site.
Whooping crane (*Grus americana*)	Bird	FE, SE	Potential migrant via plains throughout most of state to coast; winters in coastal marshes of Aransas, Calhoun, and Refugio counties.	No – fragmented habitat, site area not coastal. Potentially infrequent migrant.
Wood Stork (*Mycteria americana*)	Bird	ST	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt water. Breeds in Mexico and moves into Gulf states in search of mud flats and other wetlands.	No – insufficient habitat to support colony. No large trees or woody wetlands to support nesting.

[4] Species in bold text were determined to be possibly present and were evaluated in the SLERA.
[5] **FE** – Federally listed, endangered: species in danger of extinction throughout a significant portion of its range; **FT** – Federally listed, threatened: species likely to become endangered within the foreseeable future; **SE** – State listed, endangered; **ST** – State listed, threatened

Species[4]	**Species Category**	**Listing Status**[5]	**Associated Habitat**	**Potentially on Affected Property?**
Louisiana Black Bear (*Ursus americanus luteolus*)	Mammal	ST	Possible transient, bottomland hardwoods and large tracts of inaccessible forested areas.	No – site is urban and not large enough to attract this species.
Red wolf (*Canis rufus*)	Mammal	FE/SE	Extirpated	No – extirpated
Alligator snapping turtle (*Macrochelys temminckii*)	Reptile	ST	Perennial water bodies; deep water of rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near deep running water; usually in water with mud bottom and abundant aquatic vegetation; may migrate several miles along rivers	No – Moon Creek is perennial, but not deep (< 3 feet except after rain events). Limited aquatic vegetation.
Timber Rattlesnake (*Crotalus horridus*)	Reptile	ST	Species found in swamps, floodplains, upland pine, and deciduous woodlands. Prefers dense ground cover.	Yes – Moon Creek riparian area may provide habitat attractive to this species.
Texas pigtoe (*Fusconaia askewi*)	Mollusk	ST	Rivers with mixed mud, sand, and fine gravel in protected areas associated with fallen trees or other structures; east Texas River basins, Sabine through Trinity rivers as well as San Jacinto River	No – Moon Creek is a small creek with insufficient flow to support this species.
Sandbank pocketbook (*Lampsilis satura*)	Mollusk	ST	Small to large rivers with moderate flows and swift current on gravel, gravel-sand, and sand bottoms; east Texas, Sulfur south through San Jacinto River basins; Neches River	No – Moon Creek is a small creek with insufficient flow to support this species.

4.3.3 Assessment Endpoints

Assessment endpoints are "explicit expressions of the actual environmental value to be protected" (U.S EPA, 1997). If these endpoints are found to be significantly affected, they can trigger further action. See **6.3** in ERAG for a discussion on assessment endpoints. The assessment endpoints for the affected property are:

- Protection of wildlife, including protected species, with no unacceptable risk to species diversity and abundance (and viable reproduction) due to COCs in soils, sediment, and surface water.
- Protection of the benthic invertebrate community, including protected species in Moon Creek and the wetland, with no unacceptable risk to species diversity due to site-related COCs.
- Protection of the aquatic life community in Moon Creek and the wetland, with no unacceptable risk to species diversity due to site-related COCs.

4.4 Conceptual Site Model (Required Element 3)

Development of a CSM is required element 3. A CSM for the affected property is presented as Figure 9. This CSM illustrates the potential contaminant sources, release mechanisms, transport pathways, exposure media, and receptors considered for the SLERA.

As shown in Figure 9, the primary, and initial, sources were the industrial wood treating activities and the unlined pits and ponds. The primary release mechanisms included discharges, leaks, spills, overflow of the pits and pond, and general surface runoff.

The secondary source media are soil, sediment, surface water, and groundwater. The pathways for migration for the COCs is both physical (discharge from groundwater to surface water) and biological (uptake into biota consumed by other ecological receptors).

The exposure media evaluated in the CSM include ambient air, surface soil, subsurface soil, sediments in the creek and wetland, and surface water. Exposure routes include inhalation, ingestion, dermal contact, and ingestion of food.

Potential receptors include the terrestrial plant and soil invertebrate communities, reptiles, birds, mammals, water column community, benthic community, and amphibians.

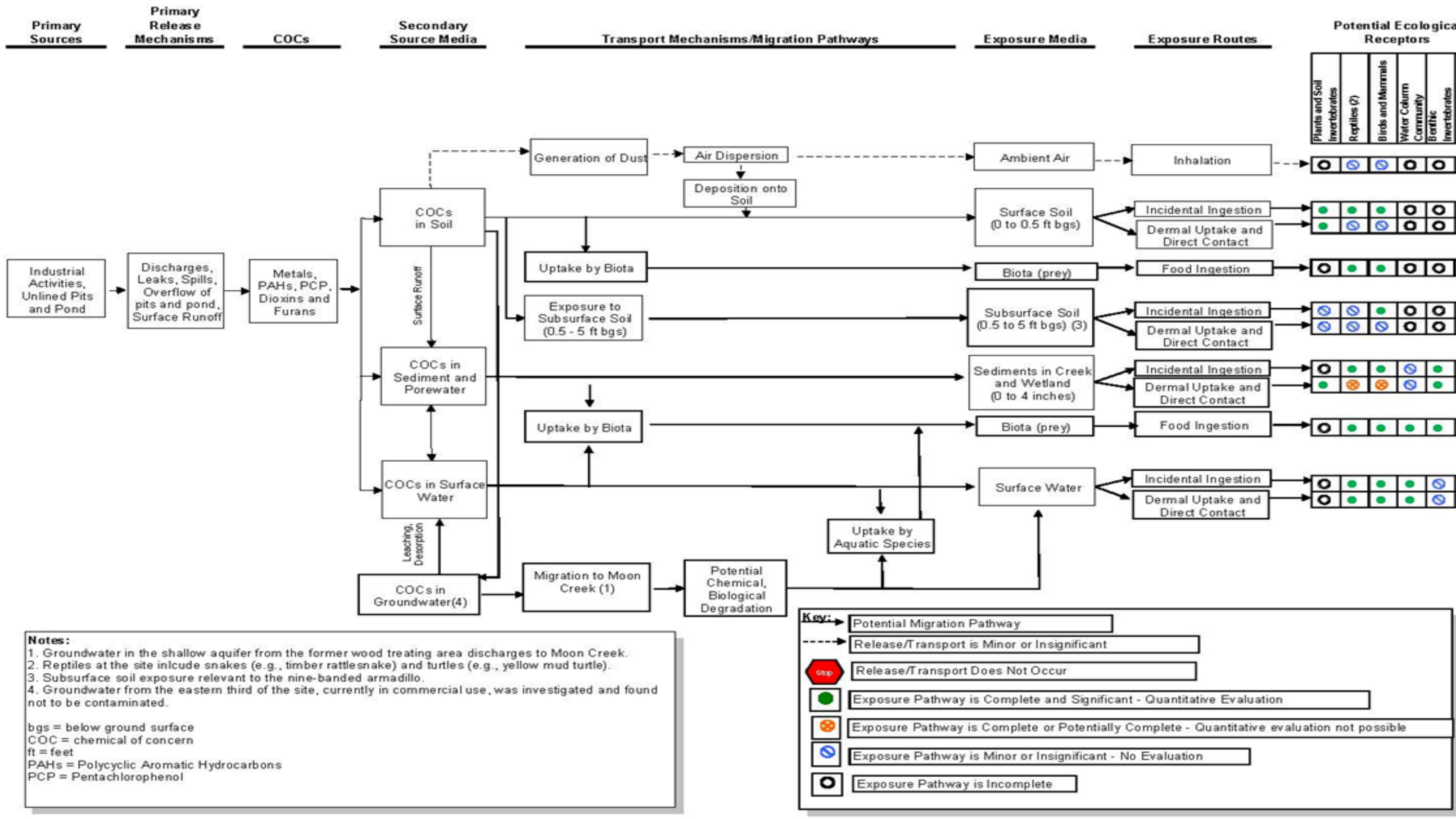

Figure 9. Former Apollo Wood Treating Company: Ecological conceputal site model.

Figure 9. Ecological conceptual site model.

4.5 Fate and Transport, Toxicological Profiles (Required Element 4)

Potential fate and transport mechanisms for the COCs at this site appear in the chemical profiles found in the PCL Database.

> If a COC is not included in the PCL Database, a discussion of the fate and transport properties should be provided. If there are site-related attributes that may influence the fate and transport properties of COCs, these should also be presented in the SLERA.

4.6 Receptor Effect Levels (Required Element 5)

TRVs are exposure concentrations that represents a conservative threshold for adverse ecological effects or no effects. Because a no observed adverse effect level (NOAEL) represents a concentration at which no adverse effects are noted, it is the preferred TRV in developing conservative screening values.

For this SLERA, both NOAELs and lowest observed adverse effect level (LOAELs) are required per ERAG. The PCL Database provides TRVs and documentation of the original sources.

4.6.1 TRVs for Birds and Mammals

The avian and mammalian TRVs used in this SLERA were taken directly from the PCL Database without any manipulations. These TRVs were associated with those receptors from the Freshwater Systems and Minor Terrestrial Habitats.

As discussed in **9.2.2** in ERAG, TRVs for wildlife are available from the PCL Database and follow a standard methodology for development.

Find TRVs in the PCL Database by going to the "PCL Calculator" page and choosing the "Chemicals" tab toward the top of the page (not the drop-down menu under Step 2). Find the COC under the "Chemical Name" column on the left side of the screen. Click on the CAS number of the COC of interest and wait for the PDF chemical profile to appear. The TRVs, and their derivation and basis for selection, are provided at the end of the chemical profile.

If a TRV for a site COC and receptor pair is not available, the person should search the open literature and follow the selection criteria in **9.2.2** of ERAG.

4.6.2 TRVs for Reptiles and Amphibians

The site could provide habitat for reptiles such as snakes, lizards, and turtles, including special status species such as the timber rattlesnake in the riparian areas. TRVs for reptiles based on ingestion studies are currently limited to lead (Salice et al., 2009) with the fence lizard as the test species. As discussed in detail in 4.8.1.2, if a reptile-based TRV was not available for assessment of reptiles, an avian TRV was applied but adjusted by a factor of 10 for uncertainty.

For amphibians potentially present at the site, the numeric water quality criteria and the ecological benchmarks specified in Supporting Documentation for the TCEQ's Ecological Benchmark Tables and accompanying excel tables (TCEQ Publication RG-263b) are assumed to be protective.

If a protected amphibian species could be exposed to a COC that **does not** have a state-adopted or federal surface water criterion, the person should further evaluate potential risk to that species through effects data from the open literature using amphibians as the test species or applying an uncertainty factor of 0.1 to the existing LC_{50}-based benchmark.

See **9.2.3.1** and **9.2.3.2** in ERAG and 4.3.1 of TRRP-15eco for discussions on health-effects data for reptiles and amphibians. Note that amphibians can be exposed to sediment, depending on site conditions and species, particularly where sediment COCs may partition to surface water.

4.7 Exposure Assessment (Required Element 5 Cont.)

Effect levels (e.g., NOAEL TRV, tissue-residue effect concentrations) are also addressed in required element 5 and are discussed in **9** of ERAG. This text also discusses exposure variables such as uptake factors of COCs into food items, ingestion rates, and exposure modifying factors. How bioavailability can be incorporated into a SLERA is discussed, as well as specific information on special COC classes (e.g., metals, dioxins/furans, PAHs, explosives, radionuclides, and emerging contaminants).

4.7.1 Exposure Point Concentrations

Following analysis and determination of the soil hot spot, the data were reevaluated and a revised 95 percent UCL was calculated to carry forward into the SLERA.

Table 11 shows the summary statistics for each medium. Note that surface water and groundwater COCs are not represented in this table since these COCs were screened out in required element 1 (benchmark screening). Summary statistics were developed using EPA's ProUCL program. EPA's most recent ProUCL version software program (Version 5.1.002) was used to calculate the 95 percent UCL concentrations for the COCs. The ProUCL output can be found in a separate Excel spreadsheet on the TCEQ ERA website at: <www.tceq.texas.gov/remediation/eco/eco.html>. Both detected and non-detected values were represented in the calculations using the methods described in ProUCL.

Data from the riparian areas (Figure 2) associated with the wetland and Moon Creek were combined so that a 95 percent UCL could be calculated. The UCL recommended by the ProUCL program was used as the 95 percent UCL for this SLERA.

