Prepared for:

Montrose Chemical Corporation of California

Bainbridge Island, Washington

CONCEPTUAL SITE MODEL FOR THE MONTROSE CLOSED PONDS SITE ASSESSMENT AREA

HENDERSON, NEVADA

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Conceptual Site Model to Address Soils for the Former Montrose Closed Ponds Site Assessment Area Henderson, Nevada

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I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession, and to the best of my knowledge, comply with all applicable federal, state and local statutes, regulations and ordinances.

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24 April 2009

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LIST OF ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
BCL	Basic Comparison Level
BHC	Lindane
Converse	Converse Consultants
CPA	Closed Ponds Area
CSM	Conceptual Site Model
DNAPL	Dense Non-aqueous Phase Liquid
ECA	Environmental Conditions Assessment
ECI	Environmental Conditions Investigation
EPA	United States Environmental Protection Agency
FID	Flame Ionization Detector
foc	Fraction Organic Content
ft bgs	Feet Below Ground Surface
GAC	Granular Activated Carbon
gpm	Gallons per Minute
GWTS	Groundwater Treatment System
Hargis	Hargis & Associates, Inc.
HHRA	Human Health Risk Assessment
K_H	Henry's Law Constant
LOU	Letter of Understanding
MCL	Maximum Contaminate Level
µg/l	Microgram per Liter
mg/kg	Milligram per Kilogram
mm	Millimeter
Montrose	Former Montrose Chemical Company of California
NAPL	Non-Aqueous Phase Liquid
NDEP	Nevada Division of Environmental Protection
OSSM	Olin, Stauffer, Syngenta, and Montrose
PCBs	Polychlorinated biphenyls
PID	Photo Ionization Detector
ppm	Parts per Million
PVC	Poly Vinyl Chloride
Qal	Quaternary Alluvium
RAO	Remedial Action Objective
RAS	Remedial Alternative Study
RBCs	Risk-based Concentrations
RCRA	Resource Conservation and Recovery Act

RSLs	Regional Screening Levels
SBR	Still-bottom Residue
SMC	Stauffer Management Company
SRCs	Site-Related Chemicals
SVE	Soil Vapor Extraction
SVOCs	Semi-Volatile Organic Compounds
TDS	Total Dissolved Solids
xMCF	Transitional upper Muddy Creek formation
UMCf	Upper Muddy Creek formation
USCS	Unified Soil Classification System
VOCs	Volatile Organic Compounds

1. INTRODUCTION AND OVERVIEW

1.1 Document History

This Conceptual Site Model (CSM) Report addresses soils, groundwater, and vadose zone issues for the Closed Ponds Area (CPA) of the former Montrose Chemical Company of California (Montrose) facility (Site) located in Henderson, Nevada (Figure 1-1). This document is a second revision of Montrose's Conceptual Site Model for the Montrose Closed Ponds Site Assessment Area dated April 11, 2008 and then revised as of January 16, 2009. The Nevada Division of Environmental Protection (NDEP) commented on the first revision in a letter dated March 11, 2009 and requested development and submittal of a revised document. A letter containing responses to those comments is included in this document as Appendix A.

The initial draft of the CSM submitted to NDEP in April 2008 included: 1) a CSM that addressed soil and groundwater issues at the CPA; and 2) a preliminary Remedial Alternative Study (RAS) for groundwater at the CPA. Based on comments and discussions with NDEP, this revised document is intended to provide only a comprehensive CSM for the CPA. The RAS process for the CPA will continue following NDEP's approval of this CSM and the RAS Process document, which is currently under development by the OSSM (Olin, SMC, Syngenta and Montrose) Companies.

1.2 CPA Source Area-Specific CSM Objectives

This report is designed to provide a comprehensive CSM for the CPA as shown on Figure 1-2. Consistent with the American Society for Testing and Materials (ASTM) Standard Guide for Developing Conceptual Site Models for Contaminated Sites (ASTM, 2008) the components of this CSM include:

- The physical, lithologic and hydrostratigraphic setting;
- The operational history and decommissioning of the ponds;
- A summary of previous environmental investigations;
- An evaluation of the potential exposure pathways and potential receptors;
- An analysis of data gaps;
- Discussion that addresses the technical infeasibility (and NDEP's concurrence) for the collection of additional data within the CPA boundary; and
- A discussion of the path forward for the CPA.

It should be noted that laboratory data derived from historical investigations have not been processed through the formal Data Usability Evaluation.

2. BACKGROUND

2.1 Physical Setting

The Former Montrose CPA resides within the geographical boundary of the Olin property, as shown on Figure 1-1. The CPA Site Assessment Area, as defined for the purpose of this CSM and the future RAS Process, spans an area that is approximately 1150 feet long by 450 feet wide (approximately 20 acres) and is illustrated on Figure 1-2. The CPA has been surrounded by a locked and fenced enclosure since the former ponds were decommissioned and capped during the 1980s.

To understand the lithology and hydrostratigraphy at the CPA, several cross-sections were constructed. These cross-sections are illustrated on Figures 2-1 and 2-2. These cross-sections include several types of information: Unified Soil Classification System (USCS) designation, flame ionization detector (FID)/photo ionization detector (PID) reading obtained during drilling, well construction information, and water level data. Boring logs from soil borings or monitor wells that were installed during the previous investigations were used to construct these cross-sections; available logs for this area are presented in Appendix B. Additionally, a 3-D block diagram illustrates the conceptual setting of the CPA relative to the lithologic and hydrostratigraphic zones and is provided on Figure 2-3.

Based on this information, two of the three hydrostratigraphic units described in NDEP's January 6, 2009 Letter (NDEP, 2009) have been encountered at the CPA. The hydrostratigraphic zones are depicted on Figures 2-1 and 2-2. The lithologic units encountered by exploratory borings in the CPA vicinity include the Quaternary Alluvium (Qal), the transitional Muddy Creek formation (xMCf) and the Upper Muddy Creek formation (UMCf). The Qal in the CPA consists predominantly of unconsolidated silt, sand, gravel, cobbles, and caliche. The xMCf consists of reworked fine-grained facies of the UMCf including clay, silt, and fine-grained sand. The UMCf consists of predominantly low permeability, unconsolidated to semi-consolidated silt and clay, with occasional thin, laterally discontinuous interbeds of fine- to medium-grained sand with silts and gravels.

The water table in the CPA intersects each of these lithologies. In the south, upgradient of the former ponds, the Shallow Zone (water table) is within the UMCf. Moving north, downgradient, to the northern CPA boundary, the water table intersects the xMCf and the Qal. Consistent with the NDEP's January 6, 2009 letter (NDEP, 2009), wells

installed in the CPA are completed within the Shallow Zone and Middle Zone hydrostratigraphic units.

The third hydrostratigraphic unit, the Deep Zone, occurs at depths of approximately 275 – 300 feet bgs in other areas of the Site (Hargis, 2008a). This unit was not encountered in the CPA, because the deepest drilling in the area to date was to a depth of 150 feet bgs. However, as discussed later in the document, an upcoming drilling program will target this zone in the northern part of the CPA.

2.2 Pond Construction and Operation

When operational, the CPA consisted of six different ponds that were constructed during the 1970s and associated conveyance pipelines that conveyed process waste water to the five evaporation ponds. Beginning in November 1973, Montrose constructed Ponds 1 through 4 on property leased from Stauffer Management Company (SMC). This lined pond system was completed and put into service by May 1976 to receive acid waste streams from: 1) the dichlorobenzil process washing and product drying steps; and 2) sulfide wastes from the polychlorinated benzenes and chloral processes. Construction details for Ponds 1 through 4 are provided in Exhibit A.

Concerns over the mixing of sulfuric acid and hydrochloric acid wastes that occurred in Ponds 1 through 4 from 1976 to early 1979 led to the construction of Pond 5 in March 1979. Pond 5 received the hydrochloric acid wastes along with Pond 2, which was converted between August and October 1979 to handle Pond 5's overflow. Pond 6 was constructed in August 1976 to receive polychlorinated benzene still-bottom residues from the chlorinated benzene distillation process. Prior to mid-1976, this material was disposed of at the BMI Landfill (Converse, 1993). Construction details for Pond 5 are provided in Exhibit B.

The operation of the ponds and their decommissioning process are discussed in Sections 2.3 and 2.4 as source areas, while Section 2.5 describes other potential source areas in the CPA.

2.3 CPA Source Areas

Information regarding the contents of the ponds during their operation was obtained from the Phase I Environmental Conditions Assessment (ECA) Report prepared by Converse Consultants (Converse, 1993). The information is summarized below for groups of ponds that received similar wastes. The wastes that were received by the ponds are discussed along with the more mobile constituents associated with those

wastes. The more mobile constituents have a greater potential mass flux into groundwater (potentially resulting in higher concentrations) and would likely be detected first in the downgradient monitor wells.

2.3.1 Ponds 1, 3, and 4

Ponds 1, 3, and 4 mainly received dichlorobenzene wash water, waste acid streams, sulfuric acid, and chloride wastes. The more mobile inorganic constituents associated with these wastes are sulfate from sulfuric acid and chloride from chloride wastes and phosphorous trichloride. Potential organic constituents from these three ponds would have included: the dichlorobenzenes, chlorobenzene, and chloroform, based on the presence of these compounds in the waste stream directed to the ponds.

2.3.2 Ponds 2 and 5

Ponds 2 and 5 were used for hydrochloric and sulfuric acid wastes, acidic chlorinated benzene wastes, and wastes from the chlorobenzene processes. The more mobile constituents associated with these wastes are chloride from hydrochloric acid, polychlorinated benzene acid wash, "chloride-bearing wastes," and the hydrochloric acid process wastes. Potential organic constituents from these ponds would have included: benzene, the dichlorobenzenes and chlorobenzene.

2.3.3 Pond 6

Pond 6 was used to store still-bottom residue (SBR) from the chlorinated benzene distillation process from 1976 to 1981. SBR is a tar-like substance containing a wide range of chlorinated benzenes including chlorobenzene, dichlorobenzene, trichlorobenzene, and polychlorinated biphenyls (PCBs). The more mobile organic constituents of SBR would be the dichlorobenzenes and chlorobenzene.

