CITY OF LOMITA

September 20, 2022

Mr. Kevin Lin
Water Resources Control Engineer
320 West 4th St., Suite 200
Los Angeles, Ca. 90013
Kevin.Lin@waterboards.ca.gov

Dear Mr. Lin:

The City appreciates the Los Angeles Regional Water Quality Control Board's (Los Angeles Water Board's) willingness to work with the City of Lomita in engaging the community, sharing pertinent information and efforts in protecting the health and safety of Lomita residents related to the clean-up of contamination emanating from the Skypark Commercial Properties (SCP) located at 2530, 2540, and 2600 Skypark Drive as well as 24701 – 24777 Crenshaw Boulevard in Torrance.

As you know, the City of Lomita relies on a single drinking water well that produces ground water to meet the needs of our residents, and we remain concerned about the migration of the SCP plume over time, and the potential for it to impact our residents' groundwater supply. In August of 2019, the City requested that the Los Angeles Water Board incorporate requirements for the Responsible Parties to conduct comprehensive and updated groundwater modeling to assess the effectiveness of their groundwater remedy in mitigating contaminant migration specifically to our ground water supply well, well No.5. To the City's knowledge, no off-site groundwater remediation has begun, nor has there been modeling to assess the potential impact on Lomita's water supply specifically. While the City's demand is currently being met through imported water connections, Lomita will soon be restarting operations of its drinking water well. In preparation for this, and in the absence of specific modelling from the Responsible Parties, the City hired a hydrogeologic firm to perform a modeling evaluation and High-Level Evaluation of Potential Impacts from Chlorinated Solvents on Lomita Well No. 5 (attached).

While the results of the model show the potential for migration of the contaminants into Lomita's water supply, there are many data gaps which required assumptions in order to perform the modeling. In light of this report, the City specifically requests that the Los Angeles Water Board order the Responsible Parties:

1.) To expedite off-site groundwater remediation for the SCP plume near and within the City of Lomita to prevent further migration of contaminants into Lomita neighborhoods and potential migration into Lomita's drinking water supply.

2.) To install sentry wells between the plume and Lomita's groundwater source to track migration of the plume and to trigger further action if contaminants are detected.

3.) To fill the data gaps that exist, including conclusive determination of the flow directions and merging of Gage and Silverado Aquifers, as well as additional deep (Silverado) groundwater monitoring.

Again, the City appreciates the Los Angeles Water Board's cooperation and hopes it can help bring prompt action by the Responsible Parties on the above items. Should you have any questions, please contact my office at (310) 325-7110, or Director of Public Works, Carla Dillon at (310) 325-7110 ext. 124.

Sincerely,

Ryan Smoot

Ryan Smoot
City Manager
CITY OF LOMITA

Attachment: High-Level Evaluation of Potential Impacts from Chlorinated Solvents on Lomita Well #5

Cc: Dmitriy Ginzburg, State Water Resources Control Board, Division of Drinking Water
Milagros Alora, State Water Resources Control Board, Division of Drinking Water
Aram Chaparyan, City of Torrance
Joseph Liles, Water Replenishment District of Southern California

High-Level Evaluation of Potential Impacts from Chlorinated Solvents on Lomita Well #5

City of Lomita

30 August 2022

318160-40240

Advisian
Worley Group

advisian.com

Disclaimer

Company details

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3621 S. Harbor Boulevard, Suite 100
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Signatures

This report and Advisian's work contributing to this report, were reviewed by the undersigned and approved for use.

Exp. 03/31/2024

Mark Trudell Principal Hydrogeologist California State Hydrogeologist No. 866	**Melanie M. Myden** Senior Hydrogeologist California State Hydrogeologist No. 1100
Stephanie Botha Project Manager / Senior Hydrogeologist	**Martin Hendrie** Senior Hydrogeologist

Advidian
Worley Group

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Acronyms and Abbreviations

Acronym/abbreviation	Definition
CDWR	California Department of Water Resources
COCs	Contaminants of Concern
CSM	Conceptual Site Model
cVOCs	Chlorinated Volatile Organic Compounds
DCE	Dichloroethene
DWR	Department of Water Resources
F_{OC}	Fraction of Organic Carbon
HSC	Hi-Shear Corporation
K_{OC}	Soil Adsorption Coefficient
MCL	Maximum Contaminant Level
PCE	Tetrachloroethene
RWQCB	Regional Water Quality Control Board
RWTA	Regional Water Table Aquifer
SCP	Skypark Commercial Properties
SVE	Soil Vapor Extraction
SWRCB	State Water Resources Control Board
TCE	Trichloroethene
TRI	Toxic Release Inventory
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VC	Vinyl Chloride
WCBBP	West Coast Basin Barrier Project
WRD	Water Replenishment District

1 Introduction

The City of Lomita (the City) contracted Worley Group Inc., operating as Advisian, to conduct a high-level assessment of potential future impacts of chlorinated volatile organic compounds (cVOCs) in groundwater, originating from the Skypark Commercial Properties (the SCPs), on the City's sole groundwater production well (Lomita Well #5). The locations of the SCPs and Lomita Well #5 is shown in Figure 1-1.

The SCPs include several properties located within a single assessor parcel number (APN No. 7377-006-906) which is in and owned by the City of Torrance, located approximately 1.25 miles northwest (hydraulically upgradient) of Lomita Well #5.

The SCPs have been under investigation under the oversight of the Regional Water Quality Control Board (RWQCB) since at least 1991, and specifically since 2009 under a California Water Code Section 13267 Investigative Order, to delineate the lateral and vertical extent of cVOCs (i.e., trichloroethene [TCE], tetrachloroethene [PCE], dichloroethene [DCE] and vinyl chloride [VC]), in soil, soil vapor and groundwater. To date, cVOC impacts have been reported within the Gage aquifer, a regional water table aquifer (RWTA) that is an important water bearing zone in the area. A cVOC plume in groundwater is interpreted to be migrating east-southeast with the RWTA beneath residential properties located east of Crenshaw Boulevard in Lomita, California.

This report provides an overview of the conceptual site model (CSM) and subsequent analytical modelling used to evaluate the long-term fate and transport of cVOCs from the SCPs and potential future impacts on Lomita Well #5.

1.1 Purpose and Scope of Work

The following scope of work was conducted to provide a preliminary analysis of potential water quality impacts due to migration of contamination towards Lomita Well #5:

- Review available data/information including current site conceptual model(s), water levels, water quality data, pumping rates and other data as available and applicable to develop an understanding of groundwater flow conditions and contaminant distribution
- Develop an analytical model to simulate potential migration of contamination towards Lomita Well #5
- Assess modeling results to evaluate potential travel time and water quality impacts at Lomita Well #5
- Conduct sensitivity analysis simulations to understand potential uncertainty relating to model input parameters and assumptions; and
- Document findings in a brief technical memorandum.

Figure 1-1   Map Showing Location of Skypark Commercial Properties, Lomita Well #5, and Approximate Project Area

2 Conceptual Site Model

This section contains an overview of the CSM for the Project Area (refer to Figure 1-1). The CSM is based on publicly available data and has been developed to include descriptions of the environmental setting, potential sources, contaminants of concern (COCs), contaminant fate and transport processes and pathways, and potential receptors.

The information summarized below is not intended to provide a comprehensive description of the SCPs or include all historical activities, but to provide context for the CSM that provided the basis of the evaluation herein.

Additional information on environmental conditions and site characterization associated with the SCPs has been documented by numerous authors including the consulting firms Hygienetics, Inc. (1991), SCS Engineers (1991a, 1991b and 1992), Camp Dresser & McGee (1991), Geosyntec Consultants (1995), BBL Environmental Services Inc. (BBL; 2000 and 2001), Environmental Engineering & Contracting, Inc. (EEC; 2008), Winefield & Associates (2010) Alta Environmental (Alta; 2013), Terraphase (2022a and 2022b), and Genesis Engineering and Redevelopment (2021). Historical reports are maintained on the State Water Resources Control Board (SWRCB) GeoTracker website (SWRCB 2022).

2.1 Site Location and Land Use

The Project Area encompasses both the City of Torrance (where the SCPs are located) and the City of Lomita (where Lomita Well #5 is located). The Project Area is located in southern Los Angeles County, California, approximately 15 miles south-southwest of downtown Los Angeles.