If more than one UCL is listed as "suggested UCL to use" then the highest concentration was chosen. The lower of the maximum detected concentration and the 95 percent UCL is considered the EPC for the exposure area.

Table 11. Summary statistics of COCs.

COC	Media and General Area	Max Detect (mg/kg)	Detections	95% UCL[6] (mg/kg)	EPC (mg/kg)
Chromium	Surface Soil On-Site (hot spot removal assumed)	22	25/26	11.98	11.98
Copper	Surface Soil On-Site (hot spot removal assumed)	24.9	26/26	6.11	6.11
Lead	Surface Soil On-Site (hot spot removal assumed)	52	26/26	13.57	13.57
Zinc	Surface Soil On-Site (hot spot removal assumed)	127	26/26	61.15	61.15
PCP	Surface Soil On-Site (hot spot removal assumed)	2.3	11/26	0.808	0.808
TPAHs	Surface Soil On-Site (hot spot removal assumed)	30.76	26/26	7.01	7.01
TCDD TEQ (Avian)	Surface Soil On-Site (hot spot removal assumed)	1.2E-06	10/10	8.5E-07	8.5E-07
TCDD TEQ (Mammal)	Surface Soil On-Site (hot spot removal assumed)	1.9E-06	10/10	1.4E-06	1.4E-06
Chromium	Subsurface Soil On-Site	35	10/10	27.49	27.49
Copper	Subsurface Soil On-Site	29	10/10	13.75	13.75
Lead	Subsurface Soil On-Site	26	10/10	19.92	19.92
Zinc	Subsurface Soil On-Site	132	10/10	97.25	97.25
PCP	Subsurface Soil On-Site	0.0069	2/10	NA	0.0069
TPAHs	Subsurface Soil On-Site	15.12	10/10	8.86	8.86
TCDD TEQ (Avian)	Subsurface Soil On-Site	1.5E-06	4/4	NA	1.5E-06
TCDD TEQ (Mammal)	Subsurface Soil On-Site	1.0E-06	4/4	NA	1.0E-06
Chromium	Surface Soil Off-Site Riparian	98	10/10	28.81	28.81

[6] See EPC ProUCL Output Excel file for more information on the suggested 95% UCL and other statistical information. The EPC is the lower of the maximum detected concentration and the 95% UCL.

COC	Media and General Area	Max Detect (mg/kg)	Detections	95% UCL[6] (mg/kg)	EPC (mg/kg)
Copper	Surface Soil Off-Site Riparian	30	10/10	24.44	24.44
Lead	Surface Soil Off-Site Riparian	62.8	10/10	40.41	40.41
Zinc	Surface Soil Off-Site Riparian	119	10/10	91.34	91.34
PCP	Surface Soil Off-Site Riparian	0.0091	8/10	0.00764	0.00764
TPAHs	Surface Soil Off-Site Riparian	3.80	10/10	3.10	3.10
TCDD TEQ (Avian)	Surface Soil Off-Site Riparian	1.1E-06	4/4	NA	1.1E-06
TCDD TEQ (Mammal)	Surface Soil Off-Site Riparian	5.7E-07	4/4	NA	5.7E-07
Cadmium	Sediment - Moon Creek	0.94	4/10	NA	0.94
Chromium	Sediment - Moon Creek	46	10/10	32.90	32.90
Copper	Sediment - Moon Creek	58	10/10	34.94	34.94
Lead	Sediment - Moon Creek	72.8	10/10	53.29	53.29
Zinc	Sediment - Moon Creek	250	10/10	191.7	191.7
PCP	Sediment - Moon Creek	0.56	4/10	NA	0.56
TPAHs	Sediment - Moon Creek	9.79	10/10	6.93	6.93
TCDD TEQ (Avian)	Sediment - Moon Creek	2.1E-06	5/5	NA	2.1E-06
TCDD TEQ (Mammal)	Sediment - Moon Creek	2.2E-06	5/5	NA	2.2E-06
Cadmium	Sediment - Wetland	6.74	16/20	3.340	3.34
Copper	Sediment - Wetland	203.1	20/20	131.60	131.60
Zinc	Sediment - Wetland	408	20/20	335.10	335.10
PCP	Sediment - Wetland	1.04	18/20	0.62	0.62
TPAHs	Sediment - Wetland	46.14	20/20	27.95	27.95

COC	Media and General Area	Max Detect (mg/kg)	Detections	95% UCL[6] (mg/kg)	EPC (mg/kg)
TCDD TEQ (Avian)	Sediment - Wetland	4.1E-06	10/10	3.5E-06	3.5E-06
TCDD TEQ (Mammal)	Sediment - Wetland	4.2E-06	10/10	3.3E-06	3.3E-06

4.7.2 Input Data and Exposure Calculations

Food web ingestion-based modeling calculations can be performed to characterize potential exposures to COCs via the food web and to identify potential risks for upper trophic level mammals and birds. Ingestion modeling is based on species-specific exposure parameters and ingestion intake requirements. The following general equation from the PCL Database was used to calculate PCLs for wildlife receptors:

$$PCL_{soil/sediment} = \frac{TRV}{(BAF\ x\ FIR) + SSIR}$$

Where:

$PCL_{soil/sediment}$ = the protective concentration level for soil or sediment (mg/kg dry weight)

TRV = the toxicity reference value of the chemical (mg/kg-day)

BAF = the bioaccumulation factor

FIR = the food ingestion rate (kg/kg BW - day)

SSIR = the soil or sediment ingestion rate (kg/kg BW - day)

If inputs are not taken directly from the PCL Database, the literature sources used for intake and exposure variables should be clearly indicated and justified. Where literature information is modified for use in a Tier 2 SLERA, the modifications should be indicated in the discussion. For example, a literature-derived food ingestion rate may be adjusted to reflect wet weight or dry weight, as appropriate. Where a variety of choices are available for a receptor (e.g., body weight, dietary composition), the person should indicate how any one reference was selected from those available, particularly where the selection is a less-conservative exposure factor.

The purpose of food web modeling is to characterize potential exposures to COCs via ingestion, and to identify potential risks for upper trophic-level organisms. Through food web modeling, COCs are either retained for further evaluation or eliminated from the SLERA. The food web modeling occurs in two phases per TCEQ required elements 6 and 7:

1. A conservative NOAEL-based analysis is performed in required element 6. The hazard quotient (HQ) is based on reasonably conservative exposure assumptions (e.g., 100 percent bioavailability and no adjustment for area use) and a representative NOAEL-based TRV.
2. For required element 7, a less-conservative NOAEL- and LOAEL-based analysis is performed. In this less-conservative phase, bioavailability remains at 100

percent for each COC, but the area-use factor (AUF) for each receptor can be modified depending on site size and receptor home range.

4.8 Hazard Quotient Analysis (Required Elements 6 and 7)

HQ analysis in the SLERA is applied to the terrestrial wildlife receptors on-site and off-site (riparian areas) and the receptors associated with Moon Creek and the wetland (i.e., benthic invertebrates, water column receptors, and wildlife).

Predictions of the likelihood for adverse effects, if any, for the food web modeling are typically based on HQs (U.S. EPA, 1997). HQs are calculated by dividing the estimated dose by the TRVs for each COC and receptor pair.

$HQ_{NOAEL} = Dose \div TRV_{NOAEL}$

$HQ_{LOAEL} = Dose \div TRV_{LOAEL}$

The HQ value of 1 is the threshold for indicating that adverse effects may occur. An HQ less than or equal to a value of 1 (to one significant figure) indicates that adverse impacts to wildlife are considered unlikely (U.S. EPA, 1997). An HQ greater than 1 is an indication that further evaluation may be necessary to evaluate the potential for adverse impacts to wildlife.

For the initial conservative analysis, as described in ERAG (**11.2**), HQs are normally calculated using NOAEL-based TRVs, assuming 100 percent bioavailability and no other exposure modifying factors [required element 6]. As outlined in the ERAG, if the HQ is greater than one in the initial conservative analysis, then the refined (less conservative) analysis is completed.

Required element 7 requires that the exposure parameters are retained as in the initial conservative analysis (e.g., body weight, ingestion rates, and the EPC), but other inputs such as the AUF can be used to modify the dose, depending on the species and site conditions.

The HQ is calculated with the same NOAEL TRV used in the initial conservative analysis, but a LOAEL-based TRV is added and the exposure is modified, as appropriate, using the receptor's home range in relation to the exposure area size.

Other possible exposure modifications, such as exposure frequency (primarily for protected species), can be applied appropriately at this step.

The PCL Database can be used to address both the conservative analysis and less-conservative analysis. Instead of using HQs, the PCL Database relies on PCLs to indicate potential risk. However, the PCL Database can still be used to address required elements 6 and 7. This is demonstrated by adjusting the HQ equations:

HQ_{NOAEL} = Dose ÷ TRV_{NOAEL} = 95 percent UCL ÷ PCL_{NOAEL}

HQ_{LOAEL} = Dose ÷ TRV_{LOAEL} = 95 percent UCL ÷ PCL_{LOAEL}

4.8.1 On-Site Soil Assessment Summary

4.8.1.1 Community Analysis (Plants and Earthworms)

Table 12 shows the 95 percent UCL for on-site surface soil (with the hot spot removed) compared to the community soil benchmarks for invertebrates and plants. The EPCs for the COCs were below the Texas median background concentrations or the benchmarks. There are no soil benchmarks based on protection of the soil invertebrate and plant community for TPAHs or dioxins/furans (as individual congeners or as 2,3,7,8-TCDD TEQs). The Uncertainty Analysis section (4.9.2) discusses the lack of screening values.

The TRRP rule [30 TAC 350.4(a)(27)] specifically states that PCLs are not intended to be directly protective of receptors with limited mobility or range (e.g., plants, soil invertebrates, and small rodents). Additionally, plants and invertebrates are not directly evaluated for risks associated with soil COCs because the habitat and foraging areas of wildlife that depend on them are frequently large enough to compensate for any localized losses in food or shelter.

Table 12. Soil community analysis.

COC	General Location	EPC (mg/kg)	Median Bkgd (mg/kg)	Soil Invertebrate Benchmark (mg/kg)	Plant Benchmark (mg/kg)	Soil Community COC?
Chromium	On-site (hot spot removal assumed)	11.98	30	0.4	1	No - EPC < background
Copper	On-site (hot spot removal assumed)	6.11	15	80	70	No - EPC < background
Lead	On-site (hot spot removal assumed)	13.57	15	1700	120	No - EPC < background
Zinc	On-site (hot spot removal assumed)	61.15	30	120	160	No - EPC < invert and plant benchmarks
PCP	On-site (hot spot removal assumed)	0.808	NA	31	5	No - EPC < invert and plant benchmarks
TPAH[7]s	On-site (hot spot removal assumed)	7.01	NA	NA	NA	See Uncertainty Analysis
TCDD TEQ (Avian)	On-site (hot spot removal assumed)	8.6E-07	NA	NA	NA	See Uncertainty Analysis
TCDD TEQ (Mammal)	On-site (hot spot removal assumed)	1.4E-06	NA	NA	NA	See Uncertainty Analysis
Chromium	Off-site (riparian)	28.81	30	0.4	1	No - EPC < background
Copper	Off-site (riparian)	24.44	15	80	70	No - EPC < invert and plant benchmarks
Lead	Off-site (riparian)	40.41	15	1700	120	No - EPC < invert and plant benchmarks
Zinc	Off-site (riparian)	91.34	30	120	160	No - EPC < invert and plant benchmarks
PCP	Off-site (riparian)	0.0076	NA	31	5	No - EPC < invert and plant benchmarks
TPAHs	Off-site (riparian)	3.10	NA	NA	NA	See Uncertainty Analysis
TCDD TEQ (Avian)	Off-site (riparian)	1.1E-06	NA	NA	NA	See Uncertainty Analysis
TCDD TEQ (Mammal)	Off-site (riparian)	5.7E-07	NA	NA	NA	See Uncertainty Analysis

[7] The previous uses of EPA Eco-SSLs of 29 mg/kg and 18 mg/kg for low and high molecular weight PAHs, respectively, are now considered inappropriate as concentrations below these levels may impart risk to wildlife (e.g., the Eco-SSL value for mammals is 1.1 mg/kg and the Database Conservative PCLs for the American robin, house finch, and lark sparrow range from 2.78 mg/kg to 4.7 mg/kg).