2.4 Pond Decommissioning History

The ponds at the CPA were decommissioned in the 1980s. A detailed description of the ponds' construction, operation, and decommissioning is presented in the *Draft Phase II Environmental Conditions Investigation (ECI) Report, Former Montrose Facility, Henderson, Nevada* (SECOR, 1997). A brief summary of the decommissioning of the ponds is presented in the sections below, with information taken from the Phase II ECI Report prepared by SECOR (SECOR, 1997) unless specified otherwise:

2.4.1 Ponds 1, 3, and 4

These ponds were operated from 1976 through June 1983. The decommissioning of these ponds began in October 1983 and was completed in December 1989. The decommissioning process began by evaporating the liquid contents of the ponds to near dryness followed by thoroughly mixing the residual sludge with crushed limestone to neutralize residual acid. This activity was completed in January 1984 and used an estimated 33,250 cubic yards of limestone fill. The ponds were then filled with native fill in compacted lifts in the partially-filled impoundments to restore them to original grade. The decommissioning of these ponds was completed in 1989 with the placement of an engineered cap, installed concurrently with the engineered cap constructed for Ponds 2 and 5 (see Section 2.4.2).

SECOR reports that at the same time the cap was being installed over Ponds 2 and 5 in 1989, an additional cap was placed atop Ponds 1, 3, and 4. This additional cap for Ponds 1, 3, and 4 is reported to be limited to a compacted, graded sand cap. In addition, cap construction drawings for Ponds 2 and 5 included with the Phase II ECI report show a polyvinyl chloride (PVC) membrane only extending across Ponds 2 and 5. The *Phase I ECA for Former Montrose Chemical Corporation Facility, Henderson, Nevada* prepared by Converse Consultants describes that an engineered cap, including a PVC membrane, was constructed atop Ponds 1, 3, and 4 (Converse, 1993). This cap is reported to include: a 12-inch layer of compacted clay overlain, in turn, by a 20-millimeter (mm) PVC membrane overlain, in turn, by a 9-inch layer of sand and 12-inches of native fill (Converse, 1993).

During active operations, wastes contained in Ponds 1, 3, and 4 were classified as Resource Conservation Recovery Act (RCRA) hazardous on the basis of corrosivity. Neutralization of the acid in these ponds during decommissioning eliminated the requirement for a RCRA Post-Closure Permit and in May 1987, the NDEP issued a determination that the ponds were adequately neutralized and did not require "further closure as RCRA impoundments" (NDEP, 1987).

2.4.2 Ponds 2 and 5

Pond 2 was constructed in December 1975 and Pond 5 was constructed in March 1979. During active operations, wastes contained in these ponds were classified as RCRA hazardous on the basis of corrosivity and toxicity. Accordingly, both ponds were decommissioned in 1989 pursuant to RCRA regulations, in accordance with 40 CFR 264 Subpart N, as if they were hazardous waste landfills. Decommissioning of Ponds 2

and 5 was performed in accordance with NDEP-approved "Closure and Post-Closure Plans," dated December 12, 1986 and May 20, 1987, respectively; NDEP's letter to Montrose, dated August 18, 1987; and comments provided to NDEP by United States Environmental Protection Agency (EPA), Region IX, dated August 14, 1987.

SECOR reports that the initial steps taken in the NDEP-approved decommissioning process for Ponds 2 and 5 mirrored those performed for Ponds 1, 3, and 4, whereby the liquid contents of the ponds were evaporated to near dryness, the residual sludge was mixed with crushed limestone, and native fill was then placed and compacted in lifts in the impoundments to restore them to original grade. The Phase I ECA report prepared by Converse Consultants indicates that the ponds were evaporated to dryness followed by filling of the ponds with dry soil to original grade (Converse, 1993). Both reports identify (albeit with minor differences in layer thicknesses) that an engineered cap was installed to cover Ponds 2 and 5 consisting of: a 20-mm PVC membrane overlain, in turn, by a sand filter, geotextile fabric, and compacted native fill. A diagram depicting the cap cover design is provided in Exhibit C.

2.4.3 Pond 6

Pond 6 was operated from August 1976 through March 1980. The decommissioning of this pond was completed in October 1981, under NDEP oversight. NDEP approved the Montrose plan for decommissioning Pond 6 in an order dated April 14, 1981 (NDEP, 1981). The NDEP-approved decommissioning process began by the removal of the liquid waste from the pond, followed by the excavation and offsite disposal of the pond solids (SBR), liner, and underlying soils. An estimated 9,800 cubic feet of soil beneath the pond was excavated and transported offsite for disposal, per the NDEP-approved cleanup criterion of 50 milligrams per kilogram (mg/kg) of PCBs. The impoundment was then filled with soil, a clay layer, and capped with an additional soil layer.

2.4.4 Current Conditions

The cap over Ponds 1 through 6 is inspected after each significant storm event to examine the integrity of capping materials, and repairs are made as necessary. The graded cap surface is maintained to control storm water runoff to minimize erosion and eliminate the growth of native plants. The area has been fenced since decommissioning of the ponds, is under surveillance by the Olin security staff, and deed restrictions are in place. Photographs of the current conditions of the fenced and capped CPA are included in Exhibit D.

As part of RCRA "closure and post-closure activities," four groundwater monitor wells were installed: MW-1 is the upgradient well, while MW-2, MW-3, and MW-4 are the downgradient wells (Figure 2-4). These wells have been sampled and analyzed generally for volatile organic compounds (VOCs), selected pesticides, dichlorobenzil, specific electrical conductance, and pH. The results have been reported regularly to NDEP since May 1989.

A more complete history of the pond construction, operation, and decommissioning timelines can be found in the *Review of Remaining Category II Comments* letter (SECOR, 1999), Phase II ECI Report (SECOR, 1997) and the Phase I ECA Report (Converse, 1993).

2.5 Other Potential Source Areas within the CPA

2.5.1 Waste Stream Conveyance Line

The waste stream from the Montrose Former Plant Site was conveyed to the former evaporation ponds in the CPA via two 2-inch diameter conveyance pipelines (Converse, 1993). The pipelines were located along the western perimeter of the CPA and were removed during decommissioning of the ponds.

2.5.2 SBR Storage Tank Area

Subsequent to the decommissioning of Pond 6 in 1981, SBR was stored in three aboveground steel tanks located east of Pond 5 (Figure 1-2). The tanks ranged in capacity from 26,000 to 95,000 gallons and were located in a concrete containment area. The only documented release within this area occurred in 1981 and resulted in the release of approximately 20 gallons of SBR adjacent to the 26,000 gallon tank. This area was demolished in 1983 through 1984 following termination of facility operations. The tank contents and liquids used for decontamination were transported offsite for incineration (Hargis, 2008a).

In 2001, Pioneer reported an unknown substance located on the ground surface approximately 300 feet east-northeast of the tank area. Due to the physical appearance of the material and the potential of it being SBR, a limited soil investigation was conducted by SECOR. As part of the investigation, samples of the material, and a sample of the underlying material were submitted for laboratory analysis. Comparison of analytical results of the unknown material and Montrose's SBR analytical records indicate that the material is not consistent with SBR (SECOR, 2001). NDEP disagreed

with this finding; however, in September 2002 Pioneer excavated and transferred 48 cubic yards of the material and surrounding soil to an off-site landfill for disposal.

2.5.3 SBR Drum Storage Area

The SBR drum storage area was located approximately 250 feet north-northeast of the SBR storage tank area (Figure 1-2). Subsequent to the decommissioning of former Pond 6, SBR and other PCB containing materials were contained in sealed drums within the drum storage area from 1981 to 1983. Closure of the area was completed in July 1994 and included decontamination using kerosene-based wet and dry methods and offsite disposal of all tanks, drums, and concrete (Hargis, 2008a).

2.5.4 Granular Activated Carbon

As part of the active Montrose soil vapor extraction (SVE) system operating within the former plant site north of the CPA, granular activated carbon (GAC) is used for the adsorption of VOCs from the extracted soil vapors. The GAC requires periodic replacement, and as a result, several thousand pounds of "spent" GAC are produced annually. The spent GAC is transported and temporarily stored within trailers in the CPA. On October 22, 2008, NDEP conducted a RCRA inspection of the storage area as part of a general inspection of SVE operations to assess compliance with handling and transport of hazardous wastes. No deficiencies were identified with the handling and storage of spent carbon wastes at the CPA. Hence, no further evaluation specific to the storage area is planned.

2.5.5 Dichlorobenzil Warehouse

To the east of the closed ponds is a former warehouse used for the storage of dichlorobenzil (Figure 1-2). The warehouse was not originally identified as an LOU study item; however, it has been included in the Montrose investigation program since approximately 2004.

During the 2006 Supplemental Investigation program Montrose installed an exploratory soil boring at the entrance to the Dichlorobenzil Warehouse to evaluate possible contamination. The analysis of soil samples from the soil boring indicated a release did not occur in the area of the warehouse.

2.6 Site Investigation Summary

The following summary of investigations provides a brief historical background to the progression of activities that have lead to the current day understanding of the CPA. The sequence of investigations is important as the scope of work for each investigation was built on findings and hypotheses generated by the previous investigation. In some cases, early interpretations were later modified by additional and more complete data. It is this accumulation of data and refinement of understanding that makes this CSM possible. These investigations are summarized in the following documents listed below:

- *Summary Report on Soil Sampling and Analytical Reports for Closure on Ponds No. 2 and 5* (Converse, 1988).
- *The Bi-annual Compliance Well Groundwater Sampling Program* (Converse, 2007).
- *Phase I Environmental Conditions Assessment (ECA)* (Converse, 1993).
- *Phase II Environmental Conditions Investigation (ECI) Programs:*
  - *Phase II ECI (SECOR, 1997);*
  - *Additional Groundwater Investigation (SECOR, 2000);*
  - *Deep Water-bearing Zone Investigation (SECOR, 2001);*
  - *Soil Vapor and Soils Investigation (Hargis, 2008a);*
  - *DNAPL Investigation (Hargis, 2008a); and*
  - *Aquifer Testing (Hargis, 2008a).*
- *Downgradient CPA Groundwater Investigation (Geosyntec, 2008)*

These previous environmental investigations are summarized briefly in the sections that follow.