Land use within the vicinity of the SCPs is a mix of commercial and industrial use and contains the Torrance Municipal Airport. The SCPs are bordered by Skypark Drive on the north, the Pacific Coast Highway on the south and Crenshaw Boulevard to the east. Residential communities within the City are located east and southeast of Crenshaw Boulevard.

As indicated in the City of Lomita Water Master Plan Update (KEC Engineers, Inc. [KEC] 2015), Lomita Well #5 is located at 26112 Cypress Street, Lomita, California, approximately 1.25 miles southeast of the SCPs, as shown on Figure 1-1. The well is the main component of the Cypress Water Production Facility and is located in an area which includes a mixture of commercial and residential properties.

2.2 Historical Site Information

The SCPs comprise an approximately 12.25-acre property that is owned by the City of Torrance and has reportedly been occupied by Hi-Shear Corporation (Hi-Shear) and other parties since at least 1954. Hi-Shear's primary business is understood to be the manufacture of metal fasteners used in the aerospace industry (BBJ Group and Ramboll 2021 and GE&R 2021a).

Various subsurface features are reported to have existed at the SCPs, including underground storage tanks (USTs) and clarifiers (which included storage of TCE-containing solvents), an industrial wastewater treatment plant, and various above ground storage tanks for plating operations. Historical records also indicate that Hi-Shear had degreasing units that used PCE, and several spray booths for paints and solvents. Annual Toxic Release Inventory (TRI) Form R reports also indicate that several chemicals (including PCE, TCE, and 1,1,1-Trichloroethane [1,1,1-TCA]) were used at the SCPs (Hygienics 1991; BBJ Group and Ramboll 2021).

The SCPs have been subject to environmental site assessments and investigations since at least 1991, according to records (SWRCB 2022) that indicate a Phase I Environmental Site Assessment was performed by Hygienetics, Inc. in May 1991. The earliest soil and groundwater investigations were performed by Camp Dresser & McKee, Inc. (1991) and SCS Engineers (1991), both of whom reported cVOCs impacts to the shallow soil and groundwater system. The primary COCs include TCE and PCE. Several subsequent site investigations conducted at the SCPs confirmed cVOCs impacts to soil, soil vapor, and groundwater (perched and regional) and aimed to delineate the vertical and lateral extent of contamination, as summarized by BBL (2001), EEC (2008), Winefield & Associates (2010), and GE&R (2021a & b).

In addition to environmental investigation activities, various remediation approaches including soil vapor extraction (SVE) (intermittently since at least 1999 [BBL 2000] and recently restarted), and groundwater remediation (with various phases from pilot to full-scale studies between approximately 2012 and 2017) have been implemented at the SCPs (Alta 2017; Terraphase 2022a and 2022b).

While some source removal of cVOCs has occurred, a groundwater plume remains on-site that extends downgradient from the source area at the SCPs to the east-southeast beneath neighboring properties in the City of Lomita (GE&R 2021a and MK Environmental 2021).

2.3 Regional Geologic Setting

The Project Area is located within the West Coast Basin, a sub-basin of the Los Angeles Basin. The West Coast Basin encompasses approximately 140 square miles, extending from the Pacific Ocean southeast to the Palos Verdes Hills, San Pedro Bay, and Orange County (California Department of Water Resources [CDWR] 1961). The West Coast Basin is separated from the Central Basin to the east by the Newport-Inglewood uplift, a regional anticlinal fold, which extends approximately 40-miles southeast from Beverly Hills to Newport Beach (USGS 2003).

The West Coast Basin contains a series of aquifers and aquicludes. Aquifers are composed of thick, permeable sediments that are a source of water to groundwater wells. The term "aquiclude" describes the less permeable silt and clay layers that separate the aquifers in some locations. The shallowest groundwater underneath the Project Area is an unconfined semi-perched aquifer. This semi-perched aquifer is composed of Recent age marine and estuarine deposits. Beneath the semi-perched aquifer is the Bellflower Aquiclude. Regionally, the Bellflower Aquiclude is approximately 100 to 120 feet (ft) thick and composed of finer-grained sediments (clay, silt, sandy silt, silty sand, clayey sand, sandy clay, and gravelly clay). Where the Bellflower Aquiclude is found, the finer-grained sediments inhibit groundwater movement between the semi-perched aquifer and the underlying Gage Aquifer.

The semi-perched aquifer is underlain by the Upper Pleistocene marine and nonmarine alluvial terrace deposits of the Lakewood Formation, a heterogenous unit dominated by sandy silts and silty sands interbedded with varying thicknesses of sand. The entire Lakewood aquifer system ranges in thickness from 150 to 400 ft and includes the Gage Aquifer system (USGS 2003). The Gage Aquifer is the regional water table aquifer (RWTA) which underlies the Project Area. It is approximately 200 ft thick near the SCPs and regionally consists primarily of sand with trace amounts of gravel and thin beds of silt and clay. According to geologic reports, the Bellflower Aquiclude may be absent in the vicinity of the Project Area and aquifers present are thought to be in hydraulic continuity with the surface (CDWR 1961).

The Lakewood Formation is underlain by the Lower Pleistocene San Pedro Formation, which is underlain by the Pliocene Pico Formation. The San Pedro Formation includes the Silverado Aquifer. The uppermost portion of the San Pedro Formation consists of a clay layer between 40 to 100 ft thick which separates the Gage Aquifer and underlying Silverado Aquifer. Although Alta (2012) reports that the clay layer may be locally absent in the Torrance area as noted by Hargis and Associates (1991) in BBL (2002). Reportedly, in this area the Gage and Silverado Aquifers appear to merge. The Silverado Aquifer, the lowermost aquifer of the San Pedro aquifer system, produces the most water in the system and is estimated to be between 250 and 500 ft below the SCPs. The Pico Formation is composed of mostly marine sediments which include interbedded layers of sandstones, siltstones, and mudstones (CDWR 1961).

The Pico Formation is underlain by the Miocene Monterey Shale and Puente Formation. Basement rock beneath this sedimentary sequence is the Catalina schist facies of the Franciscan Formation.

A summary of the regional geological stratigraphy is shown in Table 2-1.

Table 2-1 Regional Geological Stratigraphy in Project Area

Age	Formation	Aquifer/Aquitard
Holocene (Recent)	Active Dune Sand	Semi-Perched Aquifer
	Alluvium	Bellflower Aquitard Gaspur/Ballona Aquifer
Upper Pleistocene	Older Dune Sand	Semi-Perched Aquifer
	Lakewood Formation	Exposition-Artesian Aquifer Gage Aquifer (200 ft sand aquifer)
Lower Pleistocene	San Pedro Formation	Hollydale Aquifer Jefferson Aquifer Lynwood Aquifer (400 ft gravel aquifer) Silverado Aquifer Sunnyside Aquifer Lower San Pedro Aquifer
Upper Pliocene	Pico Formation	