4.8.1.2 Wildlife Analysis

Using the PCL Database and the list of COCs following the benchmark screening, required element 6 was completed. As was shown in Table 11, the 95 percent UCLs, which represent the on-site exposures after the hot spot has been removed, are the EPCs for the on-site soil. These EPCs are compared to the Conservative PCLs for the refined species list in Table 13 for birds and reptiles and Table 14 for mammals.

From this analysis, zinc and TPAHs are carried forward to the next phase of analysis. Exceedances are shaded on Table 13. The EPCs for chromium, copper, lead, PCP, and the avian and mammalian dioxin TEQs are less than the most conservative PCL and can be removed from further consideration (Table 14). Similarly, the surface and subsurface soil evaluation for the armadillo indicated no exceedances using the higher EPC for all dose calculations (Table 15).

The Texas rat snake is listed as a terrestrial receptor in the Minor Habitat, but lead is the only COC in the PCL Database with a reptile TRV. For COCs other than lead, the PCL Database was used to estimate PCLs for the Texas rat snake by applying avian NOAEL TRVs, adjusted by an uncertainty factor of 0.1, and then incorporating exposure parameters specific to the Texas rat snake (see Exhibit 3). Table 13 shows the PCLs protective of the Texas rat snake. There are no EPC exceedances of these NOAEL-based reptile PCLs.

> To determine the Conservative PCL for the Texas rat snake, the most conservative avian NOAEL TRV listed in the PCL Database for the Minor Habitat-Terrestrial was placed into the "Literature NOAEL" and "Literature LOAEL" boxes but modified by 0.1. The Texas rat snake exposure inputs (e.g., body weight, food ingestion rate) were used to calculate the PCLs.[8]
>
> The modified NOAEL TRV was used in both boxes because the Conservative PCL is based on the NOAEL TRV only. If this PCL was exceeded, then an avian LOAEL TRV would have been input to the Literature LOAEL box with an uncertainty factor of 0.1 to develop an Average TRV PCL. The Person should choose the NOAEL and LOAEL TRV pair based on generation of the lowest PCL.

Table 16 shows the comparison of the EPCs with the required element 7 Average TRV PCLs for zinc and TPAHs. Neither of these EPCs are greater than their associated Average TRV PCLs (no adjustments for area use or exposure modifying factors are needed); thus, wildlife are not at risk from on-site soil.

[8] It is anticipated that this methodology will be incorporated seamlessly into the PCL Database soon (i.e., reptile PCLs will be provided for those COCs that have bird TRVs). Note that a reptile TRV for lead is currently available.

Table 13. Required element 6 surface soil analysis for avian and reptile receptors using the PCL Database.

COC	American Robin PCL (mg/kg)	American Woodcock PCL (mg/kg)	Bobwhite Quail PCL (mg/kg)	Mourning Dove PCL (mg/kg)	Northern Cardinal (mg/kg)	Red-Tailed Hawk PCL (mg/kg)	Texas Rat Snake PCL (mg/kg)	EPC (mg/kg)	Evaluate in Required Element 7?
Chromium	52.59	56.13	283.49	151.67	121.30	807	388	11.98	No; EPC < all avian conservative PCLs
Copper	258.05	264.45	759	757	228.04	2730	1313	6.11	No; EPC < all avian conservative PCLs
Lead	22.84	24.37	112.92	60.67	48.14	352	299.31	13.57	No; EPC < all conservative PCLs
Zinc	32.64	35.75	359	223.70	135.82	768	369	61.15	Yes; EPC > Robin and woodcock PCLs
PCP	2.70	3.63	14.62	7.91	6.19	817	393	0.808	No; EPC < all conservative PCLs
TPAHs	2.78	4.20	12.50	6.12	5.86	2263	1088	7.01	Yes; EPC > several PCLs
TCDD TEQ (Avian)	1.1E-04	1.0E-04	1.2E-03	7.6E-04	4.7E-4	2.9E-04	1.4E-04	8.6E-07	No; EPC < all conservative PCLs

Table 14. Required element 6 surface soil analysis for mammal receptors using the PCL Database.

COC	Deer Mouse PCL (mg/kg)	Eastern Cottontail PCL (mg/kg)	Least Shrew PCL (mg/kg)	Nine-banded Armadillo PCL (mg/kg)	Raccoon – Terrestrial PCL (mg/kg)	Red Fox PCL (mg/kg)	EPC (mg/kg)	Evaluate in Required Element 7 for mammals?
Chromium	1368	3129	641	6015	4020	6516	11.98	No; EPC < all mammal conservative PCLs
Copper	345	2941	177.25	2141	3088	4033	6.11	No; EPC < all mammal conservative PCLs
Lead	2321	5318	1096	10024	6827	11832	13.57	No; EPC < all mammal conservative PCLs
Zinc	1416	6069	756	12087	8761	9461	61.15	No; EPC < all mammal conservative PCLs
PCP	3.68	13.44	3.12	46.85	25.23	94.64	0.808	No; EPC < all mammal conservative PCLs
TPAHs	23.70	71.28	24.70	357	139	596	7.01	No; EPC < all mammal conservative PCLs
TCDD TEQ (Mammal)	3.1E-04	8.2E-04	7.9E-05	9.2E-04	4.4E-04	1.3E-04	1.4E-06	No; EPC < all mammal conservative PCLs

Table 15. Required Element 6 conservative soil analysis using the PCL Database for the nine-banded armadillo.

COC	Media	Nine-banded Armadillo Conservative PCL (mg/kg)	EPC (mg/kg)	Evaluate in Required Element 7?
Chromium	On-Site Surface Soil (with hot spot removed)	6015	11.98	No; EPC < PCL
Copper	On-Site Surface Soil (with hot spot removed)	2141	6.11	No; EPC < PCL
Lead	On-Site Surface Soil (with hot spot removed)	10024	13.57	No; EPC < PCL
Zinc	On-Site Surface Soil (with hot spot removed)	12087	61.15	No; EPC < PCL
PCP	On-Site Surface Soil (with hot spot removed)	46.85	0.808	No; EPC < PCL
TPAHs	On-Site Surface Soil (with hot spot removed)	357	7.01	No; EPC < PCL
TCDD TEQ (Mammal)	On-Site Surface Soil (with hot spot removed)	9.2E-04	1.4E-06	No; EPC < PCL
Chromium	On-Site Subsurface Soil	6015	27.49	No; EPC < PCL
Copper	On-Site Subsurface Soil	2141	13.75	No; EPC < PCL
Lead	On-Site Subsurface Soil	10024	19.92	No; EPC < PCL
Zinc	On-Site Subsurface Soil	12087	97.25	No; EPC < PCL
PCP	On-Site Subsurface Soil	46.85	0.0069	No; EPC < PCL
TPAHs	On-Site Subsurface Soil	357	8.86	No; EPC < PCL
TCDD TEQ (Mammal)	On-Site Subsurface Soil	9.2.E-04	1.0.E-06	No; EPC < PCL

Habitat:	none	**BAF - soil to plant:**	0.041	**BAF - sediment to fish:**	0.161	**Legend:**	
Chemical:	CHROMIUM, TOTAL(CAS: 7440-47-3)	**BAF - soil to earthworm:**	0.306	**BAF - sediment to benthic invertebrate:**	0.083	Value from Literature	
Log K_{ow} :	0	**BAF - soil to arthropod:**	0.0651			Calculated Value	
swqb :	0.042 mg/L	**BAF - soil to wildlife:**	0.0846	**Texas Median Soil Background:**	30 (mg/Kg)	User Overridden Value	
						Calculated from Overridden Value(s)	

Species	Body Wt.	BAF	Food IR	Water IR	Soil Sed IR	End-point	Literature NOAEL	Literature LOAEL	Literature LD 50	Surrogate Used	Conservative PCL	TRV NOAEL	TRV LOAEL	Average TRV PCL	AUF %	EF %	Other EMF	Refined PCL
RED-TAILED HAWK (TR)	1.1375	0.0846	0.031567	0.05654	0.000883(	GROW				CHICKEN	807	2.87	28.7	4441	100.	100	100	0
						MORT				CHICKEN	24167	85.9	859	13292(				0
						REPR				CHICKEN	21213	75.4	754	11667:				0
TEXAS RAT SNAKE (TR)	1.729	0.0846	0.006565	0	0.000183(	GROW	0.287	0.287		--		0.287	0.287	388	100.	100	100	388
						MORT	8.59	8.59		--		8.59	8.59	11620				11620
						REPR	7.54	7.54		--		7.54	7.54	10200				10200

Exhibit 3. PCL Database screenshot - Texas rat snake Conservative PCLs for chromium.

Table 16. Required element 7 soil analysis using the PCL Database

COC	American Robin Average-TRV PCL (mg/kg)	American Woodcock Average-TRV PCL (mg/kg)	Mourning Dove Average-TRV PCL (mg/kg)	Northern Cardinal Average-TRV PCL (mg/kg)	EPC (mg/kg)	Final Soil COC?
Zinc	163.78	179.34	1122	681	61.15	No; EPC < Avg TRV PCL
TPAHs	15.29	23.43	33.68	32.21	7.01	No; EPC < Avg TRV PCL

4.8.2 Off-Site Riparian Soil Assessment Summary

4.8.2.1 Community Analysis

Table 12 shows the EPC for surface soil (with the hot spot removed) compared to the community soil benchmarks for invertebrates and plants. The EPCs for the COCs were below the Texas median background concentrations or the benchmarks.

There are no soil benchmarks based on protection of the soil invertebrate and plant community for TPAHs or the dioxins/furans (as individual congeners or as 2,3,7,8-TCDD TEQs). The Uncertainty Analysis (Section 4.9.2 of this publication) discusses the lack of screening values.

4.8.2.2 Food Web Analysis

As shown in Table 17, the EPCs for the riparian soil are compared to the Conservative PCLs from the PCL Database for the terrestrial receptors from the Freshwater Systems Habitat. Lead, zinc, and TPAHs are to be further evaluated in required element 7. Exceedances are shaded in Table 17.

The timber rattlesnake is a protected species in Sunny County and could be present in the riparian areas. As was previously discussed for the Texas rat snake, the only TRV derived (in the PCL Database) using a reptile as a test species is for lead. To address this data gap, the PCL Database was used to estimate PCLs for the timber rattlesnake via avian NOAEL TRVs adjusted by a factor of 0.1 and then applying exposure parameters specific to the snake (see footnote 2 in Section 4.8.1.2 of this publication).

Table 17 shows the PCLs protective of the timber rattlesnake. There are no EPC exceedances of these NOAEL-based reptile PCLs.

Table 18 shows the comparison of the EPCs with the required element 7 Average TRV PCLs for lead, zinc, and TPAHs. None of the EPCs are greater than the Average PCL (without any adjustments for area use or exposure modifying factors).

Table 17. Required element 6 soil analysis using the PCL Database riparian soil-based receptors.

Receptor	Chromium Conservative PCL (mg/kg)	Copper Conservative PCL (mg/kg)	Lead Conservative PCL (mg/kg)	Zinc Conservative PCL (mg/kg)	PCP Conservative PCL (mg/kg)	TPAHs Conservative PCL (mg/kg)	TCDD TEQ (Avian) Conservative PCL (mg/kg)	TCDD TEQ (Mammal) Conservative PCL (mg/kg)
Riparian Soil EPC (mg/kg):	**28.81**	**24.44**	**40.41**	**91.34**	**0.00764**	**3.09**	**1.1E-06**	**5.7E-07**
American kestrel	253.63	455	107.55	208.27	26.66	33.04	1.2E-04	NA
American robin	52.59	258.05	22.84	32.64	2.69	2.78	1.1E-04	NA
American woodcock	56.13	264.45	24.37	35.75	3.63	4.26	1.0E-04	NA
Cotton mouse	1996	365	3356	1867	5.57	39.79	NA	3.4E-04
Eastern cottontail	3129	2941	5318	6069	13.44	71.28	NA	8.2E-04
Least shrew	641	177.25	1096	756	3.12	24.76	NA	7.9E-05
Red fox	6516	4033	11832	9461	94.64	596	NA	1.3E-04
Timber rattlesnake	293.65	993	226.38	279.35	297.07	823	1.1E-04	NA
Virginia opossum	4751	1898	8018	8459	29	190.63	NA	4.8E-04

Table 18. Required element 7 soil analysis using the PCL Database riparian soil-based receptors.