2.6.1 Summary Report on Soil Sampling and Analytical Reports for Decommissioning of Ponds No. 2 and 5

An investigation conducted in 1988 consisted of sampling and collection of six soil samples collected from around Pond 5; 16 soil samples collected from around Ponds 1 through 4; and, three soil samples from the former PCB storage tank site near Pond 5 (Converse, 1988). Soil sample locations are provided on Figure 2-5. Borehole logs are not available for this sampling effort.

Soil samples collected during this investigation were analyzed for pH, phenols, VOCs, semi-volatile organic compounds (SVOCs), organochlorine pesticides, PCBs, cyanide, and an assortment of metals. While the data from this investigation cannot be validated due to the age of the program and a lack of documentation, the results are summarized in Table 2-1 for historical reference, as they provided the basis for later investigations. Subsequent soil investigations have geographically encompassed the previous locations, and data from those investigations are discussed in later sections of this CSM.

2.6.2 Bi-Annual Post-Closure Well Sampling Program

This RCRA "Post-Closure" monitoring program at the CPA consists of periodic sampling and analysis of groundwater samples from four monitor wells surrounding the CPA (MW-1, MW-2, MW-3, and MW-4) to meet the requirements of the Post-Closure monitoring plan. This program has been conducted since May 1989 in accordance with the *Amended Closure / Post Closure Plan, Henderson Facility Ponds #2 & #5, dated September 28, 1987* (Montrose, 1987). Since its inception, forty-one groundwater sampling events have been conducted. Initially, these sampling events were conducted on a quarterly basis (May 1989 to April 1992), then semi-annually since October 1992. Borehole logs are provided in Appendix B.

Currently, the monitor wells are sampled for VOCs, dichlorobenzil, pesticides, pH, and specific electrical conductance. The most prevalent compounds identified by monitoring the downgradient wells have been chloroform, chlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, and benzene.

Results of the monitoring program indicate that the CPA is the source of concentrations of VOCs in groundwater immediately downgradient of the assessment area. Over the time period covered by the post-closure monitoring program, the prevalent VOC concentrations have shown variable trends. Benzene concentrations have decreased in all three downgradient monitor wells (MW-2, MW-3, and MW-4). Concentrations of 1,2-dichlorobenzene, 1,4-dichlorobenzene, and chlorobenzene have decreased in wells MW-2 and MW-4, but have remained erratic in well MW-3. Significant increases in chloroform concentrations have been observed in well MW-2 that coincides with significant decreases in chloroform concentrations in well MW-4. More recently chloroform concentrations have increased in well MW-3. These chloroform trends are the subject of Section 3.4.4 of this report.

2.6.3 Phase I Environmental Conditions Assessment (1993)

As part of the 1991 Consent Agreement, Montrose completed a Phase I ECA for the Montrose Facility in 1993 (Converse, 1993). The Phase I ECA discussed Montrose's former operations at the site and provided an extensive review of documents describing the manufacture, storage, and disposal of chemicals throughout the site. Known and potential releases in the vicinity of the CPA were discussed in the ECA, and are summarized in Section 4 of this report, where potential release mechanisms and transport pathways are discussed.

The Phase I ECA concluded that no further action was needed for Ponds 1 through 6, as they had been adequately capped and had post-closure monitor wells installed immediately upgradient and downgradient of the capped site pursuant to RCRA closure procedures. Although there remains contaminated soil moisture, and likely some amount of dense non-aqueous phase liquids (DNAPL), in the vadose zone underlying the ponds, the ponds themselves do not represent an ongoing source of DNAPL or liquids as they were dried, decommissioned and no longer exist. Any soil moisture contaminated by pond operations could impact groundwater; however, without an ongoing source the volume of contaminated soil moisture is finite.

2.6.4 Phase II Environmental Conditions Investigation (1997)

The objective of this investigation was to provide a preliminary evaluation of potential soil contamination at LOU areas identified as potential source areas by the ECA report. The NDEP reviewed the Phase I ECA and issued a letter of "Recommendations Based on Phase I Report," dated December 16, 1992. This letter identified 23 study items throughout the former Montrose facility where additional site study, site evaluation or sampling was needed. A Phase II LOU letter was issued by the NDEP to Montrose on August 15, 1994 (NDEP, 1994), to form the basis of further evaluation work.

These study items, known as "LOU" study items, were subsequently organized by Montrose on the basis of common characteristics and proximity into five logical groupings called site assessment areas for the former Montrose facility. The CPA is one of those five site assessment areas and consists of the following LOU study items (SECOR, 1997):

- LOU Item 6 (SBR Storage Tank Area);
- LOU Item 15 (Ponds 1, 3, and 4 and associated 2" Waste Line);
- LOU Item 16 (Ponds 2 and 5); and
- LOU Item 17 (Pond 6).

The other four site assessment areas, based on these groupings for the former Montrose facility are: Former Tank Farm; Former Plant Site; Former Benzene Storage Tank; and Site-wide Groundwater (SECOR, 1997).

The Phase II ECI for the CPA was completed during late 1996 and 1997 (SECOR, 1997). At that time, a decision was made not to conduct sampling activities within the actual ponds, because the existing cap extended beyond the footprint of the closed ponds. Instead, three shallow borings (PSS-1 through -3) were installed to a depth of 10 feet along the waste lines that fed the ponds while they were in operation. The Phase II ECI Report (SECOR, 1997) concluded that concentrations of the target compounds were found below the NDEP's Action levels. The analytical results for soil from this investigation are summarized on Table 2-2.

2.6.5 Additional Groundwater Investigation (2000)

A groundwater investigation was conducted downgradient of the Montrose CPA between October 1999 and January 2000 (SECOR, 2000). The objective of this investigation program was to evaluate the nature and extent of contaminated groundwater downgradient from the CPA. The investigation consisted of the installation of eight exploratory boreholes (SB-1 through SB-8) in an east-west transect along the downgradient, northern edge of the CPA. These eight boreholes were drilled to 70 feet bgs and sampled every 5 feet with continuous coring between 50 and 60 feet bgs Groundwater grab samples were also collected from each boring and analyzed for VOCs and selected inorganic constituents. Figure 2-6 shows results of groundwater grab samples collected from SB-1 through SB-8 along with sampling results for all current groundwater sampling locations in the vicinity of the CPA

Laboratory analysis of the groundwater grab samples obtained from the eight exploratory boreholes showed that the most significant concentrations of compounds are bounded by SB-8 to the west and SB-2 to the east. Decreased groundwater concentrations of target compounds were found toward the west in the groundwater grab sample from SB-8, and results were non-detectable further west in Well H-13. Similarly, to the east, concentrations were non-detectable, except for chloroform in groundwater grab samples from SB-2 and SB-3.

Soil samples obtained from drilling were not submitted for laboratory chemical analysis. However, headspace readings were recorded and are provided on the borehole logs in Appendix B. Headspace readings are shown to be the highest immediately downgradient of the CPA in borehole SB-1 at the groundwater interface. Headspace

readings for boreholes SB-2 and SB-3, located east of SB-1 and northeast of the ponds, did not show any positive readings at the groundwater interface. A decrease in headspace readings was observed further west of the CPA from boreholes SB-4 through SB-8, with no observable readings in SB-8.

Two soil samples were also analyzed for physical parameters; one from the water-bearing zone (between 50 and 60 feet bgs) and another collected at 70 feet bgs. These physical property results are summarized on Table 2-3.

2.6.6 Deep Water-Bearing Zone Investigation (2001)

The objective of this program was to investigate the presence and nature of the next significant water-bearing zone below the alluvial aquifer near the CPA and the former plant site. The work was conducted in the vicinity of the CPA between September 2000 and January 2001 at the request of the NDEP to determine if chemical contaminants in the alluvial aquifer may have migrated deeper (SECOR, 2001). A series of subsurface soil samples and a groundwater grab sample were obtained from a single boring (CP-1) constructed to 130 feet bgs located downgradient of the CPA. The borehole log for CP-1 is provided in Appendix B.

A summary of soil analytical results from this boring is provided on Table 2-4. This borehole was converted to a "deep-zone" (a term used for this investigation) monitor well with a total depth of 125 feet with ten feet of screen from 115 to 125 feet bgs in the UMCf. The well has been sampled (11 times) since September 2000. As shown in Table 2-5, concentrations of 1,4-dichlorobenzene and 1,2- dichlorobenzene were initially above the EPA Maximum Contaminate Level (MCL), however they have not exceeded the MCL since October 2000. Benzene concentrations have remained below the MCL since April 2007 and chloroform has not been detected at concentrations exceeding the MCL since October 2004 (Table 2-5). It is likely that the initially high concentrations of dichlorobenzenes resulted from cross contamination during drilling, where soil cuttings from higher in the soil column were dragged down into the screened section by the hollow-stem augers. Over time the groundwater sampling has become more representative of in-situ conditions, which show that the Middle Zone (UMCf) does not contain MCL exceedances at this location. This well is located approximately 70 feet downgradient of the CPA.

In addition to sampling for various compounds (SECOR, 2002), a step-drawdown test was conducted to evaluate the sustainable hydraulic yield of the Middle Zone (UMCf). The findings of this investigation are summarized below:

- Thin intermittent water-bearing zones were observed between 70 and 124 feet below ground surface (ft bgs), with a deep water-bearing zone observed between 119 and 124 feet bgs.
- A chemically impacted soil layer measuring 0.9 feet in thickness was observed in the saturated zone at 99 feet bgs during drilling. Subsequently, this material has been identified as a multi-component organic chemical DNAPL (SECOR, 2001).
- While not an appropriate method for determining hydraulic conductivity (K), SECOR estimated K to be 12 feet per day (ft/day) using the step-drawdown data. Subsequent formal pumping test conducted by Hargis in 2008 resulted in a K value of 0.05 ft/day, which is more indicative of the sediments underlying the Site.