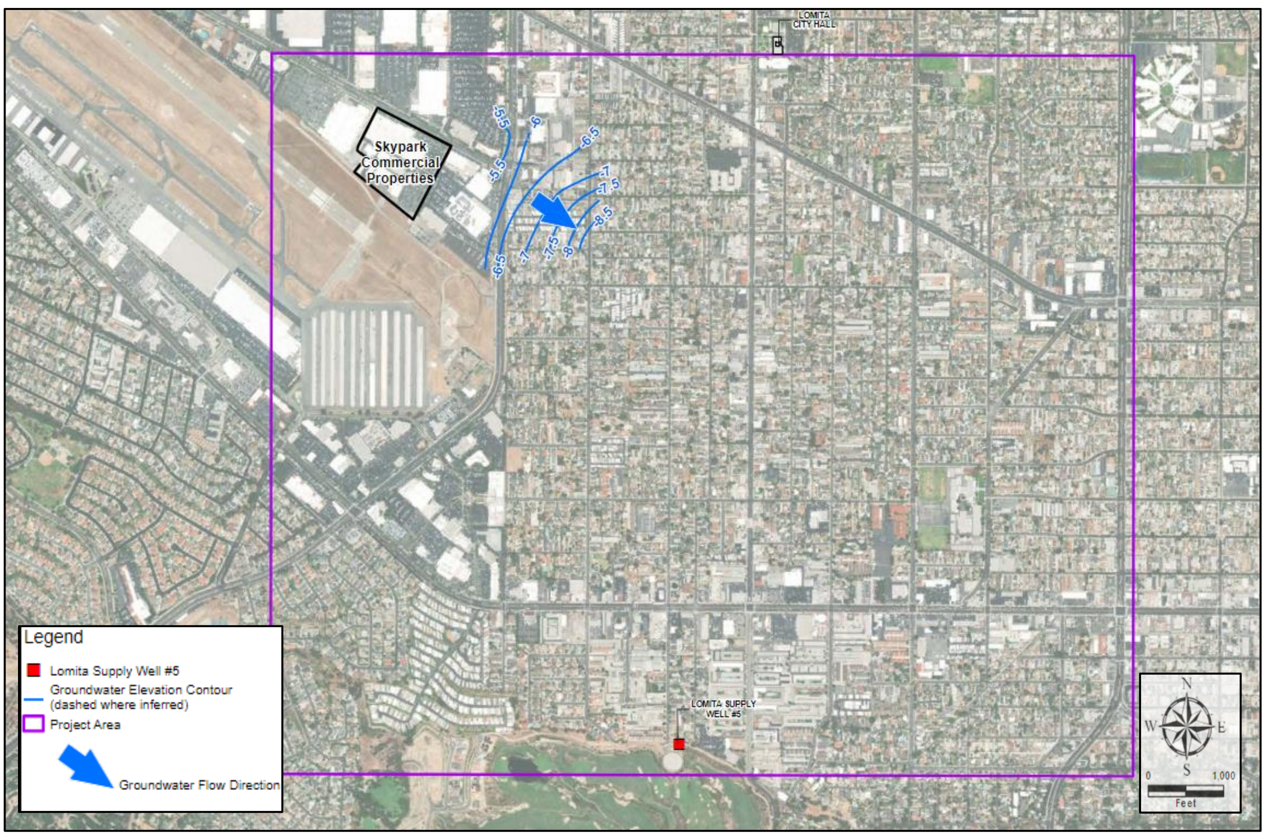
Source: USGS Water Resource Investigation Report 03-4065 (USGS 2003)

2.4 Regional Hydrogeologic Setting

A review of Bulletin 104 (CDWR 1961) indicates that the RWTA is interpreted to be within the Gage Aquifer. The review suggests a depth to the top of the Gage Aquifer of approximately 60 ft. The RWTA was encountered during site investigations at the SCPs at approximately 80 to 90 ft below ground surface (bgs) (BBL 2002; Alta 2013; and GE&R 2021a & b) and at 133 to 138 ft bgs near Lomita Well #5 (ETIC 2020 and PIC 2022). Near the SCPs, the RWTA is known to extend to a depth of at least 285 ft bgs, indicating a saturated thickness of at least 190 ft (Alta 2013).

As shown on Figure 2-1, groundwater flow in the RWTA is generally towards the east-southeast direction with a horizontal hydraulic gradient between 0.0008 to 0.004 (with an average of 0.0021) as reported in Alta (2017) and GE&R (2021). The regional groundwater flow direction has not changed since monitoring began (in 1991) and is thought to be impacted by injection of water to the west via the West Coast Barrier Basin Project (WCBBP) and regional groundwater extraction southeast of the SCPs (Alta 2013 and GE&R 2021a). Injection wells in the WCBBP create a north-south trending mound of fresh water from the Los Angeles International Airport area, south to the Palos Verdes Hills. Injection wells also form a protective mound at the Dominguez Gap Barrier located southeast of the Project Area near Wilmington (CDWR 2021).

Figure 2-1 Groundwater Flow in the Gage (RWTA) Aquifer

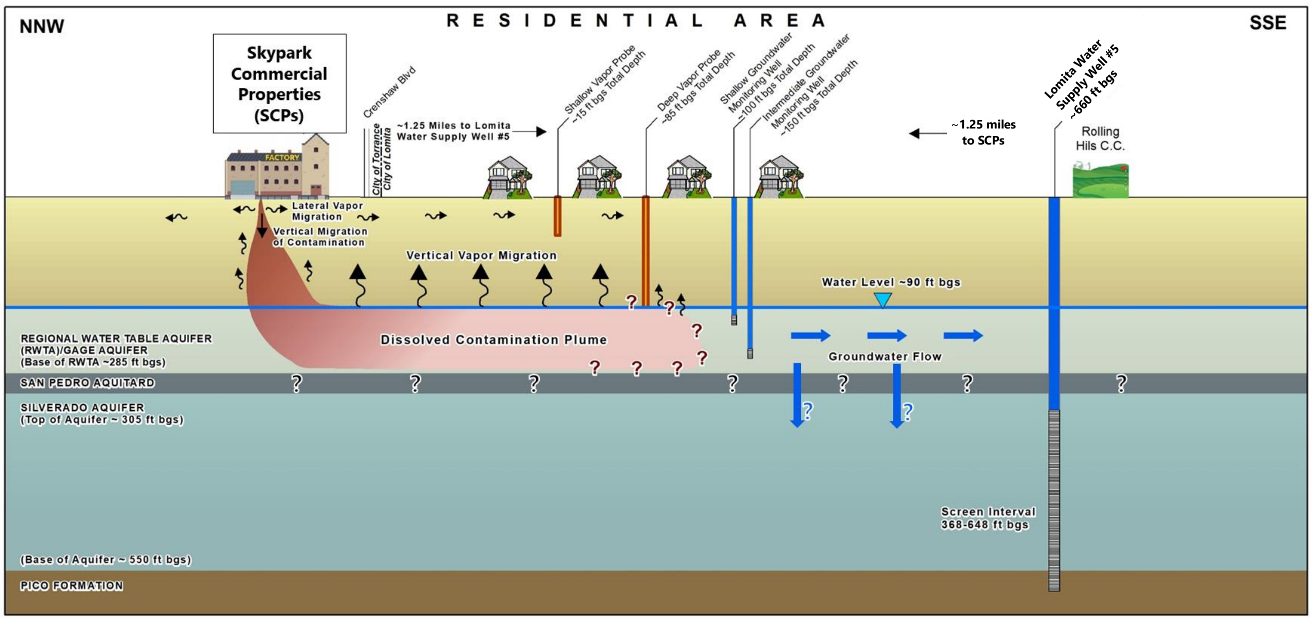


The Water Replenishment District (WRD) has one nested monitoring well (Lomita #1) within the Project Area. There are six individual zones that are screened as part of the nested monitoring well, including screens installed within (from shallowest to deepest): the Gage (two zones), Lynwood, Silverado (two zones) and Pico Aquifers. Screen depths range from 120 to 1260 ft bgs (WRD 2021). Historically, water levels in the Silverado Aquifer are generally deeper than those of the Gage Aquifer by approximately 1 to 4 ft (WRD 2021).

In 2002, BBL reported that the vertical groundwater flow gradient in the RWTA observed in cluster wells was directed downward; however, more recent data (Geosyntec 2010) for the cluster wells are inconclusive. A review of TCE concentrations in one well cluster (BBL 2002) also suggested that chlorinated solvents are primarily migrating laterally through the RWTA versus vertically.

A conceptual model of the hydrogeological setting is shown as Figure 2-2.

Figure 2-2 Conceptual Model of Hydrogeological Setting



2.5 Lomita Well #5

The City of Lomita's only groundwater production well (Lomita Well #5) is located approximately 1.25 miles southeast of the SCPs. Lomita Well #5 was drilled and completed in January 1971, with an approximate production capacity of 1,500 gallons per minute (gpm; Dudek 2022). The well is 660 ft deep and is perforated from 368 to 648 ft bgs within the Silverado Aquifer (KEC 2015). The City currently has adjudicated rights of 1,352 acre-feet of groundwater, annually (WRD 2021a).

In 2018, the Los Angeles Regional Board received notification of a benzene detection in Lomita Well #5. Analytical testing data from Lomita Well #5 reported concentrations of benzene at 0.54 micrograms per liter (µg/L) in May 2018, 3.2 µg/L in April 2019, and 3.7 µg/L in May 2019, and Lomita Well #5 was subsequently taken off-line. The Los Angeles Regional Board has initiated an investigation to identify the source(s) of benzene impacting Lomita Well #5. Investigations of USTs that were used to store gasoline at several sites located hydraulically upgradient from Lomita Well # 5 haven recently been undertaken; however, to date, the source(s) of benzene in the Silverado Aquifer has not been determined (ETIC 2020 and PIC Environmental Services [PIC] 2022).