COC	EPC (mg/kg)	American robin Average-TRV PCL (mg/kg)	American woodcock Average-TRV PCL (mg/kg)
Lead	40.41	125.61	134.05
Zinc	91.34	163.78	179.34
TPAHs	3.09	15.29	23.43

4.8.3 Moon Creek Sediment Assessment

4.8.3.1 Community Analysis

Following benchmark screening for sediment, several metals and PAHs were retained for further analysis.

Table 19 shows the EPCs for the sediment data collected adjacent to the site compared to the default benthic PCLs. There are no exceedances of the midpoint benthic PCLs. There are no benthic PCLs for the dioxins/furans (as individual congeners or as 2,3,7,8-TCDD TEQs). The Uncertainty Analysis (4.9.2 of this publication) discusses the lack of screening values.

4.8.3.2 Food Web Analysis

Table 20 shows the comparison of the EPCs for Moon Creek sediment against the Conservative PCLs protective of relevant receptors from the Freshwater Systems Habitat in the PCL Database. Figures 7 and 8 show the data graphically. Based on this analysis, lead, zinc, and TPAHs are carried forward to required element 7. The EPCs for cadmium, chromium, copper, PCP, and the avian and mammalian dioxin TEQs are less than the most conservative PCL and can be removed from further consideration.

The cottonmouth water moccasin, plain-bellied water snake, snapping turtle, spiny softshell turtle, and yellow mud turtle are listed as aquatic reptile receptors in the Freshwater Systems Habitat. The PCL Database was used to estimate PCLs for these reptiles by applying avian NOAEL-TRVs adjusted by a factor of 0.1 (except for lead) and then using exposure parameters specific to the reptile (see instruction box in Section 4.8.1.2 of this publication).

Table 20 shows the Conservative PCLs that are protective of the reptiles. There are no EPC exceedances of these NOAEL-based reptile PCLs.

Table 21 shows the comparison of the sediment EPCs with the required element 7 Average TRV PCLs for lead, zinc, and TPAHs. Except for the white-faced ibis for lead and zinc, all the EPCs are less than the Average PCL (without any adjustments from exposure modifying factors).

The sediment exposure area in Moon Creek potentially impacted by releases from the site that is accessible to these birds is 8,600 square feet (0.2 acres). This size was derived by multiplying the length of the creek (860 linear feet) by the estimated width of the foraging area (10 feet). Sample locations SED-11 to SED-20 (Figure 3) bound the length of the exposure area. The average width of Moon Creek is 20 feet and the depth averages 3 feet under normal conditions. Because of the three-foot depth, a bird foraging for invertebrates would be present primarily in the shallow water edges and exposed sediments of the shoreline; therefore, it was conservatively assumed that birds could forage within a five-foot swath on both sides of the creek.

The home range for the white-faced ibis is 2,960 acres, resulting in an AUF of less than 1 percent and PCLs greater than 1,439 mg/kg for lead and 13,549 mg/kg for zinc. Following the application of AUFs, there is no ecological risk to the white-faced ibis in Moon Creek. Table 22 summarizes this information. Exhibit 5 shows the PCL Database screenshot of this calculation.

> When using the PCL Database to assess wildlife exposure to PAHs, it is best to evaluate for TPAHs, as opposed to groups of low and high molecular weight, or on an individual basis. This is because, as a total, all individual compounds within this class are included and the TRVs selected for use are those for the most toxic PAH compounds.
>
> This methodology ensures protection against PAH mixtures dominated by the more toxic compounds, and consistency between the soil and sediment evaluations.

Table 19. Sediment benthic community analysis.

Analyte	Area	EPC (mg/kg)	Sediment Benthic PCL (mg/kg)	Benthic Community COC?
Cadmium	Moon Creek	0.94	2.99	No - EPC < PCL
Chromium	Moon Creek	32.90	77.2	No - EPC < PCL
Copper	Moon Creek	34.94	90.3	No - EPC < PCL
Lead	Moon Creek	53.29	81.9	No - EPC < PCL
Zinc	Moon Creek	191.7	290	No - EPC < PCL
Pentachlorophenol	Moon Creek	0.56	1.2	No - EPC < PCL
TPAHs	Moon Creek	6.93	12.2	No - EPC < PCL
TCDD TEQ (Avian)	Moon Creek	2.1E-06	NA	See Uncertainty Analysis
TCDD TEQ (Mammal)	Moon Creek	2.2E-06	NA	See Uncertainty Analysis
Cadmium	Wetlands	3.34	2.98	Yes - EPC > PCL
Copper	Wetlands	131.60	90.3	Yes - EPC > PCL
Zinc	Wetlands	335.10	290	Yes - EPC > PCL
Pentachlorophenol	Wetlands	0.62	1.2	No - EPC < PCL
Total PAHs	Wetlands	27.95	12.2	Yes - EPC > PCL
TCDD TEQ (Avian)	Wetlands	3.5E-06	NA	See Uncertainty Analysis
TCDD TEQ (Mammal)	Wetlands	3.3E-06	NA	See Uncertainty Analysis

Table 20. Required element 6 sediment analysis using the PCL Database - Moon Creek sediment-based receptors.

Receptor	Cadmium PCL (mg/kg)	Chromium PCL (mg/kg)	Copper PCL (mg/kg)	Lead PCL (mg/kg)	Zinc PCL (mg/kg)	PCP PCL (mg/kg)	TPAHs PCL (mg/kg)	TCDD TEQ (Avian) PCL (mg/kg)	TCDD TEQ (Mammal) PCL (mg/kg)
EPC (mg/kg):	**0.94**	**32.9**	**34.94**	**53.29**	**191.7**	**0.56**	**6.93**	**2.1E-06**	**2.2E-06**
American mink	47.37	2495	168.56	3683	12834	6.18	394.00	NA	3.6E-05
American wigeon	16.32	490	1868	198.65	459	14.27	11.22	3.8E-03	NA
Belted kingfisher	11.37	107.57	346	37.55	349	2.52	23.70	3.4E-05	NA
Black-crowned night heron	18.44	217.64	468	67.31	304.44	4.57	17.48	6.1E-05	NA
Cottonmouth water moccasin	20.39	198.23	793	127.71	587	7.12	138.27	7.6E-05	NA
Green heron	45.61	439	1307	155.89	1108	10.43	69.28	1.4E-04	NA
Mallard	19.85	478	1053	193.60	387	10.50	12.64	2.5E-04	NA
Marsh rice rat	16.12	1844	542	3165	1858	3.03	36.08	NA	2.0E-05
Marsh wren	6.80	83.25	143.02	33.42	71.86	1.79	3.78	2.4E-05	NA
Muskrat	36.67	7286	5216	12564	9211	18.49	99.21	NA	3.4E-03
Plain-bellied water snake	20.72	162.01	686	100.97	914	4.93	97.02	6.5E-05	NA
Raccoon Semi-Aquatic	50.92	3026	1303	5041	5179	8.14	126.98	NA	4.6E-05
Red-winged blackbird	6.95	243.26	551	98.76	182.94	5.94	4.89	1.9E-03	NA
Snapping turtle	24.64	303.75	533	211.81	277.32	6.29	14.63	8.3E-05	NA
Snowy egret	14.00	129.84	462	37.56	594	3.43	64.01	4.6E-05	NA
Spiny softshell turtle	26.58	262.92	675	172.27	439	6.58	25.17	8.7E-05	NA
Spotted sandpiper	5.70	49.71	125.65	19.80	64.75	1.79	3.64	2.2E-05	NA
Swamp rabbit	29.64	3700	3477	6287	7175	15.89	84.27	NA	9.7E-04
Virginia opossum	49.07	4751	1898	8018	8459	29.00	190.62	NA	4.8E-04
White-faced ibis	11.91	103.92	262.73	41.39	135.38	3.75	7.62	4.7E-05	NA
Yellow-crowned night heron	53.22	827	1094	335	543	12.95	27.72	1.7E-04	NA
Yellow mud turtle	21.33	287.31	512	200.24	259.80	5.89	12.91	8.1E-05	NA

Table 21. Required element 7 sediment analysis using the PCL Database - Moon Creek sediment -based receptors.

Receptor	Lead Avg-TRV PCL (mg/kg)	Zinc Avg-TRV PCL (mg/kg)	TPAHs Avg-TRV PCL (mg/kg)
EPC (mg/kg):	**53.29**	**191.7**	**6.93**
Belted kingfisher	206.53	NA	NA
Marsh wren	183.80	361	20.80
Red-winged blackbird	NA	918	26.89
Snowy egret	206.56	NA	NA
Spotted sandpiper	108.88	325	20.04
White-faced ibis	41.39	135.38	NA

Table 22. Required element 7 sediment analysis refined PCLs - Moon Creek sediment-based receptors.

Receptor	Lead Average TRV PCL (mg/kg)	Zinc Average TRV PCL (mg/kg)	Home Range (Acres)	Exposure Area (Acres)	Area Use Factor (%)	Refined Lead PCL (mg/kg)	Refined Zinc PCL (mg/kg)
EPC (mg/kg):	**53.29**	**191.7**	NA	NA	NA	**53.29**	**191.7**
White-faced ibis	41.39	135.38	2960	0.2	<1	> 4,139	> 13,539

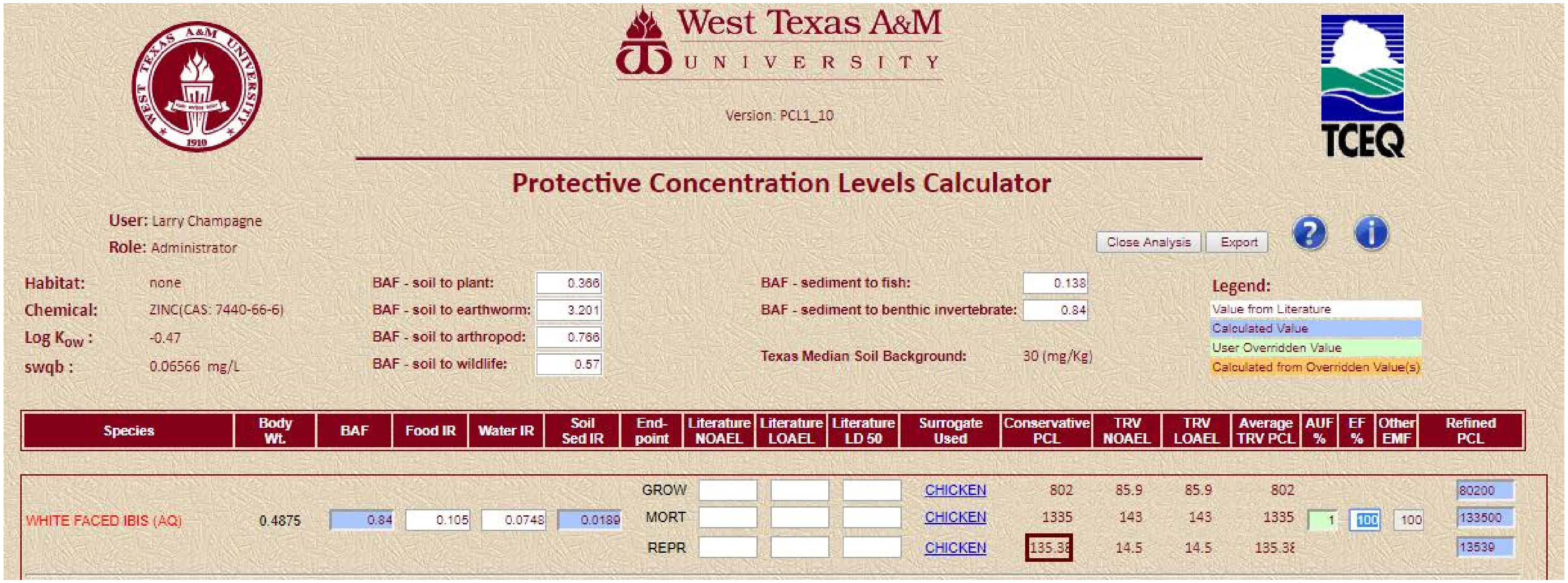

Exhibit 4. PCL Database screenshot - Refined PCLs for the white-faced ibis.

4.8.4 Wetland Surface Water and Sediment Assessment

4.8.4.1 Community Analysis

As shown on Table 5, the surface water samples collected from the wetland have exceedances of the chronic freshwater benchmarks for arsenic, cadmium, chromium, copper, lead, PCP, naphthalene, chrysene, fluoranthene, and pyrene. Surface water benchmarks are not available for several of the PAHs [acenaphthalene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, and indeno(c,d-123)pyrene] and this is discussed further in the Uncertainty Analysis (4.9.2 of this publication).