2.6.7 Supplemental Investigations (2006 - 2008)

Supplemental investigations were performed in the vicinity of the CPA in 2006 through 2008 with the objective of expanding previous investigation knowledge to cover the entire range of Montrose site-related compounds (SRCs). The program included evaluation of soils, soil vapor, and groundwater, as well as a special evaluation of DNAPL occurrence. These investigations are summarized in the Site-wide CSM (Hargis, 2008a) and included the following:

- **DNAPL Investigation:** Four DNAPL reconnaissance borings (RBs) were drilled to nominally 150 feet bgs downgradient of the CPA in late 2006 (Hargis, 2008a). These borehole locations are referred to as RB-05 through RB-08 and were located along the northern perimeter of the CPA. Figure 2-7 shows the locations of all boreholes in which soils were screened for the potential presence of DNAPL, including boreholes RB-5 through RB-8. Borehole logs are provided in Appendix B.

  At these locations screening for DNAPL materials included using PID/FID measurements, FLUTe™ ribbon applications, soil sampling, and visual observation. Evidence of DNAPL was not found in any of the investigation boreholes downgradient of the CPA (RB-05 through RB-08).

  Analytical results for soil from these four borings are summarized in Table 2-6. The analytical results show chloroform was the most prevalent compound with the highest concentrations observed at the saturated zone

between 60 to 70 feet bgs. Soil samples analyzed from RB-06 and RB-07, immediately downgradient of the CPA, had the highest detectable concentrations of chloroform and other volatile compounds. The westernmost boring, RB-08, had the lowest detectable concentrations of volatile compounds.

- **Soils:** In addition to the four RB borings described above, soil was sampled at 12 other locations within the perimeter of the CPA (Figure 2-8). Eight of these were deep borings of approximately 50 feet, while the remaining four were shallow (less than 10 feet). Borehole logs are provided in Appendix B

  Analytical results for soil are summarized in Table 2-7. In general, analytical results show presence of compounds including VOCs, SVOCs, aldehydes, PCBs, and various inorganics. However, chloroform was the most prevalent compound present with the highest concentrations found in the deeper samples (50 feet bgs).

- **Soil Vapor Investigation:** A soil-vapor study was conducted in the immediate vicinity of the CPA and throughout the then undeveloped land to the west of the CPA in April and May of 2006 (Hargis, 2008a). Soil vapor was sampled from several depths at locations surrounding the CPA (Figure 2-9). The soil vapor points were advanced to approximately 50 feet bgs and sampled approximately every 5 to 10 feet. The soil vapor samples were analyzed for VOCs via EPA Method 8260B. Of the more than 90 samples analyzed, chloroform was the predominant compound detected. Only one detection of benzene was observed, while detections of chlorobenzene, 1,2-dichlorobenzene, or 1,4-dichlorobenzene were not observed.

  While chloroform was observed in soil vapor throughout the area of the CPA, concentrations decreased significantly within approximately 100 feet of the CPA boundary to the west, east, and south (Figure 2-9). Analytical results for soil vapor are summarized in Table 2-8.

- **CPA Downgradient Groundwater and DNAPL Investigation:** The objective of this investigation was to expand groundwater characterization to the east and northeast of the ponds area primarily to evaluate the extent of chloroform migration in that direction. Additionally, borings were installed to further evaluate the possibility of DNAPL presence or migration in the northeast direction away from the CPA.

Five DNAPL reconnaissance borings were drilled to nominally 150 feet bgs downgradient of the CPA in July 2008 (Geosyntec, 2008). These boreholes were subsequently converted to groundwater monitoring wells referred to as AA-MW-20 through AA-MW-24 (Figure 2-7). Investigation at these locations included screening for DNAPL materials using a PID, FLUTe™ ribbon applications, soil sampling, and visual observation. Evidence of DNAPL was not found in any of these investigation boreholes.

In general, elevated volatile organic compound concentrations in groundwater were observed immediately downgradient of the CPA with concentrations diminishing significantly in monitor wells situated further downgradient towards the north and northeast (Figure 2-6). Selected groundwater analytical results are summarized in Table 2-9. Borehole logs are provided in Appendix B.

3. EXTENT OF CONTAMINATION

3.1 Overview

Section 3 describes the nature and distribution of contamination in soil, soil vapor, and groundwater. These discussions are based on the cumulative data set collected as part of the investigations described in Section 2. These data indicate that releases from the ponds occurred during the operational time period of the ponds, as a result of occasional leaking liners and overtopping. Soil and soil vapor data show that the ponded liquids historically migrated predominantly vertically through the vadose zone to the saturated zone. Once within the saturated zone, contaminant mass migrated laterally downgradient generally to the north along the direction of groundwater flow (Figure 2-3).

Regarding the potential occurrence of DNAPL, direct investigation for DNAPL below the former ponds has been prevented by the presence of the cap over the ponds, which Montrose and NDEP have agreed would be imprudent to penetrate (NDEP, 2008). Hence, only indirect evaluation has been possible. As to DNAPL in the dowgradient vicinty of the ponds, only one of nine wells (CP-1) or DNAPL reconnaissance borings have exhibited the physical presence of DNAPL. However, given sufficient chemical mass, DNAPL may have migrated to the more impermeable lithologic zones, as observed in boring CP-1. The degree of migration would have been a function of the density, volume of the release, and the intrinsic properties of the soil.

During decommissioning procedures in the 1980s, Ponds 1-5 were first allowed to dry, the remaining solids were treated to raise pH, and the ponds were backfilled and capped with clean fill and a geotextile membrane (Section 2.4). Thus, further liquid releases were not possible from the ponds after their decommissioning, and the ponds themselves do not represent continuing releases of contamination to the vadose zone or groundwater.

Pond 6, designed to hold SBR wastes, was decommissioned by a different method (total excavation of contents, liner and surrounding soils). However, its total removal from service eliminated any future migration of the pond contents, as discussed above.

3.2 Soil and DNAPL

3.2.1 Extent and Distribution

The vertical transport hypothesis described above is based in part on the analytical data and observations recorded during the investigations described in Section 2. Specifically, the 12 borings completed within the CPA area and the four borings completed north of the CPA show low PID and FID readings (Figures 2-1 and 2-2) and low concentrations of SRCs (Table 2-7) in the vadose zone. These borings are completed within 150 feet of the pond footprints, and in some cases immediately adjacent to the ponds.

The boring north of the CPA and the 12 borings within the CPA show very low PID and FID readings in the vadose zone, generally less than 10 parts per million (ppm) (Figures 2-1 and 2-2), and visual observations of affected soil were not observed in the vadose zone (see Appendix B). Consistent with these observations, vadose zone soil analytical data collected from the 12 borings within the CPA were below the Basic Contaminant Levels (BCLs) with the exception of arsenic and chloroform.

As summarized in Table 2-7, the only analyte that consistently exceeded its respective BCL[1] value in shallow soils (0.5 ft to 12 ft bgs)[2] is arsenic with a BCL of 1.77 mg/kg. In addition, one sample from soil boring CPA-10S had an Arochlor 1260 concentration of 1 mg/kg that exceeds its BCL of 0.826 mg/kg. Locations of exceedances in shallow soil are shown on Figure 3-1. In deeper soils (12 ft to 50 ft bgs), the only analytes that were detected above their respective BCL values were arsenic and chloroform. Locations of exceedances in deep soil are shown on Figure 3-2.

North of the ponds, which is in the downgradient groundwater flow direction, only one boring has an exceedance in deep soils. RB-06, located north of the center line of the ponds, has a chloroform concentration above the BCL value (0.58 mg/kg) at a maximum depth of 110 feet bgs. This suggests that north (downgradient) of the ponds, the distribution of deep residual soil contamination is limited to the central portion of the ponds.

These investigative findings are consistent with the vertical transport of liquids through the vadose zone beneath the footprint of the CPA, and do not support the presence of

[1] Industrial commercial worker BCL values were used for this comparison (NDEP, 2008).
[2] Shallow soils are defined as the upper 12 feet of the soil column. This depth is selected to be consistent with a construction worker exposure scenario.

DNAPL beyond the pond footprints within the vadose zone, with the possible exception of CP-1 north of the ponds. The magnitude and distribution of soil impacts in the vadose zone directly beneath the ponds is not known; however, the potential for the contaminated soil to act as a continuing source of groundwater and soil vapor contamination does exist.

As discussed in Section 5, additional investigations to assess the distribution beneath the ponds are not recommended, because such investigations would require placing heavy equipment on the cap areas and drilling through the engineered cap. In addition, the NDEP concurred with Montrose during a meeting on September 4, 2008 that drilling through the former ponds is not feasible and it was further noted that direction drilling would be impractical (NDEP, 2008). Furthermore as NDEP points out, there are significant difficulties in conducting DNAPL investigations, including the fundamental assertion that the absence of DNAPL evidence does not preclude the potential presence of DNAPL. Therefore, further efforts to evaluate the presence and distribution of DNAPL beneath the ponds are not advisable.

3.2.2 Volume of Contaminated Soils

The volume of contaminated soil beneath the former ponds can only be approximated based on soil sampling results as there is no available soil analytical data below the former pond footprints. If it is assumed that all soil beneath the ponds is affected by leakage or overtopping, the volume of affected soil between the bottom of the ponds and the water table is approximately 800,000 cubic yards. In addition, the volume of soil used to backfill the ponds to grade is estimated to be approximately 537,100 cubic yards, including the cap material.

3.3 Soil Vapor

Evaluation of soil vapor can characterize the nature and extent of VOC soil contamination due to the diffusive properties of the media. Based on the data collected during the investigations summarized in Section 2 (see Table 2-8), a diagnostic signature of soil vapor contamination from the CPA was evaluated. Identifying such a signature simplifies the discussion of the extent of contamination. Therefore, the prevalence, chemical-specific toxicity, and concentrations of detected compounds were evaluated.

The results indicated that chloroform is the best signature of CPA soil vapor contamination based on its prevalence, and detected concentrations relative to its toxicity. Figure 2-9 illustrates the location of the soil vapor sampling points and their

corresponding minimum and maximum chloroform concentrations detected from the multiple sampling depths at each location. Based on these assessments, the extent of soil vapor contamination is discussed as a function of chloroform distribution in Section 3.3.1. To augment this discussion, an assessment and distribution of the cumulative risk (cancer and hazard) was developed and is discussed in Section 3.3.2.