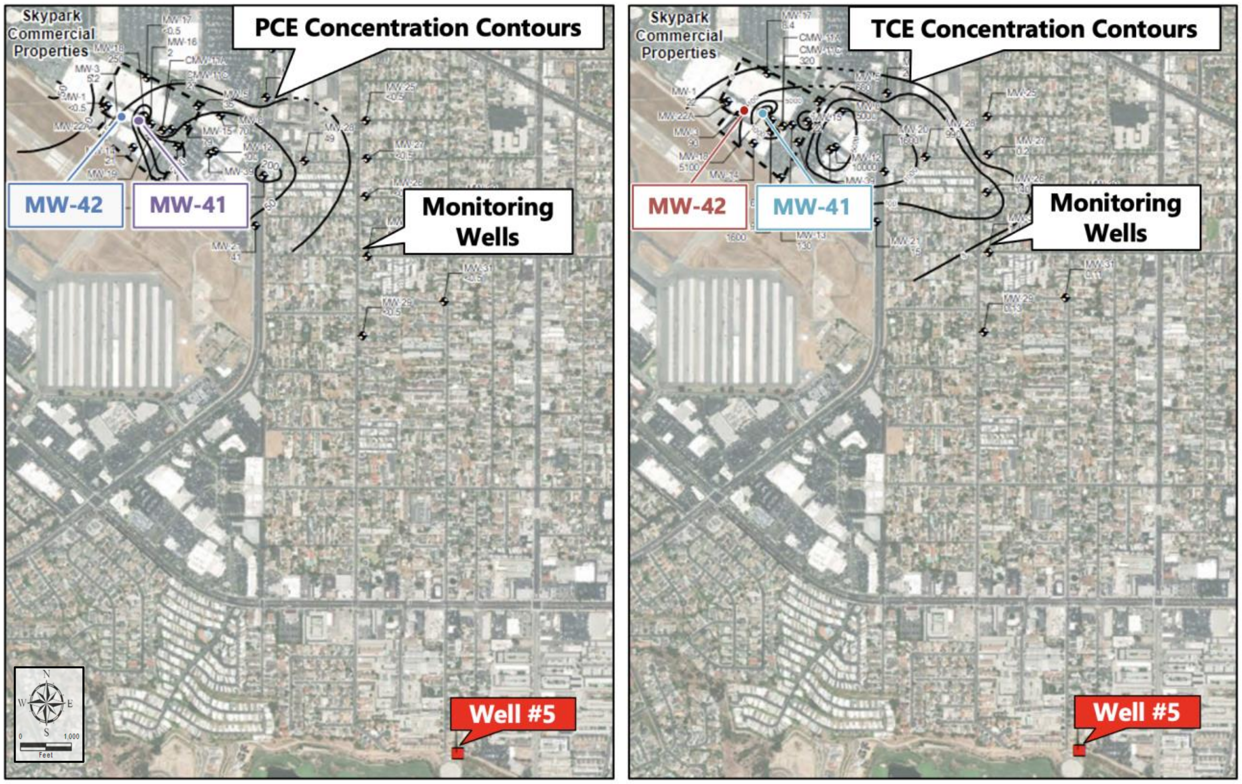
2.6 Contaminants of Concern (COCs)

Substantial releases of cVOCs (specifically PCE and TCE) have occurred within the SCPs due to activities and infrastructure at the site which have impacted soil, soil vapor and groundwater. Degradation products of PCE and TCE, including cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE), 1,1-dichloroethene (1,1-DCE) and vinyl chloride (VC) have also been detected above respective screening levels in groundwater. In 1991, the first reported groundwater well (MW-1) was installed within the RWTA at the SCPs. Reported concentrations of PCE, TCE, and 1,1-DCE were 220, 6,600, and 20 µg/L, respectively (Hygienetics 1991).

Since 1991, a number of site investigations have been performed to delineate the source concentration area(s) and plume migration over time. Historical site investigations have consistently shown that cVOCs within the RWTA have migrated as a co-mingled plume east-southeast from the SCPs impacting downgradient properties east of Crenshaw Boulevard (Winefield & Associates 2010; Alta 2016; and GE&R 2021a).

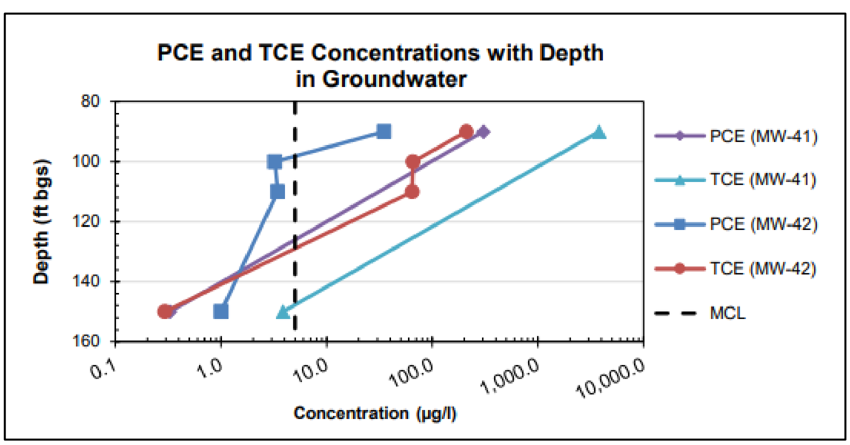
A summary of PCE and TCE concentrations and iso-concentration contours are shown on Figure 2-3. The figure is based on recent data (from November 2019) showing the area of groundwater impacted beneath and downgradient of the SCPs beneath the City of Lomita, east of Crenshaw Boulevard (GE&R 2021a).

Figure 2-3 PCE and TCE Concentration Contours in the RWTA, November 2019 (from GE&R 2021a)



Vertical delineation of groundwater impacts was undertaken in 2021 (GE&R 2021b). As shown on Figure 2-3, PCE and TCE concentrations in the RWTA progressively decrease with depth to concentrations below the maximum contaminant level (MCL) of 5 µg/L at approximately 150 ft bgs. No impacts to the Silverado Aquifer have been reported to date. However, the number of wells installed in this aquifer are limited in the Project Area.

Figure 2-3 PCE and TCE Concentrations with Depth in Groundwater (from GE&R 2021b)



3 Modelling Methodology

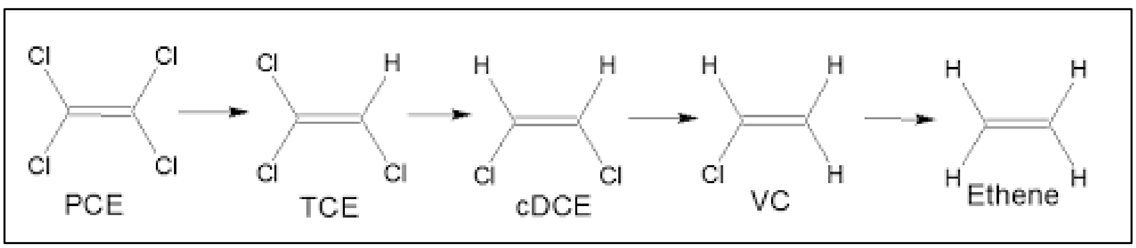
3.1 BIOCHLOR Model

The analytical model BIOCHLOR (version 2.2), developed by the United States Environmental Protection Agency (USEPA 2000 and 2002), was used to model the fate and transport of cVOCs in the Project Area. BIOCHLOR is designed to solve the problem of solute transport in uniform (one dimensional, steady state) groundwater flow.

In BIOCHLOR, solute transport is analytically solved using the modified Domenico model (Domenico 1987) with first order biotransformation and source decay. Mechanisms for the transport of solute include advection and three-dimensional dispersion, sorption of the solute onto soil, and biotransformation of the solute from parent to daughter compound via first order decay. BIOCHLOR is specifically designed to model the fate and transport of chlorinated solvents through sequential decay (i.e., the PCE-TCE-DCE-VC sequence).