Table 19 shows the EPCs for the COCs in sediment for the wetland compared to the benthic PCLs. Cadmium, copper zinc, and TPAHs have EPCs greater than the benthic PCLs. There are no benthic PCLs or surface water benchmarks for the dioxins/furans (as individual congeners or as 2,3,7,8-TCDD TEQs). The Uncertainty Analysis (Section 4.9.2) discusses the lack of screening values.

4.8.4.2 Food Web Analysis

Table 23 shows the comparison of the EPCs for wetland sediment against the conservative PCLs protective of relevant receptors from the Freshwater Systems Habitat in the PCL Database. Figures 7 and 8 show the data graphically. Based on this analysis, copper, zinc, and TPAHs are carried forward to required element 7. The EPCs for cadmium, PCP, and the avian and mammalian dioxin TEQs are less than their most conservative PCLs and are removed from further consideration. Reptiles were evaluated using avian NOAEL TRVs adjusted by 0.1, except for lead, which has a reptile-based NOAEL TRV. There were no exceedances of the reptile-based Conservative PCLs.

Table 24 shows the Average TRV PCL comparisons to the EPCs for copper, zinc, and TPAHs for wetland sediment. Most of the EPCs are less than the Average TRV PCL (without any adjustments from EMFs) except for the marsh wren and red-winged blackbird for TPAHs; and the spotted sandpiper and white-faced ibis for zinc and TPAHs.

Because the exposure area (approximately 8 acres) is larger than the home ranges for the marsh wren (home range = 0.134 acres), red-winged blackbird (home range = 6.9 acres), and spotted sandpiper (home range = 5 acres), application of an AUF is not appropriate for any of these species.

Wildlife-based PCLs for zinc (based on the spotted sandpiper) and TPAHs (based on the spotted sandpiper, marsh wren, and red-winged blackbird) are carried forward to PCL development (required element 9) for determination of final ecological PCLs. The AUF for the white-faced ibis is less than 1 percent with the resulting Refined PCLs greater than 13,539 mg/kg for zinc and greater than 762 mg/kg for TPAHs. No further evaluation of the white-faced ibis is warranted. Table 25 summarizes this information.

Table 23. Required element 6 sediment analysis using the PCL Database - wetland sediment-based receptors.

Receptor	Cadmium PCL (mg/kg)	Copper PCL (mg/kg)	Zinc PCL (mg/kg)	PCP PCL (mg/kg)	TPAHs PCL (mg/kg)	TCDD TEQ (Avian) PCL (mg/kg)	TCDD TEQ (Mammal) PCL (mg/kg)
EPC (mg/kg):	**3.34**	**131.6**	**335.1**	**0.62**	**27.95**	**3.5E-06**	**3.3E-06**
American mink	47.37	168.56	12834	6.18	394.00	NA	3.6E-05
American wigeon	16.32	1868	459	14.27	11.22	3.8E-03	NA
Black-crowned night heron	18.44	468	304.44	4.57	17.48	6.1E-05	NA
Cottonmouth water moccasin	20.39	793	587	7.12	138.27	7.6E-05	NA
Green heron	45.61	1307	1108	10.43	69.28	1.4E-04	NA
Mallard	19.85	1053	387	10.50	12.64	2.5E-04	NA
Marsh rice rat	16.12	542	1858	3.03	36.08	NA	2.0E-05
Marsh wren	6.80	143.02	71.86	1.79	3.78	2.4E-05	NA
Muskrat	36.67	5216	9211	18.49	99.21	NA	3.4E-03
Plain-bellied water snake	20.72	686	914	4.93	97.02	6.5E-05	NA
Raccoon Semi-Aquatic	50.92	1303	5179	8.14	126.98	NA	4.6E-05
Red-winged blackbird	6.95	551	182.94	5.94	4.89	1.9E-03	NA
Snapping turtle	24.64	533	277.32	6.29	14.63	8.3E-05	NA
Snowy egret	14.00	462	594	3.43	64.01	4.6E-05	NA
Spiny softshell turtle	26.58	675	439	6.58	25.17	8.7E-05	NA
Spotted sandpiper	5.70	125.65	64.75	1.79	3.64	2.2E-05	NA
Swamp rabbit	29.64	3477	7175	15.89	84.27	NA	9.7E-04
Virginia opossum	40.07	1898	8459	29.00	190.62	NA	NA
White-faced ibis	11.91	262.73	135.38	3.75	7.62	4.7E-05	NA
Yellow-crowned night heron	53.22	1094	543	12.95	27.72	1.7E-04	NA
Yellow mud turtle	21.33	512	259.80	5.89	12.91	8.1E-05	NA

Table 24. Required element 7 sediment analysis using the PCL Database – wetland sediment-based receptors.

Receptor	Copper Avg-TRV PCL (mg/kg)	Zinc Avg-TRV PCL (mg/kg)	TPAHs Avg-TRV PCL (mg/kg)
EPC (mg/kg):	**131.6**	**335.1**	**27.95**
American wigeon	NA	NA	61.71
Black-crowned night heron	NA	1527	96.17
Mallard	NA	NA	69.53
Marsh wren	NA	361	20.80
Red-winged blackbird	NA	918	26.89
Snapping turtle	NA	1391	80.87
Spiny softshell turtle	NA	NA	138.44
Spotted sandpiper	143.79	325	20.04
White-faced ibis	NA	135.38	7.62
Yellow-crowned night heron	NA	NA	152.47
Yellow mud turtle	NA	1303	71

Table 25. Required element 7 sediment analysis refined PCLs - wetland sediment-based receptors.

Receptor	Average TRV Zinc PCL (mg/kg)	Average TRV TPAHs PCL (mg/kg)	Home Range (Acres)	Exposure Area (Acres)	Area Use Factor (%)	Refined Zinc PCL (mg/kg)	Refined TPAHs PCL (mg/kg)
EPC (mg/kg):	**335.1**	**27.95**	NA	NA	NA	**335.1**	**27.95**
Marsh wren	NA	20.80	0.134	8	NA	NA	20.80
Red-winged blackbird	NA	26.89	6.9	8	NA	NA	26.89
Spotted sandpiper	325	20.04	5	8	NA	325	20.04
White-faced ibis	135.38	7.62	2960	8	< 1	> 13,539	> 762

4.9 Uncertainty Analysis (Required Element 8)

The characterization of uncertainty is a significant component of the ERA process (U.S. EPA, 1997) and is required element 8 in the TCEQ process. This SLERA did not account for site-specific factors such as chemical bioavailability or metal speciation. Such factors would most likely tend to mitigate the estimated ecological significance of loss or impairment.

The approach used in this assessment was on a chemical-by-chemical basis (except for TPAHs and 2,3,7,8-TCDD TEQs) and as such, cannot address the additive, antagonistic, or synergistic effects of the mixtures of chemicals typically present in the environment. Furthermore, SLERAs do not typically consider the nature of the specific ecosystem at a site, the potential toxicity of other constituents (anthropogenic or naturally occurring) that were not quantified, or the pervasive influence of physical stressors associated with the disruptions caused by human activities. Uncertainties applicable to this SLERA are described below.

4.9.1 Data Gaps

Lack of Surface Water and Groundwater Dioxin Data - Surface water and groundwater samples were not analyzed for dioxins/furans. For surface water, the conceptual site model indicated that contamination would likely be overland flow to Moon Creek and the wetland.

Some remediation actions have already taken place at the site, such as removing most of the potential sources of dioxins/furans; however, there are detections of dioxins/furans in the surface soil, primarily in the identified soil hot spot. Dioxins/furans are more likely to be present in sediment and not in the water column, although dioxins/furans that are sorbed to sediment particles could be re-suspended in the water column.

Groundwater Data – Two rounds of groundwater sampling have occurred over a one-year period (March and September 2015) in the three interface wells.

A review of weather data indicated that the year was average in temperature and rainfall. No extreme events were reported that could impact groundwater elevation. The site has been unchanged since the removal action in 2006 and it is likely that the concentrations in soil leaching to groundwater have stabilized.

Maximum detected concentrations in the groundwater were used in the SLERA as the EPC, thereby increasing conservatism. This SLERA assumes that groundwater concentrations are declining at the interface. If groundwater concentrations increase in the future, it could be considered a substantial change in circumstances and would require reevaluation.

4.9.2 Benchmark Screening Values

Benchmark screening values are not available for dioxins/furans in soil. The uncertainty is minimal because dioxins/furans are carried forward in the SLERA for evaluation against wildlife-based PCLs. The impact of dioxins/furans in the soil to the invertebrate and plant communities is unknown. Additionally, there is no sediment benthic invertebrate benchmark for dioxins/furans.

The benchmark soil screening value for TPAHs is based on a Conservative PCL for the American robin, and not on protection of the soil invertebrate or plant communities. The previous use of EPA Eco-SSLs of 29 mg/kg and 18 mg/kg for low and high molecular weight PAHs, respectively, are now considered inappropriate as concentrations below these levels may impart risk to wildlife (e.g., the Eco-SSL value for mammals is 1.1 mg/kg and PCL Database Conservative PCLs for the American robin, house finch, and lark sparrow range from 2.8 mg/kg to 4.7 mg/kg). The use of the 2.8 mg/kg benchmark reduces the likelihood that TPAHs are removed from the SLERA at the benchmark screening step when the concentrations could be causing risk to birds.

Surface water screening values are not available for acenaphthylene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, or indeno(1,2,3-cd)pyrene. These PAHs are not detected above sample detection limits in Moon Creek surface water or wetland surface water, and at very low concentrations in the groundwater. The remaining PAHs have surface water benchmarks and do not exceed screening benchmarks. The uncertainty is minimal.

The maximum sample detection limits for cadmium and benzo(a)pyrene are greater than the surface water chronic screening values. As shown in Table 2, the sample detection limit for cadmium is 0.00027 mg/L and the freshwater chronic benchmark is 0.000188 mg/L. The sample detection limit for benzo(a)pyrene is 0.00003 mg/L and the chronic benchmark is 0.000014 mg/L. The analytical method used was the most sensitive and in general, surface water exposure is not expected to be significant for wildlife. Cadmium and TPAHs are final ecological COCs in the wetland based on sediment exposure.

4.9.3 Media Exposure

On-Site Previously Excavated Area – Following the removal of site structures and features in 2006, there was a soil excavation to five feet below grade of the primary wood-treating area (Figure 1), which was brought back to grade with fill material.

There were four on-site soil samples and five riparian samples collected for the APAR investigation from the excavated area (Figures 4-6). The nature and source of the fill is unknown, and no supporting analytical data are available. This uncertainty is minimal because soil samples have been collected within the previously excavated area and there are no exceedances of soil benchmarks.

On-Site Soil Sample Density – The ecological terrestrial habitat is approximately 10 acres and sampling density is approximately three samples per acre. The sampling density is less in the previously excavated area. There could be uncertainty associated with the sampling density; however, based on the low concentrations of COCs along the perimeter of the area and the highest concentrations in the area used for storage of treated wood, it is unlikely that areas of significant contamination were not sampled.

On-Site Soil Hot Spot Analysis – Four samples were removed from the on-site surface soil data set following the hot spot analysis. Originally, the on-site surface soil data set was 30 samples and with the removal of the four hot spot samples, the data set was reduced to 26 samples. There are sufficient sample numbers remaining after the removal of the four samples representing the hot spot so that the calculation of the 95 percent UCL remains valid. There is minimal uncertainty with the revised 95 percent UCLs with the revised EPCs representing future exposure (post removal of the hot spot).

There is uncertainty associated with the concentrations of COCs that are in the fill material to be used to replace the contaminated soil in the hot spot. After removal of samples representing a hot spot, if the sample numbers are insufficient to calculate a statistically representative EPC, then proxy concentrations (not zeros) can be substituted for the COCs in the removed samples. For example, a proxy concentration could be the lower of an average of the remaining data points for a given COC, the site-specific background concentration, or lower of the shrew or robin PCL. The Texas median background values can be used if site-specific background data are not available. Justification of the chosen proxy values should be provided.

Wildlife Exposure to Surface Water – The exposure of wildlife to water in Moon Creek and the wetland is a complete pathway, but the route of exposure is insignificant and was therefore not evaluated.