3.3.1 Chloroform Distribution

In general, chloroform soil-vapor concentrations in the southern portion of the CPA were found to be lower than those north of the CPA (Figure 2-9). The southern portion of the CPA also shows a decrease in concentrations from west to east. The northern portion of the CPA shows higher concentrations near the middle of the area of the closed ponds and decreasing concentrations to the east and west of the CPA.

Most importantly, soil vapor concentrations of chloroform markedly decrease from the CPA boundary to within 100 feet of the boundary, as illustrated on Figure 2-9. For example, on the eastern flank of the CPA at points P-24 and P-25, chloroform concentrations ranged from 280 – 1,900 and 690 – 8,400 micrograms per liter (µg/l), respectively. These concentrations decreased to ND at S-17, 1.8 – 7.1 µg/l at soil vapor point S-16, and ND – 1.8 µg/l at S-15, all within approximately 100 feet of the CPA boundary. These data agree with the lateral soil data as described in Section 3.1.

Soil vapor in the vicinity of the CPA yielded relatively low concentrations when compared to the recent concentrations in groundwater. Converting soil vapor concentrations to "equivalent" groundwater concentrations using Henry's Law Constant (K_H), the maximum soil vapor values would be equivalent to approximately 3,200 and 4,600 µg/L as groundwater concentrations. These values are well below the maximum groundwater concentrations of 120,000 and 97,000 µg/L observed in MW-2 groundwater samples in April 2005 and October 2007, respectively. This suggests that the equilibrium partitioning is from groundwater to soil vapor; thus indicating that remaining contaminant mass in the vadose zone (in the areas sampled) is not impacting groundwater via the vapor transport pathway.

3.3.2 Cumulative Risk Distribution

The use of a single parameter (chloroform) is convenient for a general description of the extent of soil vapor contamination; however, other compounds contribute to the overall potential risk. Therefore, to augment the description of conditions in and around the CPA, the cumulative risk associated with other chemicals of potential concern is provided. The additional benefit of characterizing the cumulative risk is that it provides

context for evaluating the soil vapor concentration data, as well as the adequacy of the existing data coverage. As discussed in the following sections and shown on the referenced figures, the existing soil vapor data provide a sufficient basis for characterizing the significance of soil vapor concentrations.

Although there are minimal human exposure pathways for soil contaminants at the CPA since the former pond areas are covered with an engineered cap, occasional activities are conducted at or near the CPA for well monitoring and cap maintenance. Therefore, to evaluate potential cumulative cancer risk and noncancer hazard for occasional industrial/commercial workers at the CPA, soil vapor results were compared to Regional Screening Levels (RSLs) that were developed by USEPA (USEPA, 2008). The RSLs are based on acceptable indoor air concentrations for an industrial worker (industrial air RSLs; USEPA, 2008). In order to convert the industrial air RSLs to a corresponding acceptable soil vapor concentration, the industrial air RSL is divided by an attenuation factor of 1×10^{-3} to arrive at an acceptable soil vapor RSL. The attenuation factor was selected from Figure 3a in the *Subsurface Vapor Intrusion Guidance* (USEPA, 2002) and was based on a sandy loam soil type at the CPA.

The potential cumulative cancer risk and noncancer hazard for industrial/commercial workers who may potentially be exposed to all chemicals detected in soil vapor at a given sampling location can be estimated by using the USEPA 2008 soil vapor RSLs, heretofore called risk-based concentrations (RBCs). This is done by summing the ratios of each chemical's concentration to its RBC, and multiplying this ratio by the target risk for carcinogens or target hazard index for noncarcinogens. The ratio for each chemical provides its contribution to potential cumulative cancer risk or noncancer hazard, as follows:

Potential cumulative cancer risk (at a given sampling location):

$$CR_{tot} = \left[\sum_{i=1}^{n}\left(\frac{CV_i}{RBCV_{C,i}}\right)\right]\times TR$$

Potential cumulative noncancer hazard index (at a given sampling location):

$$HI_{tot} = \left[\sum_{i=1}^{n}\left(\frac{CV_i}{RBCV_{NC,i}}\right)\right]\times THI$$

Where:

$CR_{to\ t}$= potential cumulative cancer risk from all chemicals detected in soil vapor at given sampling location (unitless);

CV_i = maximum concentration of chemical *i* detected in soil vapor (mg/m^3);

$RBCV_{C,I}$ = risk-based concentration for chemical *i* in soil vapor based on carcinogenic effects (mg/m^3);

TR = target cancer risk (1×10^{-5}; unitless);

HI_{tot} = potential cumulative noncancer hazard quotient from all chemicals detected in soil vapor at given sampling location (unitless);

$RBCV_{NC,I}$ = risk-based concentration for chemical *i* in soil vapor based on noncarcinogenic effects (mg/m^3);

THI = target noncancer hazard index (1; unitless).

This approach can be used to identify individual sample locations where the target risk goals are exceeded for an industrial/commercial worker scenario or for other scenarios such as for trespassers. However, the trespasser scenario is unlikely given the fencing and moreover, evaluating the industrial/commercial worker scenario would be protective of this infrequent, shorter duration trespasser scenario.

The potential cumulative cancer risk and noncancer hazard results are presented in Figure 3-3 based on comparison to USEPA 2008 RSLs. As illustrated by this figure, the distribution of RBCs above the target risk levels (cancer risk level of 1×10^{-5} and the noncancer hazard levels above 1) have been adequately characterized to the east and west of the CPA, and generally to the south. The potential risk and hazard above target risk levels extend to the north to the limits of the CPA investigative area. The results of this cumulative risk evaluation indicate areas of the CPA may contain chemical concentrations that may potentially pose an unacceptable health risk based on an industrial/commercial worker scenario. However, the pathway associated with this potential is incomplete based on current land use and that of the foreseeable future.

3.4 Groundwater

The following discussion of groundwater contamination is based on data collected from groundwater monitor wells. Although grab samples of groundwater were collected and analyzed as described in Section 2, the distribution of grab samples falls within the coverage provided by monitor wells, and grab samples are not reproducible. Where the distance between monitor wells is large (such as west and east of the CPA), data from the grab samples are used to help assess the chemical distribution pattern.

There are 10 monitor wells within the CPA vicinity that are used to characterize conditions in the Alluvial and Transition Zone (Figure 2-6). There are four wells that are used to characterize conditions in the UMCf. Selected analytical data obtained from these wells are summarized in Table 2-9 and shown on Figure 2-6; a historical summary of all detected compounds is included as Appendix C. Analytical results are shown on Figures 2-6 and 3-4 through 3-6.

3.4.1 MCL Exceedances

Consistent with previous monitoring results, the organic and inorganic analytes detected above their respective MCLs in 11 wells during the most recent sampling event (October 2008) include the following:

Analytes Detected Above Their Respective MCLs	
Organics	**Inorganics**
Alluvial and Transition Zone	
Chloroform	Arsenic
Benzene	
1,2-Dichlorobenzene	
1,3,-Dichlorobenzene	
1,4-Dichlorobenzene	
Chlorobenzene	
Trichloroethene	
Carbon Tetrachloride	
Upper Muddy Creek Formation	
Chloroform	Arsenic
Benzene	
Carbon Tetrachloride	
1,4-Dichlorobenzene	

In addition to these multiple occurrences, uranium was detected above its MCL in downgradient Wells AA-MW-20 and MW-3, and iron and manganese exceeded their MCL in upgradient Well H-11. Of the MCL exceedances, the most widely distributed are chloroform and arsenic; slightly less prevalent are chlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, and benzene. For these reasons, these six compounds were used for the groundwater evaluation.

Advective transport of dissolved VOCs in groundwater within the Transition Zone has been the primary transport mechanism to transfer these SRCs to areas downgradient of the CPA. Based on the lower permeability, the dominant transport mechanism within the UMCf is likely diffusion. The distribution of MCL exceedances in the Alluvial/Transition Zone and the UMCf from the most recent sampling of each monitor well is shown on Figure 3-5 and 3-6, respectively. As shown on Figure 2-6, the distribution of MCL exceedances is characterized west, south, and east of the former ponds.

3.4.2 VOC Distribution

Figure 2-6 summarizes the most recent data for chloroform, chlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, and benzene and shows the approximate limits of contractions above MCLs. These data include groundwater grab samples and the most recent groundwater data from monitor wells. Elevated concentrations of all five compounds are present to the north in the area of MW-3 and grab sample locations P-19. All other sampling locations were mostly non-detect for chlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, and benzene, but they did contain chloroform. The samples collected from P-19 and MW-2 yielded chloroform at the highest concentrations 95,000 and 97,000 µg/L, respectively. Chloroform concentrations to the south, west, and east were substantially lower.

3.4.3 Inorganic Distribution

Figure 3-4 presents groundwater concentrations of arsenic and total dissolved solids (TDS) for the wells in the vicinity of the CPA. All but one of the wells (H-11) exceeded the arsenic MCL of 0.01 µg/L. Arsenic varies in concentration from 0.045 mg/L and 0.056 mg/L in the crossgradient and upgradient Wells AA-MW-05 and MW-1, respectively. Arsenic concentrations vary from 0.038 mg/L to 0.084 mg/L in the remaining wells, with the exception of H-11 (0.001 mg/L).

The TDS concentration in the crossgradient Transition Zone well (AA-MW-05) is 2,200 mg/L. TDS ranges from 1,300 to 8,300 mg/L in the downgradient Transition Zone wells. In the UMCf wells (MW-1, H-11, H-13, and CP-1), TDS ranges from 790 to 1,200 mg/L. In general, TDS concentrations in wells screened in the Transition Zone are lower along the upgradient, southern, CPA boundary as compared to concentrations in downgradient, northern, monitor wells. Conversely, TDS concentrations in wells screened in the UMCf are similar north and south of the CPA.