Biodegradation is an important process in the natural attenuation of chlorinated solvents. The majority of solvent biodegradation occurs by reductive dechlorination (Wiedemeier et al. 1996) as shown in Figure 3-1. Evidence of plume mass reduction is noted at the SCPs through the decreasing abundance of parent compounds (TCE or DCE) relative to degradation products (DCE and VC) at downgradient locations which indicates biodegradation is likely occurring (GE&R 2021a).

Figure 3-1 Reaction Sequence of Chlorinated Ethenes (from Parsons 2004)



For the BIOCHLOR model to be applicable, the following key assumptions must be met:

- **Uniform Flow:** The plume must be contained within a volume of porous media such that the groundwater velocity and dispersivity are relatively constant (i.e., within a single aquifer versus multiple aquifers). In general, this condition is met as the plume is thought to be migrating primarily within the Gage Aquifer (i.e., the RWTA).
- **Known Source:** A source of known size of sufficient mass to the groundwater flow field so as to maintain constant concentration. Although the size and concentration of the initial source area is unknown, there is sufficient data over a significant timeframe (1991 to 2021) to characterize the source area for the purposes of the evaluation herein.
- **First Order Decay Kinetics:** The compounds under consideration must transform as a decay chain with first-order kinetics. This is a reasonable assumption for chlorinated solvents. Degradation

coefficients can be selected via the process of model calibration to calibrate to measured solute concentrations.

- **Advection Transport:** It is assumed within BIOCHLOR that advection is the dominant transport mechanism for cVOCs in groundwater at the Site.

The BIOCHLOR model cannot mathematically accommodate and simulate a single contaminant source both before and after mass-removal remediation (within the same model). The model therefore assumes a non-remediated source, incorporating PCE concentrations at the source which reflect aquifer conditions prior to removal of the contaminant source material. In this manner, the model presents a conservative simulation as it does not account for any reduction in cVOC concentrations that might be realized from historical or proposed removal actions.

3.1.1 BIOCHLOR Model Input Parameters

A summary of all model input parameters is provided in Appendix A and discussed below.

3.1.1.1 Model Domain and Simulation Timeframe

A definitive source of cVOCs has not been identified; however, data from as early as 1991 indicates that cVOCs were identified within the shallow groundwater system at that time (Hygienetics 1991 and BBL SCS Engineers 1991). It is possible that the cVOCs could date back to a time significantly earlier than 1991 (e.g., manufacturing activities have been occurring at the SCPs since 1954) and therefore, a simulation time of 100 years was initially selected to simulate steady-state conditions.

One source area was modelled for the CSPs based on the CSM. The model source area was configured as a single-planar source the width of the groundwater plume (approximately 280 ft, based on current plume maps; GE&R 2021a) and the thickness of the RWTA interval (190 ft). A modelled area width and length of 280 and 5,000 ft, respectively, was simulated.

It is noted that the width is not necessarily critical to the modeling outcome as the modelling is used to simulate the maximum concentrations along the centerline of the plume (i.e., along the axis of the wells for which the data are modelled).

3.1.1.2 Hydrogeology

The hydraulic gradient (i) within the source area was estimated from groundwater levels measured between 2013 and 2019 (GE&R 2021a). The groundwater flow direction (east to southeast) and hydraulic gradient have remained relatively unchanged since groundwater monitoring began in 1991 based on the available data. An average hydraulic gradient of 0.0021 ft/ft was used for all simulations (as noted in Section 2.4).

Aquifer tests at the SCPs have yielded hydraulic conductivity (K) values that range in magnitude from 2.4 to 4 ft/day (BBL 2002) up to 46 to 58 ft/day (Alta 2013). The modelled K-values were varied over two orders of magnitude within a range consistent with reported values. An assumed effective porosity (n_e) consistent with that of silty sands to clean sands (0.25; Gibb et al. 1984) was used for all simulations.

As discussed above, the mean K, I, and n_e values were used as inputs to the model to determine seepage velocity (v).

3.1.1.3 Dispersion

Dispersion was calculated in the model based on the observed length of the plume using data from November 2019 (GE&R 2021a). Concentrations of TCE and PCE were observed downgradient of the assumed source area in shallow monitoring wells MW-28 (49 µg/L) and MW-21 (41 µg/L) but were not detected in monitoring wells MW-25, MW-27, MW-26, or MW-36 (all located along Pennsylvania Avenue). Based on the reported non-detectable concentrations at these wells from 2019 data (GE&R 2021), a plume length of approximately 2,000 ft was estimated for the purposes of this evaluation.

A fixed value for the longitudinal dispersivity (10 percent of the plume length), based on data summarized in Aziz et al. (2000), was employed. Transverse dispersivity was assumed to be 30 percent (0.30) and vertical dispersivity was assumed to be five percent (0.05) of the longitudinal dispersivity, respectively (Aziz and Newell 2002).

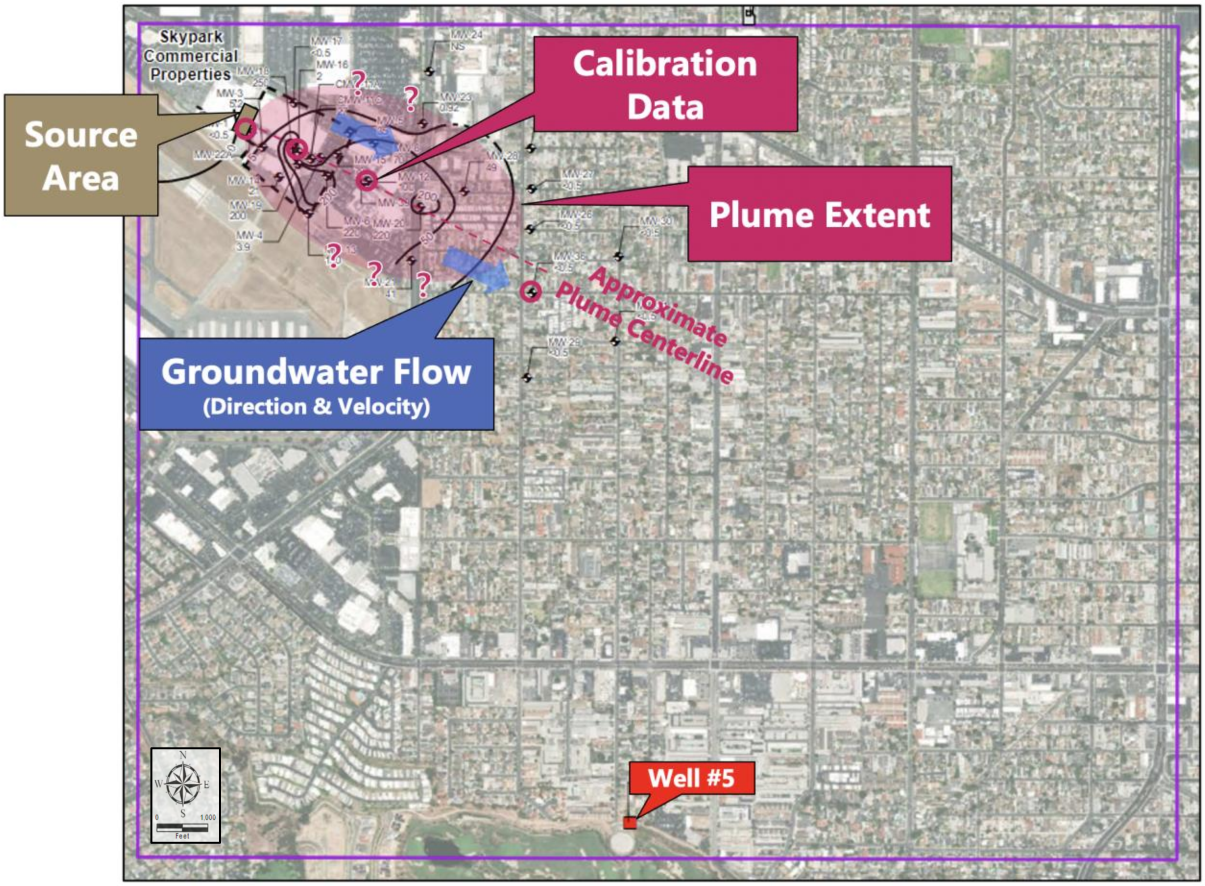
3.1.1.4 Rate Constants (Adsorption and Biotransformation)

Source area concentrations are expected to decrease through mass lost due to advection out of the source area, volatilization, and chemical and biologic degradation processes. A non-decaying source area was used in the BIOCHLOR. Source decay is described by a constant (ks) and accounts for all of the processes that reduce the source area concentration and is different from the biodegradation rate (λ), which only addresses the rate of biologic transformation.