4.9.4 Reptiles and Amphibians

It is reasonable to assume that there are a variety of reptiles and amphibians using the various terrestrial and aquatic habitats at the site. The quantitative food-chain assessment for reptiles is limited to lead because of the lack of relevant reptile toxicity data. The assessment of amphibians is completed using the surface water benchmarks and does not address the potential exposure of amphibians to sediment.

Historically, reptilian toxicology has made up a disproportionately small percentage of toxicological studies of vertebrates. Characteristics of some reptile species make them difficult to study, including long life span and generation time, low fecundity, and incompatibility with laboratory handling techniques. Reptile species are linked by many traits (e.g., ectothermia, pulmonary respiration, epidermal scales, and internal fertility), yet possess a diverse array of life history characteristics and inter-species differences (e.g., population distributions, migration patterns, diets, and metabolic processes) (Gardner and Oberdorster, 2006).

Reptiles – Exposure assumptions for reptiles are highly variable and are unlike those for mammals and birds. The assumption of a daily intake is not applicable to snakes because they usually ingest prey less frequently (monthly or weekly) (Hopkins, 2004), but the impact of this uncertainty is unknown.

Additionally, the reptilian metabolic processes during food digestion are different than the mammalian and avian intake models and the effect on COC exposure is unknown.

For lead protective of the timber rattlesnake, the PCL Database calculated a soil Conservative PCL of 226.4 mg/kg (Table 17). The EPC for the riparian soil is 40.41 mg/kg, well below the PCL.

The PCL Database was also used in this SLERA to estimate PCLs for the other COCs and reptiles listed in the various habitats. These PCLs protective of reptiles were calculated using avian toxicity data (modified by an uncertainty factor of 0.1) and the specific reptile exposure assumptions.

The application of avian toxicity data to estimate risk to reptiles is highly uncertain; however, with the limitations currently in reptile-based toxicity data, this crude but likely conservative method can be used until reptile toxicity data becomes available. Based on this analysis, which conservatively uses NOAEL TRVs, there is minimal risk to the reptiles that may use the site.

> In this case study, after evaluation, there are no COCs posing risk to reptiles; however, if there were, the uncertainty analysis would be used to evaluate the validity of the reptile-based PCL and any uncertainties in its derivation.
>
> The person should determine if adequate ingestion-based toxicity studies for reptiles have emerged for other COCs. Additionally, the PCL Database will be updated as new validated and relevant research data becomes available.

Amphibians – Research has shown that amphibians, such as frogs and salamanders, tend to be sensitive indicators of environmental stress from contaminant exposure because of their unique life history and physiology (Alford, 2010).

There are no known protected species of amphibians present or potentially present at the site. Using the surface water benchmarks for assessment of risk to amphibians, there is minimal risk (see Tables 2, 4, and 5) associated with surface water (or groundwater) exposure.

However, there is some uncertainty since only the benchmarks based on water quality criteria were derived using multiple species, including amphibians, as noted on the Benchmark Tables. Other Texas surface water benchmarks, presented in Supporting Documentation for the TCEQ's Ecological Benchmark Tables and accompanying excel tables (TCEQ Publication RG-263b) were developed using the open literature and generally were not based on amphibians as the test species. This uncertainty is minimal because of the concentrations detected in the surface water and groundwater were significantly lower than the screening level benchmarks.

Amphibians were not assessed for exposure to sediment because of lack of toxicological information in the open literature. It is assumed that benthic organisms that are permanent residents of sediments would be more at risk and the use of benthic benchmarks and PCLs would be protective of amphibians exposed to sediment.

4.10 Ecological PCL Development (Required Element 9)

Sediment in the wetland was the only exposure area where the SLERA projected unacceptable risk to benthics and wildlife.

The wildlife-based PCLs for the spotted sandpiper in the wetland are 325 mg/kg for zinc and 20.04 mg/kg for TPAHs. The PCLs protective of the benthic community are 290 mg/kg for zinc and 12.2 mg/kg for TPAHs. The lower of the wildlife-based PCL and benthic PCL is the final ecological PCL for a COC on which the ecologically-based affected property will be defined (290 mg/kg for zinc and 12.2 mg/kg for TPAHs). Note that the final PCLs for zinc and TPAHs are protective of the spotted sandpiper, red-winged blackbird, and marsh wren, which have been shown to be at risk from exposure to these COCs.

Both cadmium and copper benthic PCLs (2.99 mg/kg and 90.3 mg/kg, respectively) are also final ecological PCLs, but the SLERA did not indicate that wildlife were potentially at risk from these COCs. Table 26 summarizes the final ecological PCLs for the wetland.

Table 26. Final sediment PCLs for the wetland.

Analyte	Sediment Wetland EPC (mg/kg)	Final Sediment PCL (mg/kg)	Receptors at Risk
Cadmium	3.34	2.99	Benthics
Copper	131.6	90.3	Benthics
Zinc	335.1	290	Benthics, spotted sandpiper
TPAHs	27.95	12.2	Benthics, spotted sandpiper, marsh wren, red-winged blackbird

4.11 Ecological Risk Management Recommendation (Required Element 10)

As discussed in ERAG (**14**), the SLERA concludes with a recommendation on how to manage ecological risk at the affected property. If all COCs and pathways have been eliminated by this point, there is no unacceptable ecological risk at the affected property. However, if ecological PCLs were calculated in the SLERA, the person must do one or more of the following:

1. Proceed to additional risk assessment under Tier 3 to develop site-specific ecological PCLs or to determine that there is no apparent unacceptable ecological risk at the affected property.

2. Compare the final ecological PCL values generated in the SLERA to relevant levels protective of human health (e.g., values generated from a baseline risk assessment, or TRRP human health PCLs generated at any tier) to determine the critical PCL and remediate to those levels.

3. Evaluate and state whether the human health remedy would eliminate all ecological exposure pathways.

4. Request permission to conduct an ESA if there is no significant human health risk (i.e., the ecological PCL is the critical PCL).

Other management strategies may be possible, but the ecological risk management recommendation must describe an action that will address any exceedances of ecological PCLs.

4.11.1 Risk Management of Terrestrial Habitat

Based on the Tier 2 SLERA there are no unacceptable risks to the terrestrial receptors from the affected property, pending hot spot removal (excavated and backfilled with clean soil). Other than the hot spot removal, ecological PCLs are not required for surface soil. Prior to excavation and backfilling of the hot spot, human health pathways (addressed in the APAR) will be evaluated to determine the critical soil PCLs for the site. Confirmation samples will be collected from the excavation to ensure the soil concentrations meet the critical PCLs.

4.11.2 Risk Management of Aquatic Habitat

Based on the Tier 2 SLERA, there are no unacceptable ecological risks associated with COCs in the riparian areas, Moon Creek surface water and sediment, or wetland surface water.

There is unacceptable ecological risk in the wetland sediments from: cadmium, copper, zinc, and TPAHs to the benthic invertebrates; zinc and TPAHs to the spotted sandpiper; and TPAHs to the marsh wren and the red-winged blackbird.

Table 26 summarizes the final ecological sediment PCLs for the wetland. Figure 10 shows the PCL exceedance zone for sediment.

The potential for ecological risks are to the benthic invertebrates and the small birds that feed upon them.

It is expected that a removal action within the wetland, under the traditional remediation process, would result in severe impacts to many other wildlife receptors that rely on the wetland for food and shelter. Rather than go forward with a removal action, the risk management recommendation is to request permission to conduct an ESA.

As an alternative to documentation in the risk management recommendation, the person could also write a letter to the TCEQ requesting an ESA be conducted.

In this case, TCEQ would then contact the Natural Resource Trustees to ensure that they have the SLERA and the request to pursue the ESA as a remedy. The Natural Resource Trustees for Texas, include the TCEQ, the TPWD, the Texas General Land Office, the U.S. Department of Commerce represented by the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Department of the Interior represented by the U.S. Fish and Wildlife Service, hereinafter collectively referred to as the "Trustees." The request is reviewed by the Trustees and depending on site specifics, it may be approved or denied. If denied, the person would then move forward with implementation of Remedy Standard A or B, as appropriate.

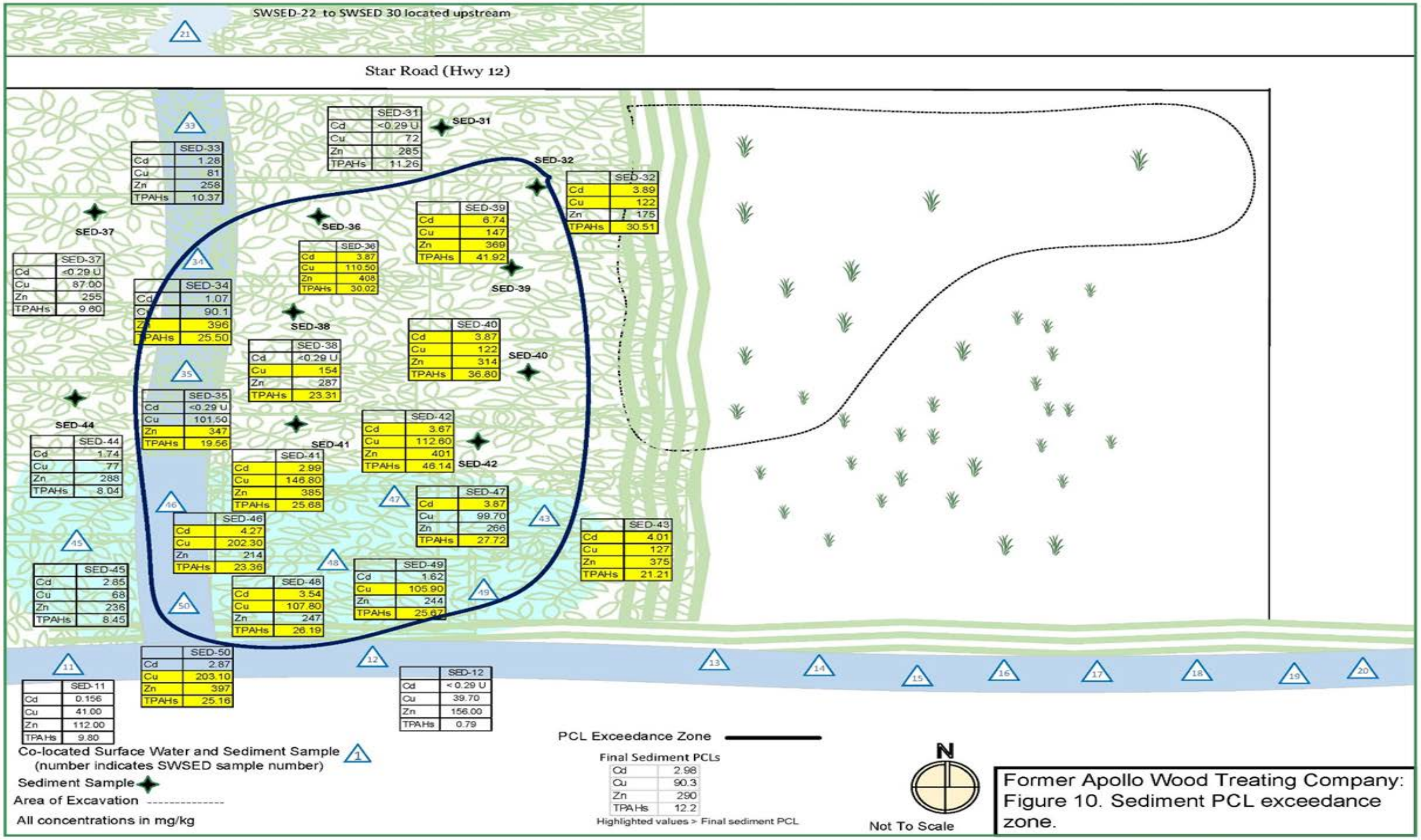

Figure 10. Sediment PCL exceedance zone.

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5.0 ESA Case Study

This ESA case study is for instructional purposes only. All assumptions and quantifications pertaining to this ESA are purely hypothetical and should not be assumed to apply to an actual ESA.

Because an ESA is a remedy, it is generally submitted to TCEQ as part of the Response Action Plan (RAP). The ESA should contain sufficient background information and site description and should not just refer to the APAR or SLERA for this information.

Further discussion of the ESA process and other types of ecological risk management (required element 10) is presented in **14** of ERAG.

A Tier 3 Site-Specific Ecological Risk Assessment (SSERA) can be completed prior to the ESA development with the specific purpose of reducing the size of the affected property by refining the ecological PCLs.