3.4.4 Evaluation of Chloroform Concentrations at the CPA

One of the reasons for conducting a detailed evaluation of the CPA at this time is the historically increasing trend in chloroform concentrations in groundwater found most significantly in the easternmost monitor well MW-2 and the decreaseing trend in MW-4. After decommissioning of the ponds, steadily decreasing concentrations of VOCs would be expected in the downgradient monitor wells. This expected pattern generally has been observed for benzene, chlorobenzene, and other compounds. However, the chloroform concentration pattern in the three downgradient Wells MW-2, MW-3, and

MW-4 has been considerably different, as shown on Figure 3-7 and described as follows:

- MW-2, which is located furthest to the east, showed decreasing chloroform concentrations from 1990 to late 1994, then a gradual increasing trend until early 2001, when chloroform concentrations started to rapidly increase. A peak concentration of 120,000 µg/L was observed during the August 2005 sampling event and was 100,000 µg/L in October 2007 and 92,000 µg/L in the October 2008 sampling event.
- MW-3, which is located generally in the center of the downgradient boundary of the CPA, has shown decreasing chloroform concentrations since 1990, then exhibited a spike to 37,000 µg/L in 2003 and increased to 35,000 µg/L in October 2007 and 32,000 µg/L in October 2008.
- MW-4, which is located to the west, has shown variable elevated concentrations from 1989 through late 1999, with a high of 97,000 µg/L in 1998, then decreasing concentrations to a low of 1,200 µg/L in October 2007. October 2008 sampling showed chloroform concentrations rebounded to 9,800 µg/L.

Chloroform concentrations with time are variable across the east-west dimension of the CPA and are inconsistent with the general decreasing pattern of the other VOCs commonly observed in the CPA area, specifically benzene and chlorobenzene (Figures 3-8 and 3-9). Concentrations at MW-2 are of particular interest, because concentrations have increased from 20,000 µg/L in the late 1990s to as high as 120,000 µg/L in April 2005.

To understand the potential cause(s) of this increasing concentration trend, numerous lines of evidence were evaluated: groundwater elevation data; well construction and lithologic information; and groundwater chemistry data. These data are discussed in the sub-sections that follow.

3.4.4.1 Evaluation of Groundwater Elevation Data

Geosyntec evaluated groundwater elevation and well construction data for the four wells surrounding the closed ponds to assess if changes in groundwater elevations or flow direction correlate with changes in chloroform concentrations in MW-2. Groundwater coming in contact with vadose-zone materials containing chloroform

residual (that was not in contact with groundwater at the beginning of the monitoring period) could influence chloroform concentrations in samples from Well MW-2.

Figure 3-10 illustrates the increasing trend of groundwater elevation data for the four post-closure monitor wells over time from May 1989 to October 2008. The increasing trend in groundwater elevations in the vicinity of the CPA began in the mid- to late-1990s for all four of the wells and continues to the most recent sampling event. It is not known what is causing the sustained elevation rise; however, it may be related to leaking infrastructure in the site vicinity.

Groundwater elevations were relatively stable within the CPA during the period from May 1989, when the monitoring program began, to November 1998. However, within the 9-year time interval from November 1998 to October 2007, groundwater elevations in the same area increased approximately 8 feet in the downgradient Compliance Wells MW-2, MW-3, and MW-4 and approximately 10 feet in MW-1, the upgradient compliance well. As a result of this water level increase, the volumes of soil thereby gaining contact with groundwater during this 9-year time interval was approximately 314,000 cubic yards. If chloroform residues (possible DNAPL residual) were present in the previously unsaturated soils, then the rise in water levels could explain the increase in chloroform concentrations in the samples from Well MW-3 and MW-2.

Further, the beginning of the rising trend in groundwater elevations at both the upgradient and downgradient wells in the vicinity of the CPA is approximately the same as the date of the beginning of increasing chloroform concentrations in samples from Well MW-2 and decreasing chloroform concentrations in MW-4 (Figures 3-11 and 3-12).

3.4.4.2 Changes in Groundwater Flow Direction

Further evaluation of groundwater elevations focused on determining if there has been any change in groundwater flow direction in the vicinity of the CPA. A recent potentiometric surface for the CPA is shown on Figure 3-13. Although the primary groundwater flow direction through the CPA is south to north, variations in an eastward or westward flow component may account for variations in contaminant concentration distribution in the three downgradient monitor wells. For example, a more easterly flow component may explain why there is a difference in the chloroform trends between MW-4 to the west and MW-2 to the east.

To perform this analysis, the difference in water levels between MW-2 and MW-3 was calculated over time and plotted along with the chloroform concentrations in MW-2.

Figure 3-14 illustrates these data and shows an increasing westward flow component prior to the late 1990s, transitioning to a decreasing westward flow component starting in the late 1990s and continuing to the present. The timing of this decreasing westward flow component corresponds to the rise in groundwater elevations.

The increasing trend from May 1989 to approximately November 1998 corresponds to a net change in "south to north" flow direction of approximately 20 degrees to the northwest (Figure 3-15). Considering the later data set, the trend from November 1998 to October 2008 represents a change of approximately 15 degrees back toward the northeast (Figure 3-16). This more easterly flow component could have directed more chloroform laden groundwater from the source area toward the location of MW-2, which again is the easternmost monitor well within the CPA.

3.4.4.3 Evaluation of Well Construction and Lithology Data

As part of this evaluation, Geosyntec also evaluated the well construction and lithology of the three downgradient wells to determine if variations in well construction or lithology may be responsible for the different chloroform time versus concentration trends in MW-2. Figure 3-17 illustrates a simple cross-section through these wells (MW-2, MW-3 and MW-4).

As illustrated, all three downgradient wells are screened in relatively low permeability zones at essentially the same depth; these three wells are screened within the Transition Zone between the more permeable alluvial materials and the less permeable UMCf. MW-3 is screened in consistently fine-grained materials while both MW-4 and MW-2 have slightly more permeable zones within their screen and/or sand pack zones. The change in flow direction could have diverted chloroform-laden groundwater away from the MW-4 direction toward MW-2. The less permeable materials in MW-3 may have prevented (or delayed) a rise in chloroform concentrations at MW-3.

During this evaluation, it became apparent that MW-1, the upgradient compliance well, is screened within the UMCf materials, as shown in the cross-sections on Figures 2-1 and 2-2. As a result, there are two wells at the CPA completed within the UMCf: CP-1 and MW-1. It should be noted that new upgradient well AA-MW-24 was installed as part of the additional groundwater work at the CPA to monitor the more shallow groundwater (Geosyntec, 2008).

3.4.4.4 Evaluation of Groundwater Chemistry

To further understand the increasing concentrations of chloroform at MW-2, Geosyntec evaluated the available groundwater chemical data. The evaluation included assessing:

- Time trends in concentrations of chloroform relative to groundwater elevation trends;
- Correlations of trends in concentrations of chloroform with concentrations of other constituents; and
- Time trends in concentrations of other constituents relative to groundwater elevation trends.

While the increasing chloroform concentrations in MW-2 may begin as early as 1995, the chloroform concentration clearly rises as the MW-2 water level rises in the late 1990s and the 2000s. A slight lag between water level rise and chloroform concentration increase is shown on Figure 3-11. The increase in chloroform concentrations after the increased groundwater elevation is consistent with a conceptual model of residual chloroform in previously unsaturated soils being dissolved into the rising groundwater. The time lag would be explained with the residual chloroform being located upgradient of the monitor wells in which the increased concentrations are observed. Data for other parameters can help in evaluation of whether this scenario is realistic.

Geosyntec also evaluated trends of other VOCs in samples from Well MW-2, to assess why these compounds, specifically benzene and chlorobenzene, do not follow the same pattern in MW-2 as chloroform concentrations in samples from Well MW-2 over time, along with the chloroform concentrations. The following trends can be deduced from Figure 3-18:

- The downward arrow in Figure 3-18 shows decreasing benzene and chlorobenzene concentrations until approximately 1994 to 2000. While the chloroform concentrations were stable in the early 1990s, the benzene and chlorobenzene concentrations were steadily decreasing or remaining stable.
- The upward arrow in Figure 3-18 shows an upward trend in the chloroform concentrations in MW-2 from October 1996 to April 2005. A slight decline in chloroform concentration was noted in the October 2006 and April 2007 sampling events. During this upward trend in chloroform concentrations,

benzene and chlorobenzene concentrations were very low, and stable or declining.

3.4.5 Potential Chloroform Sources – Former Ponds vs. In-Situ Processes

Former Ponds

The source of the chloroform is likely the native soils beneath the CPA that were likely impacted by chloroform wastes (Section 2.4) stored in the ponds during the operational time period. Based on several lines of evidence, samples are consistent with a shift in groundwater flow direction that causes MW-2 to sample water more impacted by the CPA than it was previously. These lines of evidence include: the nature of the wastes placed in each of the ponds; the observed increasing chloroform and decreasing benzene and chlorobenzene in MW-2; increases in groundwater elevations; and a more northeasterly groundwater flow direction.

In-Situ Processes

In addition to chloroform wastes in the ponds serving as the source of chloroform in groundwater, chloroform can be generated in the subsurface under certain conditions. Because of that, Geosyntec has evaluated potential in-situ chloroform production processes and evidence regarding their occurrence (or lack thereof) at the CPA. They are reductive dechlorination and decomposition of acetaldehyde.

Reductive dechlorination of carbon tetrachloride could produce chloroform. However, carbon tetrachloride concentrations at the CPA are negligible. In addition, concentrations of the product of reductive dechlorination of chloroform (methylene chloride) at the site are negligible. The lack of significant concentrations of both carbon tetrachloride and methylene chloride suggests that chloroform is not being formed in this way.

The decomposition of compounds such as acetaldehyde could potentially produce methane. Chloroform is known to be produced from methane during chlorination of wastewater (where methane produced from decomposition of organic matter is chlorinated). The chlorination process requires the presence of chlorine (Cl_2, a strong oxidizing agent) that would be toxic to methane-producing organisms. In addition, chlorination of methane would produce chloromethane and dichloromethane at concentrations similar to that of chloroform (trichloromethane), and that is not the case at the site. These facts suggest that such a process is not occurring.

Because acetaldehyde has no chlorine atoms, chlorination would have to take place in the subsurface. Without a source of chlorine (Cl_2, as opposed to the common ion, chloride), this generation from acetaldehyde would not occur.

Because of these issues, chloroform likely is not being generated in-situ at the CPA.

3.4.6 Conclusions

Based on this evaluation, it appears that the increasing chloroform concentrations observed in Monitor Wells MW-2 and MW-3 located in the central and eastern downgradient direction from the CPA and decreasing concentrations in MW-4 located in the western downgradient direction are likely caused by two factors: 1) rising groundwater elevations mobilizing residual chloroform within the previously unsaturated vadose zone; and/or 2) a northeastern shift of groundwater flow direction toward MW-2 from the majority of the CPA. The latter factor is less certain due to the lack of groundwater elevation monitoring locations east and northeast of the CPA.