Biodegradation rate constants were estimated using literature data and field data from existing monitoring wells (e.g., MW-18, MW-12, MW-28, and MW-36). These wells were used to define the approximate plume centerline, as shown on Figure 3-2. Rate constants were estimated through calibration of the BIOCHLOR model to cVOC concentration data from monitoring wells near the plume centerline. As field data to date indicates that only the Gage (RWTA) aquifer has been impacted, only cVOC data from RWTA wells were used. In addition, data were used only from wells in the part of the plume deemed to be anaerobic (i.e., dissolved oxygen values less than 1 mg/L).

To define a model retardation factor for the modeled cVOCs, the retardation factor was calculated within BIOCHLOR based on the soil bulk density, fraction organic carbon (Foc), and partition coefficient values. All parameters were initially assumed based on literature values as defined in Appendix A. As noted above, rate constants were estimated by adjusting values within literature ranges until the BIOCHLOR concentration predictions reasonably matched the field data.

Figure 3-2 Conceptual Diagram of BIOCHLOR Model Setup and Calibration Data



3.1.1.5 Source Area Concentrations and Field Data

Source area concentrations were based on data provided in the initial site investigation reports (Hygienetics 1991 and CDM 1991). A single monitoring well (MW-1) was installed within the RWTA and reported concentrations were above referenced guideline values for PCE (220 µg/L), TCE (6,600 µg/L), 1,1,1-TCA (6 µg/L), and 1,1-DCE (20 µg/L). For this evaluation, it is assumed that the initial source concentrations would be similar to (or within an order of magnitude) to the values reported in 1991 at MW-1.

Field data from the most recent site conceptual model report (GE&R 2021a) were used to calibrate the model. Concentrations of PCE, TCE, DCE and VC at monitoring wells MW-18 (proximal to the assumed source area), MW-12 (750 ft), MW-28 (1,500 ft), and MW-36 (2,425 ft), located downgradient of the assumed source area and along the plume centerline, as reported in GE&R (2021a) were used to calibrate the model.

3.1.2 Model Calibration

Model calibration involved finding a set of fate and transport parameters that result in the BIOCHLOR model output producing a reasonable match to the plume concentration distribution as measured in the field. The BIOCHLOR model was calibrated using a deterministic approach to represent current site conditions assuming steady-state groundwater flow. It is noted that the model calibration does not account for active groundwater remediation that has occurred on site but does account for biodegradation of the source.

PCE and TCE are considered the primary COCs and therefore the model calibration focused on the PCE and TCE plumes. To represent current site conditions, PCE and TCE concentration data from monitoring wells located within the assumed source area and along the centerline axis of the plume (MW-18, MW-12, MW-28, and MW-36) were used to compare against the simulation results.

Adjustments were made to the seepage velocity parameters (i.e., K and i) within range of reported values and the biotransformation (degradation) rates were adjusted for each cVOC.

For PCE, the match between simulated and observed concentrations indicate the model is generally able to reproduce field conditions under the given assumptions.

For TCE, during the initial calibration process, there was discrepancy between the model results and field data. In reviewing the model results and field data it became apparent that reported concentrations of TCE at MW-1 in 1991 (6,600 µg/L) were two orders of magnitude lower than reported concentrations at MW-3 (25,000 µg/L) in 2001 (BBL 2001), which is an indication that the original source concentration was likely much higher than that reported in 1991 or that there is more than one contributing source. Thus, the source concentration value for TCE in BIOCHLOR was increased to 70 mg/L which provided a better fit to the TCE field data.

It is noted that the model generally overestimates biodegradation in the area of the plume near the source zone and underestimates biodegradation at the leading edge of the plume. This suggests that the modelled biodegradation rate may be higher than is actually occurring in some areas or that previous remediation activities at the SCPs have affected TCE concentrations (which is to be expected). It is also noted, the TCE degradation rate used during the model runs is an averaged estimate for the entire plume; however, because the plume is heterogeneous in terms of the degradation rate in different portions of the plume, this averaged estimate is associated with some degree of uncertainty. The uncertainties in other transport parameters (e.g., use of an average K value and hydraulic gradient for the entire site when in reality heterogeneities exist) could also cause the difference between simulated and observed concentrations of TCE.

3.1.3 Sensitivity Analysis and Verification

Sensitivity analysis of the model was performed to assess the variation in results within a reasonable range of input parameters. Sensitivity analyses were conducted by varying one parameter per simulation over a range of values. There is overlap between the model calibration step and sensitivity analysis in that sensitivity analysis is conducted both during calibration (the past) and can be conducted for predictions (the future). If a parameter input is adjusted during calibration and that change in value does not affect the model calibration, then that parameter is not considered to be sensitive.

For the BIOCHLOR model, a number of parameters can affect the model including source concentrations, soil Foc and organic carbon partitioning coefficients (which together determine the retardation factor for adsorption/advection), seepage velocity, and the degradation constant(s).

The sensitivity analysis involved changing these parameters and comparing the resulting predicted plume length with the calibrated model results. A summary of sensitivity runs performed is discussed in the subsections which follow and the variation on model results for PCE concentrations are shown in Table 3-1.

Table 3-1 BIOCHLOR Model Sensitivity Analysis Results

Sensitivity Parameters	Distance from Source (in ft)			
	0	750	1500	2425
	Concentration of PCE in mg/L			
Field Data (GE&R 2021a)	**0.250**	**0.100**	**0.049**	**ND**
Calibrated Model	0.220	0.098	0.051	0.027
Seepage = 1564.4 ft/yr	0.220	0.128	0.089	0.067
Seepage = 15.6 ft/yr	0.220	0.021	0.001	0.000
Seepage = 156.4 ft/yr Foc = 0.01	0.220	0.094	0.039	0.007
Seepage =156.4 ft/yr Foc = 0.0001	0.220	0.098	0.051	0.027
Seepage = 156.4 ft/yr lambda = 0 (no degradation)	0.220	0.132	0.095	0.075

Notes: *ND – Non-Detectable Concentration*

3.1.3.1 Foc and Retardation Factor

There were no site-specific data available for Foc values, therefore the model default value (0.001) was used. The Foc parameter has a direct effect on the retardation factor.

For the sensitivity analysis, the model-default value for Foc (0.001) was adjusted an order of magnitude larger (0.01) and smaller (0.0001) to assess how the predicted plume changed in length and concentration with changing retardation values.

3.1.3.2 Seepage Velocity

Seepage velocity was used as a calibration parameter. During the calibration step, it was noted that changing the seepage velocity while keeping other parameters constant could significantly change the plume length prediction. It is unlikely that the entire modeled area has a single seepage velocity (as assumed by BIOCHLOR), thus a sensitivity analysis on seepage velocity is warranted.

As determined during calibration, a seepage velocity of 156.4 ft/year provides a reasonable match for the field data. For the sensitivity analysis, the seepage velocity was increased and decreased by a factor of 10 to evaluate resulting changes in plume magnitude.

3.1.3.3 Degradation Constant (PCE to TCE)

The calibration step also indicated that the degradation constant is a sensitive parameter as small changes to it created relatively large changes in the predicted concentrations along the centerline of the plume.

As determined in calibration, degradation constants (lambda) of 0.07 (TCE), 0.693 (PCE), 13.86 (DCE), and 1.733 (VC) yr^{-1} provide a match between model results and the field data. These values were based on ranges of degradation constants provided in Wiedemeier et al. (1999) and adjusted to match field data. For the sensitivity analysis, the degradation constants were decreased to zero (i.e., no biotransformation occurring) to evaluate resulting changes in plume magnitude.