5.1 Introduction

As stated in the TRRP rule, after the ecological risk has been quantified, PCLs established, and the ecological PCL determined to be the critical PCL (i.e., the risk driver) or the only PCL, the person may act to remove, decontaminate, or control contaminated media and COCs.

However, to afford additional flexibility where concentrations of COCs do not exceed human health-based levels (either before or after a response action) but do exceed ecological PCLs, the TCEQ allows an ESA to be conducted, as described at 30 TAC 350.33(a)(3)(B) [9]. The performance of the ESA and any required compensatory ecological restoration must be done in cooperation with (and approval from) the Trustees

After the Trustees determine that an ESA is appropriate for the site, the request to conduct the ESA is approved by the TCEQ. The ESA represents a collaborative process between the person and the Trustees. The ESA considers remediation alternatives, including complete removal and natural attenuation. The ESA identifies the ecological impacts associated with each alternative and provides a framework for developing compensatory restoration if the “leave in place alternative” is selected as the best remedy based on a variety of evaluation factors.

[9] According to 30 TAC 350.33(a)(3)(B), an ESA must be conducted whenever concentrations of COCs that exceed ecological PCLs are proposed to be left in place with the potential for continuing exposure.

NOAA's Habitat Equivalency Analysis (HEA) is often used in the ESA to compare the negative and positive effects of implementation of the evaluated remediation alternatives. An HEA is an economic model originally developed by NOAA for use in scaling restoration projects to compensate for potential ecological injuries in actions related to natural resource damage. It is a services-to-services scaling method that allows direct comparison of the services provided by one kind of habitat to another.

5.1.1 Purpose

This report represents the ESA for the Apollo Wood Treating Company's (AWTC) former facility in Sunny County, Texas. This ESA is designed to address exceedances of the ecologically-based PCLs for cadmium, copper, zinc, and TPAHs in sediment of the wetland adjacent to the AWTC property. This ESA was developed under Remedy Standard B [30 TAC 350.33 (a)(3)(B)] based on the results of the approved Tier 2 SLERA.

5.1.2 Site Description

From 1950 until 2004, the AWTC manufactured treated utility poles, foundation pilings, and lumber with creosote and pentachlorophenol.

The AWTC property is adjacent to a large, permanently inundated wetland that lies in a depressional area that receives surface runoff from upstream (north). Although surface water runoff from the site is primarily to the south, the proximity of the wetland (and its riparian area) to the former sludge pits made it susceptible to runoff from the facility during significant rain events. In addition, past disposal practices at the former facility could also have contributed to releases to the wetland.

A more detailed site description is available in 2.0 of this publication and is not repeated here for efficiency.

The person should include an adequate site description, maps, figures, site history, and habitat descriptions in the ESA; they should also refer to other relevant documents as necessary.

Site information presented thus far includes the following:

1. COCs were systematically released over an extended period from the wood-treating facility to on-property soil and groundwater and to off-property riparian soil, surface water, and sediment in an adjacent creek and wetland.
2. The releases from the facility were terminated through source control at the site.
3. A Tier 2 SLERA was conducted using analytical results from samples collected from all potentially impacted media.

4. The SLERA used the Ecological PCL Database to determine that there are no unacceptable risks to the terrestrial receptors from the affected property or from the riparian areas.
5. Additional evaluations showed no risk to aquatic receptors in Moon Creek surface water and sediment, or to wetland surface water.
6. There is unacceptable risk in the wetland sediments from several metals and TPAHs to the benthic invertebrates and the small birds that feed upon them.
7. The wetland provides food and habitat for a variety of small and large birds, mammals, fish, and invertebrates.
8. Because of biodegradation of PAHs and sedimentation of the metals, these risks are projected to dissipate to acceptable levels in 25 years.

5.1.3 Summary of the SLERA

The Tier 2 SLERA was completed under the required elements of the TCEQ's ERA Program under the TRRP rule at 30 TAC 350(c) (required elements 1 through 10).

The SLERA concluded that concentrations of metals and TPAHs within sediments located in the wetland adjacent to the facility pose unacceptable risk to benthic invertebrates and the small birds that feed on them. This conclusion was based on the PCLs developed in required element 9 of the SLERA for cadmium (2.98 mg/kg), copper (90.3 mg/kg), zinc (290 mg/kg), and TPAHs (12.2 mg/kg). A protective concentration level exceedance (PCLE) zone of 2.50 wetland acres was determined. The ecological risk management recommendation (required element 10) was to request permission to pursue the development of an ESA.

Based on the previous site investigations and the Tier 2 SLERA, COC-impacted sediments are primarily located west and southwest of the remediated area of the former facility. The area of concern, with COC-impacted sediment, was estimated to be 108,900 square feet with dimensions of approximately 344 feet long and 317 feet wide. The average depth of the overlying surface water in this area is approximately six inches. The thickness of the COC-contaminated sediment was estimated to be two feet deep, which accumulated over a period of 50 years. The PCLE zone consists of very fine-grained sediment (e.g., silt and clay), with areas of submerged rocks, dense vegetation, and debris (i.e., submerged sticks one to two inches in diameter).

5.1.4 Removal, Decontamination, Control

Under TRRP, risk management recommendations are confined to the response options available under Remedy Standard A or B. The remedy must address both human and ecological receptors, as appropriate. For each COC where the ecological PCL is determined to be the critical PCL and the corresponding media concentration of that COC exceeds that PCL, the person must: (1) consider the need for further assessment (i.e., a Tier 3 SSERA), or (2) select one or a combination of the available remedies under the TRRP rule that include remove, decontaminate, control, or conduct an ESA.

Given the assumptions above (and no or minimal risks to human health), the site risk manager must consider all appropriate risk-management options. The specific remedy options are summarized in **14.1** of ERAG and discussed in detail in 30 TAC 350, Subchapter B.

Options to remove or control (e.g., excavation or capping) the sediment exceeding the ecological PCLs will eliminate risks to the invertebrates and the small birds that eat them by breaking the exposure pathway. However, the wetland is also inhabited by many other species not at risk (e.g., larger birds, mammals, reptiles). These physical options would result in the destruction of a viable habitat currently providing many valuable direct and indirect ecological services (additional discussion of ecological services is presented in 5.2). Moreover, these options might create a condition worse than that posed by the COCs. Last, both options can be extremely costly.

Generally, decontamination options include natural attenuation, degradation, or a variety of *in situ* methods. Costs associated with natural attenuation (or degradation) would be small compared to removal costs but could result in the continuing exposure of receptors to COCs above ecological PCLs for years. Other *in situ* remediation methods, such as phytoremediation, would likely not be appropriate in a wetland.

A detailed evaluation of remediation alternatives as applied to the wetland is presented in 5.4.

5.2 Ecological Services at the Site

The freshwater wetland located adjacent to the former facility provides food and habitat for a variety of small and large birds, mammals, reptiles, amphibians, fish, and invertebrates. The wetland provides numerous ecological services common to a freshwater wetland. These services include:

- Water quality improvements as the water flows through the wetland and out into Moon Creek.
- Habitat for a diverse benthic community that serves as a food source for birds, mammals, reptiles, and amphibians.
- Nesting and foraging habitat for birds, mammals, reptiles, and amphibians, including the white-faced ibis – a protected species.

Physical remediation (e.g., excavation) in areas of elevated cadmium, copper, zinc, and TPAHs within the wetland would eliminate or diminish this flow of ecological services for a considerable period. Additionally, the disturbance by heavy equipment associated with the remediation would impact area wildlife.

5.3 Quantification of Ecological Services Reduction

The Tier 2 SLERA concluded that wetland sediment is the only medium to have unacceptable ecological risk, and therefore, potential injury[10] to natural resources (e.g., land, fish, wildlife, water).

On this basis, the service losses were calculated only for those resources present in wetland sediment. Service losses were estimated with available data (e.g., sample results indicating a depauperate benthic community). The PCLE zone was delineated based on the final ecological PCLs defined in the SLERA. Figure 10 presents the approximate PCLE zone of 2.5 acres for cadmium, copper lead, zinc, and TPAHs in freshwater wetland sediment.

> Equivalency-analysis tools should be used to compare the negative and positive effects of implementation of these various remedial options. One of the most readily accessible tools is the HEA.
>
> Through a HEA, the person can evaluate and quantitatively rank the most environmentally protective response options (in discounted service-acre-years or dSAYs) in comparison to the ecological-service reductions (or theoretical risks) currently posed by the COCs.
>
> Concurrently, the person can evaluate and rank potential restoration projects that create ecological credits, which seek to replace or offset debits at the affected property.
>
> The EPA's Science Advisory Board's (SAB) Committee on Valuing the Protection of Ecological Systems and Services has been working on a study to assess Agency valuation needs and the current state of the art and science of valuing protection of ecological systems and services. In its draft report it has been working to identify key areas for improving knowledge, methodologies, practice, and research. One of these methodologies for determining compensation needed to replace ecosystem services lost through a natural resource injury is the HEA. An excerpt from this SAB draft report provides a thorough explanation of HEA and associated inputs and can be found at: <yosemite.epa.gov/Sab/Sabproduct.nsf/WebFiles/HEA/$File/HEA-03-09-09.pdf>.
>
> The use of other equivalency-analysis tools will need to be reviewed and approved by the Trustees prior to the analysis.

[10] *Injury* is defined in 43 Code of Federal Regulations Section 11.14(v) as "a measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a discharge of oil or release of a hazardous substances, or exposure to a product of reactions resulting from the discharge of oil or release of a hazardous substances."

The ESA process addresses potential losses of ecological service associated with COCs in a habitat or from remedial activities. HEA is based on an economic valuation model. In concept, it is a summation of the proportional change in services relative to baseline services, usually calculated annually, and discounted to present value. The services lost or gained are summed over the period of interest, scaled to the habitat of reference, and multiplied by the number of acres of area. Several important requirements for the HEA are:

- Calculating the service losses (or gains), discounted to present day value and accumulated over the period of interest.
- Calculating injury based on acre-years, discounted through time.
- Calculating the services relative to the baseline services that would exist "but for" the source of injury in question.
- Assuming all ecological service flows from a given habitat are represented in aggregate by the habitat being evaluated.
- Comparing services from one time or place – from one alternative to another, or from injuries at the site to compensatory restoration at another property – is achieved by scaling factors that weight the relative value of one habitat to another based on the services each provides.

All HEA calculations will need to be developed with input from the Trustees and must be included in the ESA.

HEA can directly compare one given remedial action to another in terms of ecological services resulting from those actions, because the model has made all ecological service flows equivalent. The implicit assumption of HEA is that if one remedial action has a higher ecological services value than another, then that action is preferable. These assumptions were used because the ESA is comparing the effects of remedial alternatives on the same ecosystem.

The inputs to the HEA include the following:

1. Discounting factor
2. Commencement date
3. Areal extent of injury
4. Severity of the impact
5. Duration of impact (in years)

Discounting Factor – A standard discounting factor of 3.0 percent has been applied in other HEA and is proposed for the discounting factor in this ESA.

Commencement Date – Service reductions are calculated to begin in 2016, with the development and approval of the PCLs and Trustee approval of the request to pursue an ESA (from the risk management recommendations in the Tier 2 SLERA). The HEA model was run for a period of 100 years.

Areal Extent of Injury – Based on the sediment samples collected during the various investigations of the wetland, the area of concern with metal and PAH-impacted sediment was estimated to be approximately 2.5 acres.

Severity of the Impact – The sediment samples from the freshwater wetland were analyzed for metals and PAHs. The resulting concentrations of COCs exceeded the ecologically-based PCLs for cadmium, copper, zinc, and TPAHs. Table 21 provides the 95 percent UCL exposure point concentration as compared to the ecological PCLs. There are exceedances of all the PCLs protective of benthic invertebrates. For TPAHs, there are also exceedances for small birds. Appendix A presents the data for each sample.

Duration of Impact – Sediment sampling data collected from the site indicate concentrations of cadmium, copper, zinc, and TPAHs are stable. However, it is anticipated that substantial degradation of the PAHs within the wetland would occur over the next 25 years. Metals are extremely stable contaminants but may become bound and biologically unavailable under natural environmental conditions. In addition, sediment deposition and subsequent burial of COCs is also likely to occur over this timeframe within the wetland. Overall, degradation or sedimentation (burial) of contaminated sediments is expected to occur within 25 years.