4. CONTAMINANT FATE AND TRANSPORT

4.1 Potential Release Mechanisms

Prior investigations at the CPA indicate that pond contents migrated to soils and/or groundwater during the operating years between 1975 and June 1983 prior to the decommissioning of the ponds. The Phase I ECA Report discussed in the previous section, states that pond contents for former Ponds 1, 3, and 4 may have accidentally migrated to soils and groundwater as a result of lining damage or overflow (Converse, 1993). In addition, findings from a document review conducted by SECOR in April 1999 indicate several of the ponds were overfilled above their freeboard levels during the early years of operation; seeps of pond-like liquids were observed outside the berms of Ponds 3 and 4; pond-like liquids were routinely noted in several of the leachate collection wells; and a liquid collection trench that was constructed during decommissioning activities for Ponds 2 and 5 (SECOR, 1999). These observations represent locations of releases within the CPA.

Further, findings from SECOR's 1999 document review indicate the presence of pond-like liquids, during former pond operations, in at least one of the four leachate monitor wells surrounding Pond 2 and pumping of Pond 2 may have caused overflow into Pond 3. It was also noted that pond contents collected in the liquid collection trench (sump) diminished significantly after pond decommissioning. Finally, historic damage (which was subsequently repaired) to the southwest corner of former Pond 2 during off-loading of liquids from a vacuum truck also could have contributed to overflow during its operational history prior to decommissioning (SECOR, 1999).

In addition to the ponds, the former SBR storage tanks also were located within the CPA east of Pond 5 and held the same substances stored in Pond 6. One minor release was documented at this storage area in 1981 prior to operations ceasing and subsequent decommissioning of the CPA. This release consisted of a small spill of approximately 20 gallons adjacent to the 26,000 gallon storage tank. Given that SBR is a heavy tar-like material, it is unlikely that this small release left any remaining environmental impact after its removal. Therefore this spill is not considered further as a source of environmental impacts.

One additional release mechanism that is important in the CPA, but is not associated with former CPA activities, is the windborne transport. NDEP has indicated that shallow soils in the Site vicinity may be affected by windborne lindane (BHC), asbestos, radionuclides, and arsenic.

4.2 Transport Pathways

The potential transport pathways are discussed in the following sections. Figure 4-1 provides a graphical representation of the pathways for the various media, and supports the following discussion.

4.2.1 Air Pathway

Air dispersion of SRCs as a result of dust generation or volatilization could have potentially impacted shallow surface soils at the CPA. Because the ponds were covered with a soil cap, the cap was unaffected by dust borne CPA chemicals. However the cap could be affected by volatilization or other dust borne COCs. Specifically, shallow surface soils at the CPA may have been exposed to chemicals such as BHC, asbestos, arsenic, and/or radionuclides that originated from source areas outside of the CPA assessment area, and therefore an air pathway discussion is provided.

Contaminant transport can occur through the air pathway via two mechanisms: 1) windborne particulates, and 2) volatilization of contaminants into ambient air. Windborne particulate transport can occur when contaminated surface soils are present and particulates are mobilized and carried by wind. This pathway and mechanism can also transport contaminants from subsurface soils if they are excavated or grading exposes them to the effects of wind.

The second mechanism by which contaminants can be transported via the air pathway is the migration of volatile compounds through soil pore space. These volatile compounds can migrate into the atmosphere or can be transported deeper into the ground and potentially impact groundwater, depending primarily on the volatility of the compound, and also on molecular weight, the carbon content (fraction organic carbon [foc]) and physical properties of the soil matrix (porosity, grain size distribution, and moisture content), and temperature gradients.

The volatility of a chemical compound increases as its vapor pressure increases. Vapor pressures greater than 1 mm of mercury are considered highly volatile, vapor pressures in the range of 0.001 to 0.1 mm of mercury are considered semi-volatile and vapor pressures less than 0.001 mm of mercury are non-volatile under normal conditions. Due to the high summer temperatures at the Henderson Site, the volatile and semi-volatile compounds in the surface or near surface are susceptible to being volatized and released to the atmosphere.

VOCs dissolved in soil moisture and groundwater can also volatilize and be released to the atmosphere via soil gas respiration. The potential for these compounds to volatilize from the vadose zone soil moisture and groundwater is defined by the K_H for that compound. K_H provides a measure of the extent of chemical partitioning between air and water at equilibrium. The higher the K_H the more likely a chemical is to volatilize than to remain in water. A K_H exceeding 10^{-3} atmospheres-cubic meters per mole (atm-m^3/mole) indicates a compound that is readily volatilized from a dilute aqueous solution. Compounds that have a K_H of less than 10^{-7} atm-m3/mol are considered to have a low volatility.

The potential volatility of the SRCs range from volatile to highly volatile based on their vapor pressure and K_H (Hargis, 2008a). These data indicate that the SRCs benzene, chlorobenzene, 1,2-dichlorobenzene and 1,4- dichlorobenzene, 1,2,4-trichlorobenzene, and chloroform are volatile and that there is a potential for these compounds to be transported as vapor to the atmosphere at the Henderson Site.

4.2.2 Soil Pathway

Contaminants may be transported in soil by several mechanisms including vapor transport, dissolved-phase transport in soil moisture, and non-aqueous phase liquid (NAPL) migration from sources to the soil and/or groundwater.

At the CPA, there are minimal human exposure pathways for soil contaminants. There are occasional activities conducted at or near the CPA for well monitoring and cap maintenance to prevent erosion from wind or rainfall. Deed restrictions are in place to prevent future construction work and various other non-industrial land uses. The former pond areas are covered with an engineered cap that was installed as part of the pond decommissioning activities; its maintenance, fenced access and monitoring is expected to proceed indefinitely. As discussed, there is a potential risk of surface soil contamination of asbestos, arsenic, radionuclides, and BHC by wind-blown means from other source areas resulting in possible exposure to occasional site workers and trespassers. The potential risk of surface soil exposure will be addressed in detail during the Human Health Risk Assessment (HHRA) evaluation for site-wide shallow soils.

Based on the current conditions at the CPA, there are no liquids in the former ponds that could drive dissolved-phase transport in soil moisture, or NAPL migration from the former ponds. The liquids that were released from the ponds have, and may continue, to migrate under their own driving forces until they reach residual saturation. Transport

by infiltrating precipitation has been mitigated by the cover which deflects surface runoff beyond the footprint of the ponds. The only other soil transport mechanisms, air dispersion and windborne particulates are addressed previously in Section 4.2.1.

4.2.3 Groundwater Pathway

Potentially complete exposure pathways for SRCs in groundwater via ingestion and dermal contact were not identified, because groundwater is not used for industrial, domestic consumption, or irrigation in the vicinity of the CPA. However, the potential for dermal contact exists during groundwater sampling events.

4.2.4 Surface Water and Sediment Pathway

In general, contaminants can be transported as dissolved phase in the surface water runoff or adsorbed onto the sediment load in the runoff. Soluble contaminants can be dissolved and transported across the land surface and/or infiltrate into the subsurface, contaminating the vadose zone and potentially migrating to the groundwater. Surface water can also accumulate in topographic low areas after precipitation events and deposit dissolved contaminants through evaporation.

However, after decommissioning, which included removal of liquids from the ponds, neutralizing sediments, filling the ponds, and the construction and maintenance of an engineered cap, chemicals from the former CPA operations are buried and protected from the surface water and sediment transport. Because the cap is constructed and maintained to minimize the possibility of surface water ponding and infiltration, the surface water and sediment transport pathway is incomplete.

Again, this potential pathway of surface water/sediment is an historic one and is no longer be a viable potential pathway at the CPA based on the design of the cap.

4.3 Exposure Pathways and Potential Receptors

An exposure pathway describes a specific environmental pathway by which an individual (receptor) can be exposed to SRCs present at or originating from a source. EPA (1989) has defined the following five elements that must exist for an exposure pathway to be considered complete:

- A source of chemical;
- A mechanism of chemical release to the environment;
- A retention or transport media (e.g., soil or air);

- A point of potential contact by receptors with the medium; and
- A means of entry (i.e., intake route) at the contact point (e.g., ingestion).

There must be a complete exposure pathway from the source (i.e., from soil, air, or groundwater) to receptors for chemical intake to occur. If any one of these elements is missing, then the exposure pathway is considered incomplete. For example, if human activity patterns and/or the location of potentially exposed individuals prevent contact with the impacted media, then no completed pathways can exist.

This section addresses human and environmental receptors, with a focus on potentially complete exposure pathways that are relevant for the sources and transport mechanisms previously discussed (Figure 4-1). Potential exposure routes to be considered include both direct and indirect contact with Site media (e.g. soil, soil-vapor, groundwater). If volatile chemicals are detected in soil, indirect exposures from vapors migrating from the subsurface may occur. If metals or SVOCs are detected, the direct contact routes of exposure, such as incidental ingestion or dermal contact, are the most potentially relevant. Potentially complete exposure pathways associated with these media are discussed within this section and summarized on Figure 4-1, with the following context:

- Exposures to surface water onsite are not a complete exposure pathway, since no permanent surface water bodies exist onsite.
- Exposure to chemicals in downgradient groundwater has been described in the Site-Wide CSM and will be dealt with in the Site-Wide Groundwater RAS documents.
- In some cases, an exposure pathway may be complete but is not significant, because: 1) the exposure may be two or more orders of magnitude less than by other pathways involving the same medium at the same exposure point for the same receptor; 2) the magnitude of exposure has low toxicological significance, and/or 3) the probability of exposure is low and potential risks associated with the pathway are not high (EPA, 1989).
- Further, exposures to SRCs in groundwater via ingestion were not considered a potentially complete exposure pathway, because groundwater is not used for industrial, domestic consumption, or irrigation in the vicinity of the CPA. However, there may be potential for dermal contact by on-site workers conducting compliance monitoring sampling. The site-specific Health and Safety Plan addresses procedures to minimize potential of dermal contact during groundwater sampling.