4 Capture Zone Assessment

Assessing the capture zone of Lomita Well #5 (i.e., the Silverado Aquifer) is an important part of determining the well vulnerability as contamination present within the capture zone of a production well is likely to be drawn towards the well. Although Lomita Well #5 is screened within the Silverado Aquifer (i.e., deeper than the RWTA), historical reports suggest that the clay layer which separates the Gage Aquifer and underlying Silverado Aquifer may be absent in the Torrance area, and that the Gage (RWTA) and Silverado Aquifers merge (as noted in Section 2.3). In areas where the clay layer (i.e., the aquitard separating the RWTA and Silverado) is absent, the Silverado is vulnerable to potential cVOCs migrating downward from the RWTA.

A capture zone is generally defined as the areal extent of groundwater that is supplied to a pumping production well based on a time of travel criteria (e.g., 2, 5 or 10 years; Fitts 2013). The shape and extension of the capture zone is defined by the geometry and hydrogeologic properties of the pumped aquifer and associated boundary conditions (Feyen et. al 2001).

A semi-analytical model was used to estimate the capture zone dimensions for steady-state pumping of Lomita Well #5. The key assumptions for the capture zone analysis are as follows:

- the aquifer is homogeneous, isotropic, and infinite in horizontal extent
- a uniform regional hydraulic gradient is present
- a constant well pumping rate
- uniform flow (i.e., steady-state conditions)
- the confining layer prevents leakage between the unconfined aquifer (the Gage Aquifer) and the underlying confined aquifer (the Silverado Aquifer); and
- vertical gradients are negligible.

The saturated thickness of the Silverado Aquifer is estimated to be 245 ft thick based on regional water level measurements and estimated depth to the base of the aquifer (WRD 2022). For the Silverado Aquifer, a hydraulic gradient of 0.004 ft/ft was derived using regional water levels measured in September 2021 at WRD monitoring Wells Lomita 1 and PM-3 Madrid, located within the Project Area (WRD 2021b).

An aquifer test has not been performed on Lomita Well #5; thus, hydraulic conductivity and transmissivity values are not available for the well. Slug tests conducted on USGS monitoring wells within the West Coast Basin reported hydraulic conductivity values between 3 to 70 ft/day (USGS 2002 and 2003). Due to the uncertainty of hydraulic parameters, capture zone calculations were performed using a range of hydraulic conductivity values (from 25 to 75 ft/day) to provide a range of output parameters (i.e., stagnation point and capture zone width).

Using an average extraction rate of 426.5 gpm (based on the highest pumping rate at Lomita Well #5 from 2014 to 2018) and a bulk horizontal hydraulic conductivity of 25 to 75 ft/day, the modeled downgradient stagnation point ranges from 533 to 178 ft and the maximum width of the upgradient capture zone ranges from approximately 1675 to 560 ft, as shown in Figure 4-1.

For the scenario where pumping is increased to the City's full adjudicated rate of 1,352 acre-feet per year, the maximum pumping rate would increase to 838 gpm. For this scenario, the modeled capture zone width would increase, with estimates ranging between to 1,097 ft to 3,292 ft, for hydraulic conductivity values of 75 ft/day and 25 ft/day, respectively, as shown on Figure 4-2.

Figure 4-1 Capture Zone Assessment for Lomita Well #5 based on a range of hydraulic conductivity values with a pumping rate of 426.5 gpm

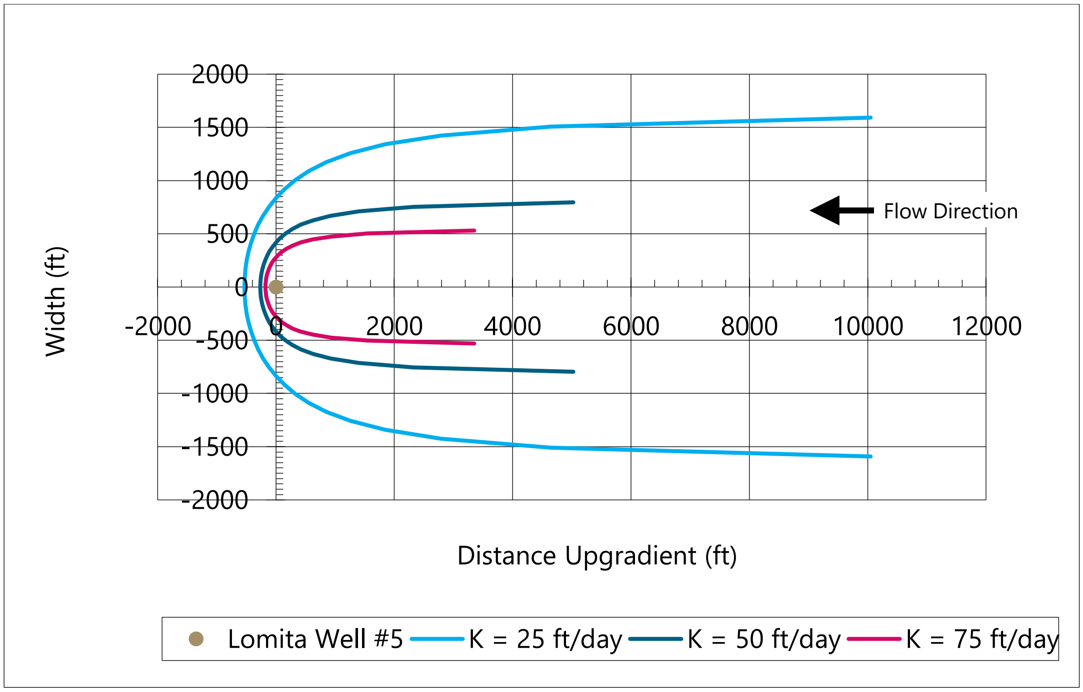
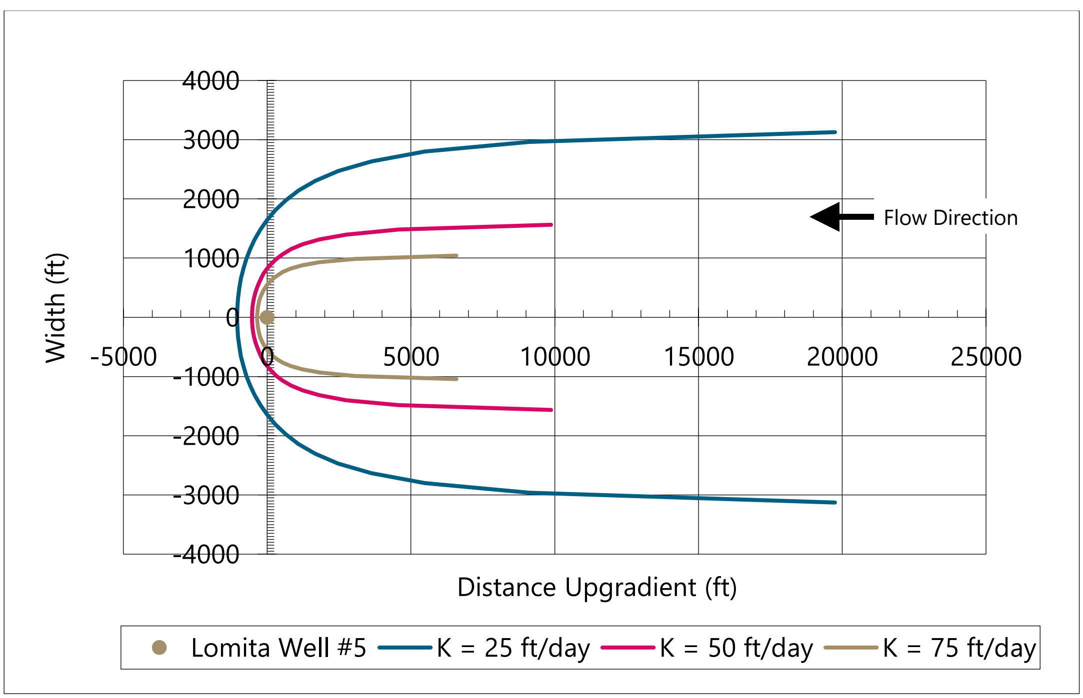


Figure 4-2 Capture Zone Assessment for Lomita Well #5 based on a range of hydraulic conductivity values with a pumping rate of 838 gpm



5 Results and Recommendations

5.1 Results

Results of the BIOCHLOR steady-state (100 year) simulation are summarized on Figure 5-1 and Figure 5-2, which show concentrations of PCE and TCE, respectively, versus distance from the assumed source (in ft). PCE and TCE are regulated contaminants with an established Maximum Contaminant Level (MCL) for drinking water at 0.005 milligrams per liter (mg/L). Results from the steady-state model show that with a continuous source of PCE over time, concentrations of PCE remain above the MCL beyond 5,000 ft from the assumed source area (Figure 5-1), while TCE concentrations decrease to below the MCL approximately 3,300 ft beyond the assumed source area (Figure 5-2). The assumed source area is approximately 1.25 miles (approximately 6,600 feet) from Lomita Well #5, although it not located directly along the centerline of the plume (as shown previously on Figure 3-2).