5.4 Evaluation of Remediation Alternatives

The purpose of this evaluation of remediation alternatives is to summarize the costs, lost services, and benefits associated with the remedial alternatives under consideration. Additionally, the evaluation considers how each remedial alternative addresses the exceedances of the sediment PCLs within the wetland.

One of these alternatives is recommended as the preferred remedy. The recommended remedial alternative balances the:

- Severity of remaining ecological risk.
- Length of time necessary for the affected property to recover to pre-release conditions (i.e., baseline).
- Appropriate compensation for the public.
- Cost.

To evaluate which response action will be selected, the person should compare the active and passive alternatives, available under Remedy Standard B, that are realistic and feasible.

Realistic estimates of the positive and negative effects of implementing an option must be demonstrated as part of the evaluation. See **14.2.2** in ERAG for additional discussion on response actions.

5.4.1 Monitored Natural Recovery (Remedial Alternative 1)

This remediation alternative would leave the contaminated sediment in place within the wetland and assumes that naturally occurring, ongoing processes (e.g., degradation) would continue to reduce the exposure of ecological receptors to COCs in sediment through time. In addition, natural sedimentation and sediment mixing would occur, which would also limit exposures and concentrations of COCs.

In this alternative the:

- Physical removal would not be used, and there would be no disturbance and resettling of contaminated sediment.
- Costs associated with this alternative would involve periodic monitoring of the site conditions for 25 years to show that sedimentation, biodegradation, and attenuation are continuing to limit exposures though time.
- Injuries to ecological services flow are assumed to decrease through time.
- Natural recovery for sediments is assumed to occur over a period of 25 years. This recovery rate leads to a decrease in injury over time.

Based on the HEA input parameters discussed previously, the total lost services provided by the contaminated sediment of the wetland would be 50 dSAYs if the COCs are left in place. The HEA was modeled for a period of 100 years following approval to pursue an ESA in 2016. Long term monitoring costs include sampling, analytical costs, and reporting.

The person must provide an estimated cost for monitoring. They must also estimate and justify the period for monitoring and natural recovery. All HEA calculations should be included as an appendix to the ESA.

5.4.2 Removal (Remedial Alternative 2)

The removal alternative would involve excavating and disposal of an average of two feet of sediments from the PCLE Zone. Because of the dense vegetation between Highway 12 and the PCLE Zone, a construction access road would have to be built in an unimpacted area of the wetland to remove the sediment.

This remedial alternative would also involve management of the surface water flowing into the area with construction of a temporary cofferdam (a watertight enclosure pumped dry to permit construction work below the waterline). Following excavation, the:

1. Contaminated sediment would be dewatered and transferred to trucks for disposal at an off-site landfill.
2. Wetland would be reconstructed by bringing in appropriate fill and replanting with wetland plant species.
3. Cofferdam, and any fill for construction of the access road into the wetland, would be removed.
4. Wetland would be restored appropriately.

The benthic community would be completely disrupted, due to the excavation activities, but would be expected to recover if sufficient water was available. Recolonization of the disturbed area by macroinvertebrates would occur through various sources including downstream drift, upstream migration from adjacent areas, and migration from deeper sediments.

It is estimated that the recovery time for a complete invertebrate community to become reestablished under the excavation alternatives is three years. This estimate is based on an overview of freshwater case studies that reviewed recovery times of macroinvertebrate communities within lentic and lotic environments due to chemical and nonchemical stressors.

Recovery of macroinvertebrate total density, biomass and species richness is expected to be at 80 percent after one year, 95 percent after two years, and 100 percent three years after excavation is completed (Niemi et al., 1990).

As the invertebrate community recovers, the area would become more attractive to wildlife. This alternative results in the lowest lost services (25 dSAYs) of the four alternatives evaluated.

> The person must provide an estimated cost for the excavation project, including disposal fees and replacement of the wetland. The person must also estimate a timeline for the project and include time for acquiring the appropriate permits.
>
> All HEA calculations should be included as an appendix to the ESA.

5.4.3 Capping (Remedial Alternative 3)

Isolation of contaminated sediment would involve capping the PCLE Zone with clean clay or fill material. The cap would physically segregate the contaminated sediments, stabilize them against erosion potential, and prevent redistribution of COCs through resuspension.

The particle size and layer of thickness of the fill material is determined based on the maximum depth, flow, velocity, bottom configuration, presence of vegetation, likelihood of future disturbance from external factors (e.g., future construction), and ability to accurately control the placement process.

Approximately one foot of clean fill material would be placed over the PCLE Zone altering the flow of surface water in the wetland. It is assumed that no compaction requirements would be needed for the fill material.

Like the excavation alternative, a construction road and temporary cofferdam would have to be installed. With this method the:

- Impacted sediments would be left in place, avoiding the handling, transportation, and disposal costs of the sediments and associated water.
- Existing creek would be rerouted so that it does not erode the capped material.
- Cap would have to be monitored for effectiveness for 25 years following implementation.

The total lost services provided by the contaminated sediment in the wetland would be 35 dSAYs if sediment capping was undertaken in 2017.

The increase in lost services under this alternative, compared to the excavation alternative, is attributable primarily to the decrease in wetland services. This is because the area could not be returned to a wetland habitat and because the extent of impacted wetland includes habitat outside of the PCLE zone needed for construction equipment access.

This alternative would result in considerable disturbance to the vegetation of the wetland and potentially along the riparian area.

> The person must provide an estimated cost for the capping project and monitoring. The person must also estimate a timeline for the project and include time for acquiring the appropriate permits.
>
> All HEA calculations should be included as an appendix to the ESA.

5.4.4 Compensatory Restoration with Natural Recovery (Remedial Alternative 4)

Under Remedial Alternative 4, the PCLE Zone would be left in place to recover naturally via sedimentation and biodegradation processes, but the injured ecological services associated with the PCLE Zone would be offset with a compensation project in the watershed. This noninvasive alternative would result in a net environmental gain, as required by the TRRP rule, 350.33(a)(3)(B), while being cost effective.

Based on the results of the HEA, an ecological "debit" of 50 dSAYs exists for lost ecological services associated with the natural recovery remediation alternative. This is greater than the lost ecological services associated with the excavation or capping alternatives. Therefore, for this alternative to be potentially feasible, it must be accompanied by some form of compensatory restoration.

Although this alternative does not remediate the contaminated sediment within the impacted area of the wetland, it does offer some environmental benefits over the other remediation alternatives. The excavation and capping alternatives likely will result in the suspension of COC-contaminated sediment particles into the overlying water column. These contaminated particles may subsequently be deposited into non-impacted areas of the wetland. In addition, the excavation and capping alternatives will result in removal of wetland vegetation and disturbance of the riparian area to provide appropriate access for equipment; whereas, any additional lost services from this alternative would be offset by the overall gain in services.

Proposed Compensation Project – The proposed compensation project is enhancement of the riparian corridor adjacent to the wetland. The planting of woody shrubs and trees along the riparian area will enhance the ecological attributes by providing a greater buffer, promoting water quality, contributing detritus used by the invertebrate community, and providing nesting and foraging habitat for wildlife.

Planted vegetation would consist of native species and these areas would be left in a "natural state." The width of these buffer zones would be a minimum of 15 to 25 feet, to provide greatest water quality and habitat benefits.

Previous studies have documented that macroinvertebrate diversity is correlated by factors associated with surrounding land use (e.g., nutrient input) with naturally vegetated areas providing the greatest benefit in terms of maintaining water quality, reducing sedimentation, and providing valuable habitat for wildlife.

The person should describe the potential compensation project in as much detail as possible. Calculate the service gains and describe the obstacles and benefits for each potential project. It is important that the proposed project increase the ecological benefits within the same watershed as the injury and provides similar ecological services.

The person will work with the Trustees to determine the compensation project.

5.4.5 Summary and Selection of Preferred Alternative

The table below summarizes the results of the ESA alternatives.

Alternative	Discounted Injuries (dSAYs)	Estimated Cost (dollars)	Time to Complete	Monitoring Required	Permit Required	Chemical Effectiveness
1. Monitored Natural Recovery	50	110,000	NA	25 years	No	None
2. Removal	25	9,160,000	1 year	None	Yes	Total

Table 27. ESA Alternatives

Alternative	Discounted Injuries (dSAYs)	Estimated Cost (dollars)	Time to Complete	Monitoring Required	Permit Required	Chemical Effectiveness
3. Capping	35	550,000	1 year	25 years	Yes	Total
4. Compensation Restoration with Natural Recovery	To be determined (TBD) [11]	TBD	1 year	Minimal	No	None

Remediation alternatives evaluated included monitored natural recovery, excavation, capping, and compensatory restoration with natural recovery. This ESA evaluated the remediation alternatives by determining several factors, including the:

- technical (chemical) effectiveness
- environmental impacts (injuries)
- permitting issues
- general costs

Remedial Alternative 4 (Compensatory Restoration with Natural Recovery) is the preferred choice, when compared to the more invasive and substantially more expensive remedial alternatives under consideration. This alternative results in the restoration and management of benthic ecological services and is based on the information presented in the preceding sections, and the summary table above.

5.5 Conclusions and Recommendations

The results of the previously conducted SLERA concluded that contaminated sediments present within the wetland may adversely affect benthic invertebrates and the small birds that feed on them. Based on the evaluated data, the SLERA identified the COCs and developed benthic PCLs for cadmium (2.99 mg/kg), copper (90.3 mg/kg), zinc (290 mg/kg), and TPAHs (12.2 mg/kg). The identified area of impaired sediments is approximately 2.5 acres. The risk management recommendation was to request permission to conduct an ESA.

Following Trustee approval to develop an ESA in 2016, the ESA recommended the evaluation of four remediation alternatives:

1. monitored natural recovery
2. excavation
3. capping
4. compensatory restoration with natural recovery

[11] The "credit" will exceed the injuries estimated under the compensatory restoration with natural recovery alternative.

Each of the remediation alternatives has positive and negative aspects. For example, the alternatives involving excavation and capping are assumed to result in COC concentrations less than the PCLs. However, these alternatives are invasive and expensive compared to the two leave-in-place options.

The total lost services provided by the contaminated sediment in the wetland would be 25 dSAYs if sediment excavation occurred in 2017. This alternative resulted in the lowest lost services of the four alternatives evaluated in the ESA. The lost services under this alternative are attributable primarily to the increase in the areal extent of the disturbed sediment substrate due to the construction of the temporary cofferdam. The cofferdam and dewatering operations would minimize the associated turbidity and deposition of contaminated sediments. However, this alternative would result in considerable disturbance to the vegetation of the wetland, and potentially along the riparian area.

It is not possible that the benthic invertebrate community would recover under the capping alternative because the capped area would be above the natural grade of the wetland. The capped area could be planted with native grasses and would develop a soil invertebrate community, but not a benthic invertebrate community. The total lost services provided by the contaminated sediment would be 35 dSAYs if sediment capping was undertaken in 2017. The increase in lost services under this alternative compared to the excavation alternative is attributable primarily to the long-term decrease in services because the area could not be returned to grade and would not be a wetland.

The total lost services provided by the contaminated wetland sediment would be 50 dSAYs if the contamination is left in place. The HEA was modeled for a period of 100 years and assumes that: concentrations of COCs in sediment would remain elevated above the PCLs; the benthic community would continue to be adversely affected during a 25-year period. This alternative resulted in the greatest lost ecological services.

To consider the natural recovery (leave-in-place) alternative as a potentially viable option for addressing the contaminated sediment, mitigation for the increased lost ecological services was evaluated. A compensatory project is presented on a conceptual basis in this ESA—the enhancement of riparian buffer areas. Existing riparian areas adjacent to the wetland would be enhanced for water quality, wildlife, and invertebrates by the planting of woody shrubs and trees. It is assumed that the buffer zone area is initially planted with native tree saplings, shrubs, and herbaceous vegetation in 2017 with this area providing 5 percent service gain after one year. The service gain is estimated to increase each year as the woody vegetation matures until the maximum services are reached.

Based on the total dSAYs of 50 calculated for the natural recovery alternative, a compensatory riparian buffer area of 7 acres would be required to offset the lost services under this option. The specific details regarding the selected compensatory restoration alternative will be further developed as a component of the RAP.

Sediment removal activities associated with the excavation and the capping alternative would directly impact the benthic invertebrate community residing within the affected area, while disturbing surrounding unimpacted areas for construction equipment access.

It is therefore concluded that the least invasive and most cost-effective option would be leaving the contaminated sediment in place in conjunction with a compensation project, as well as potentially offering additional benefits over disturbing the impacted substrate

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