The remainder of this section first describes the human receptor populations and their related exposure pathways, followed by a discussion of the ecological receptors and pathways.

4.3.1 Human Receptors and Exposure Pathways

The CPA has been used exclusively for industrial purposes, has deed restrictions and access controls, and will continue as such into the future. Land use immediately and further downgradient of the CPA is currently exclusively industrial. In fact, land use for the entire Site north of the CPA to the Groundwater Treatment System (GWTS), a distance of 3.5 miles is currently industrial, and communications with current land owners indicates that it will remain industrial for the foreseeable future.

As a result and as shown on Figure 4-1, the only human exposure pathways that are complete are associated with onsite worker and trespassers. These pathways are discussed below.

4.3.1.1 Worker Exposure Pathways

For the industrial/commercial workers at the CPA and adjacent areas within the Henderson Site, the following exposure scenarios have been identified:

- Outdoor workers who spend the majority of their workday outside;
- Construction workers who are assumed to contact shallow and subsurface soils; and
- Groundwater sampling contractors monitoring downgradient compliance wells at the CPA who could potentially contact pumped groundwater.

For indoor workers, the primary exposure media is indoor air; however, no structures/buildings are located within this assessment area. Therefore, the indoor air exposure pathway for industrial/commercial workers is not a complete exposure pathway. Outdoor workers could potentially be exposed to volatile SRCs that volatilize from soils or groundwater to ambient air and thus be exposed via inhalation. Additionally, fugitive dust containing non-volatile SRCs that is generated from wind erosion or soils handling activities could also be transported via ambient air.

The outdoor worker scenario is designed to represent employees of commercial or industrial facilities within the study area who spend the majority of their workday outdoors. The primary exposure media for outdoor workers are soils and ambient air.

Two potentially complete exposure pathways involved in direct contact with soils are incidental ingestion and dermal contact. These direct contact pathways are assumed to be limited to surface soils. Outdoor workers could potentially be indirectly exposed to SRCs in soils via inhalation of fugitive dusts or volatile SRCs released into ambient air. Inhalation of volatile SRCs released from groundwater and migrating into ambient air is also a potentially complete exposure pathway for outdoor workers. Direct contact with impacted groundwater is not considered a complete exposure pathway, because it is not used at the Site and the depth to groundwater precludes outdoor workers from direct encounters with groundwater. While there may be potential for dermal contact by on-site workers conducting monitoring and sampling, the site-specific Health and Safety Plan addresses procedures to minimize potential of dermal contact during groundwater sampling.

The construction worker scenario reflects temporary activities that could occur within the study area. The construction worker is assumed to be exposed to surface soils. In addition, it is assumed that the worker will be exposed to subsurface soils that may be exposed as part of excavation activities occurring at the Site. For this receptor, potentially complete exposure pathways resulting from direct contact with soils are incidental ingestion and dermal contact. In addition, construction workers could potentially be exposed to SRCs in soil via the inhalation route through volatilization and from fugitive dusts released to ambient air through wind erosion or soils handling. Inhalation of volatile SRCs released from groundwater is also a potentially complete pathway for the construction worker scenario.

4.3.1.2 Trespassers and Residential Exposure Pathways

Non-occupational exposures in the study area can occur onsite as a result of trespassing or offsite in the adjacent residential areas. While unlikely given the fencing, the trespasser scenario is assumed to involve adolescent and teenage children from residential areas in local proximity to the Site. The potential exposures associated with trespassing onsite would be infrequent and for a short duration. Trespassers could potentially be exposed to soils in the study area via incidental ingestion and dermal contact. Inhalation exposures to SRCs in soils could potentially occur via releases from wind erosion and soils handling, and from volatilization. Volatile SRCs released from impacted groundwater could also migrate into ambient air and contribute to the inhalation exposure, although significant ambient air dilution and limited time spent onsite would likely reduce their exposures. No other groundwater-related exposures would be complete for the trespasser scenario.

All other residential scenarios are assumed to take place in the off-site portions of the Site-wide CSM study area, and as such will be discussed as part of the Site-wide analysis, and not the CPA-specific analysis.

4.3.2 Ecological Receptors and Pathways

Ecological receptors are limited to the areas downgradient of the Henderson Site. No natural habitats exist onsite given the developed and industrial manufacturing operations at the Site. Therefore, by agreement with NDEP, potential ecological receptors and exposure pathways can only occur in the downgradient area and through potential exposures to groundwater. Groundwater pathways have been described and discussed in the Site-wide CSM (Hargis, 2008a) and will be addressed in the upcoming Site-wide Groundwater RAS document.

5. DATA GAP ANALYSIS AND POTENTIAL FUTURE INVESTIGATION WORK

Based on the information presented in this document, there are several potential data gaps that have been identified. These data gaps need to be filled to support further progress toward the development of a risk assessment, remedial alterative study and eventually closure of the CPA. Each category of data is discussed below:

- **Site Subsurface Soil Characterization Data**

  Based on the review of previous site soil and soil-vapor investigations at the CPA, discussed above in Sections 3.1 and 3.2, the sample population and spatial distribution of subsurface soil and soil-vapor samples are sufficiently extensive for interpretation of the characteristics of vadose zone soils within the vicinity of the former ponds. Therefore, further site characterization of subsurface soils is not necessary as there are no data gaps.

- **Shallow Soils Data for Risk Assessment**

  There is a data gap in the shallow soils data currently available to support risk assessment for the CPA. Very limited or no data are available for the broad suite of SRCs in shallow surface soils, including the following chemical groups: asbestos, arsenic, BHCs, dioxins, furans, and radionuclides. The extent of these data needs is not currently known. This uncertainty will be resolved after the site-wide risk assessment Work Plan is completed (expected in May 2009). Once the data density for conducting a risk assessment is determined and the usefulness of the existing data set is known, a plan for additional shallow soil sampling will be developed.

- **Soil Vapor Data for Risk Assessment**

  Another data gap associated with the needs of a risk assessment is the transportation of volatile SRC compounds from the soil and groundwater to the atmosphere. Volatility of the SRCs range from volatile to highly volatile based on their vapor pressure (Hargis, 2008a). Volatility data indicate that volatile SRCs include benzene, chlorobenzene, 1,2- dichlorobenzene and 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, and chloroform are volatile and that there is a potential for these compounds to be transported as vapor to the atmosphere at the Site. AT this time, it is anticipated that this data gap will be

addressed using the existing soil vapor data to estimate the potential volatilization to the atmosphere.

- **DNAPL Presence and Distribution**

  There is a data gap in the understanding of the possible presence and distribution of DNAPL beneath the closed ponds. However, as discussed with NDEP and their consultants at the September 4, 2008 meeting in Las Vegas, invasive collection of subsurface soil samples within the footprints of the cap at the CPA would not be practical as it would require drilling into the existing RCRA cap with the risk of compromising its integrity (NDEP, 2008). The various parties at the meeting were in agreement that such investigation activities would not be worth the considerable environmental risk and that investigating for DNAPL beneath the ponds could be inconclusive. Furthermore, EPA guidance documents state that at most sites where the potential for DNAPL exists, direct observation of DNAPL is usually not possible. Given the heterogeneous nature of DNAPL, additional drilling would likely only identify where DNAPL is not present rather than defining its distribution. Therefore, the location of DNAPL beneath the CPA is likely an irreconcilable data gap.

- **Vertical Distribution of Contamination in Groundwater**

  The characterization of the vertical extent of contamination in groundwater is incomplete in the vicinity of the CPA, and is a data gap. Current groundwater monitoring resources only cover the Shallow Zone alluvial aquifer (MW-3) and the Middle Zone UMCf (CP-1). While both of these existing wells are well located to evaluate vertical contamination (being located downgradient of the center of the CPA), there is no monitoring available for the Deep Zone. Current data indicates an upward head gradient is present between the two upper zones. The result of that observation is reflected in data collected from Well CP-1. Although CP-1 was the only boring in the CPA that showed direct evidence of DNAPL during the installation of the well, the well has since tested below MCLs for all VOCs since late 2006. Hence, these data suggest that there is limited downward migration of dissolved VOC contaminants dowgradient of the CPA.

  Nevertheless, the lack of a Deep Zone well at this location is still considered as a data gap. This gap will be resolved late in the 2nd quarter of 2009 when a Deep

Zone well will be installed adjacent to CP-1 as part of the vertical delineation program approved by NDEP December 18, 2008 (Hargis, 2008b).

6. PATH FORWARD

In general, future activities anticipated for the CPA Site Assessment Area are summarized below in sequence:

- Conclude the RAS Process Document underway by Geosyntec and (anticipated to be completed in the 2nd quarter of 2009).
- Conclude the development of the site-wide Risk Assessment Work Plan underway by Integral (anticipated in May 2009).
- Conclude the Data Usability Evaluation by Integral (anticipated in the 2nd quarter of 2009).
- Evaluate the groundwater data from the upcoming vertical delineation study in the 2nd quarter of 2009.
- From the information obtained from the Risk Assessment Work Plan and the Data Usability Evaluation, assess the need, if any, for further site characterization of shallow soils at the CPA, as necessary to complete a risk assessment. This effort will be coordinated with other ongoing work, and it is anticipated that the work will be done in early 3rd quarter of 2009.
- If additional site characterization for the subsurface soils is recommended, prepare a formal sampling and analysis plan per NDEP's RAS Guideline memorandum (NDEP, 2007) and the upcoming RAS Process Document. This effort will be coordinated with other ongoing work, and it is anticipated that the work will be done in the early part of the 3rd quarter of 2009.
- If required, perform a HHRA Evaluation per the RAS Guideline memorandum (NDEP, 2007). This work is anticipated for late in the 3rd quarter of 2009.
- Develop a CPA-specific Soil RAS per the RAS Guideline memorandum (NDEP, 2007) and the upcoming RAS Process Document. This work is anticipated for the 3rd to 4th quarter of 2009.

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Tables

Figures

Exhibits

Appendix A

Response to NDEP Comments Letter

Appendix B

Available Boring Logs

Geosyntec consultants

Appendix C

Historical Summary of Detected Compounds in Groundwater and Comparison with MCLs – Alluvial Aquifer and Upper Muddy Creek Formation Monitor Wells