Figure 5-1 Modeling Results of PCE Concentrations During Steady-State (100 year) Simulation

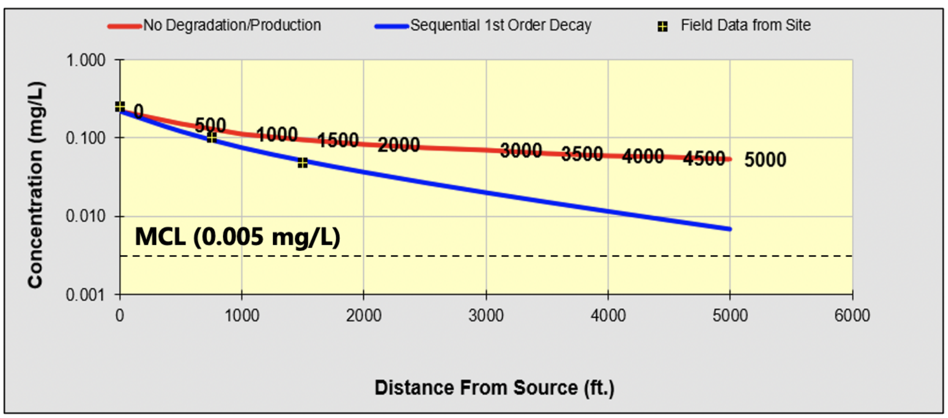
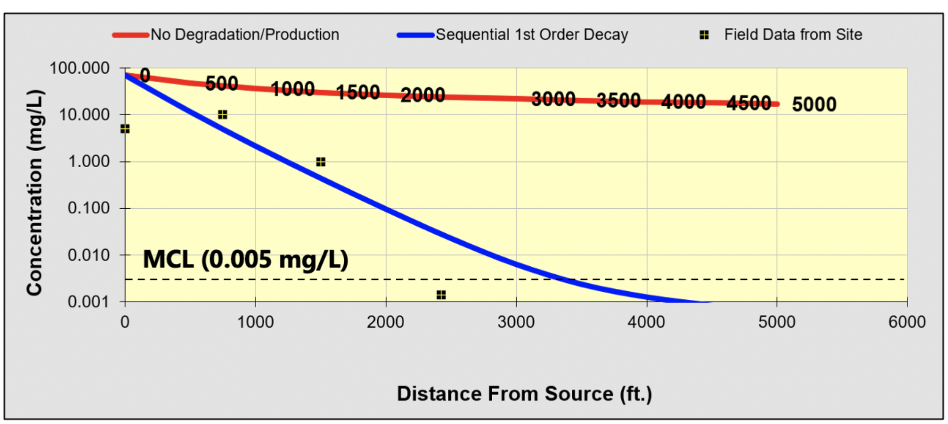


Figure 5-2 Modeling Results of TCE Concentrations During Steady-State (100 year) Simulation



A simulation run of 40 years (i.e., 1991 to 2031) predicts that the PCE concentration above the MCL (0.005 mg/L) may migrate from the original source to a total distance of approximately 4,500 ft within the next 10 to 20 years (Figure 5-3) and that TCE above the MCL may migrate as far as 3,300 ft (Figure 5-4). Although Lomita Well #5 is not directly downgradient of the source (i.e., along the plume centerline), the capture zone of the production well may overlap with the predicted plume margins, most notably if the pumping rate at Lomita Well #5 is increased to the full adjudicated rate, hydraulic conductivity values of the Silverado Aquifer are higher than assumed, or the groundwater flow direction is more southerly than anticipated. Both scenarios assume no source control and/or remediation occurs at the SCPs.

Figure 5-3 Modeling Results of PCE Concentrations During Steady-State Simulation of 40 years

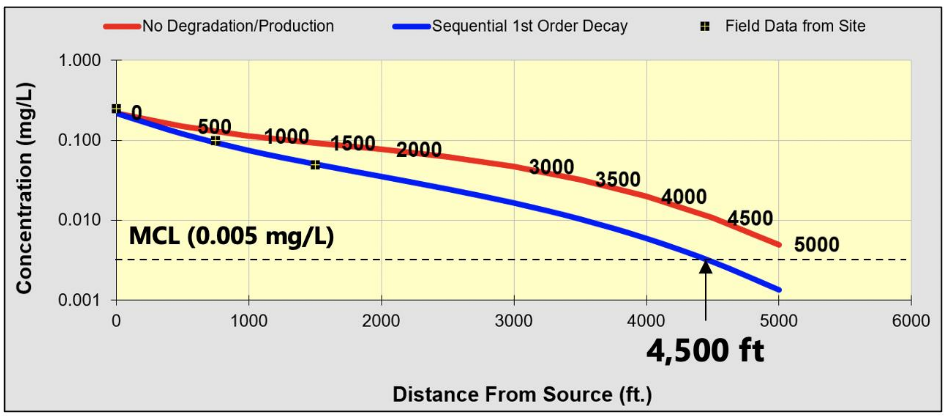
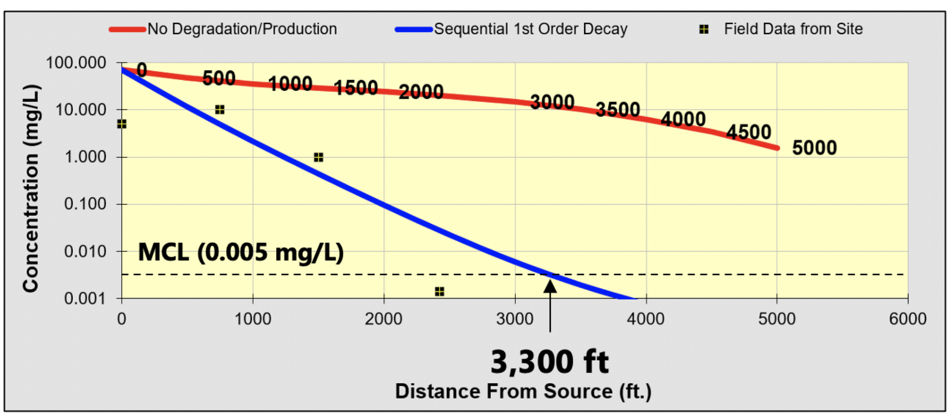


Figure 5-4 Modeling Results of TCE Concentrations During Steady-State Simulation of 40 years



Overall, based on the data available and assumptions summarized above, results of the BIOCHLOR model predict that there is a potential for unmitigated cVOCs to reach the capture zone of Lomita Well #5 at concentrations above the current MCL within the next 10 to 20 years. However, the potential travel times of cVOCs within the capture zone to Lomita Well #5 have not been estimated and are outside the scope of this report.

Recent benzene impacts at Lomita Well #5 also indicate that the well may be susceptible to groundwater contamination. Although the source of benzene has not yet been identified, it is inferred that benzene impacting Lomita Well #5 traveled from a near surface source (i.e., an UST or surface spill), which would indicate that the Silverado Aquifer near Lomita Well #5 is also vulnerable to vertical downward migration of potential cVOC impacts. However, there is currently no indication that cVOCs have migrated vertically from the Gage Aquifer to the Silverado Aquifer at the SCPs since deep monitoring wells at the SCPs have reported non-detectable concentrations of cVOCs since their installation (BBL 2001 and GE&R 2021b).

Although the predicted migration of the cVOC plume within the Gage Aquifer reaches the capture zone of Lomita Well #5 over time, there is uncertainty with respect to the hydraulic connectivity between the Gage Aquifer and Silverado Aquifer within the Project Area. Notably, there is uncertainty as to whether the cVOCs would travel vertically through the aquitard underlying the Gage Aquifer and then into the Silverado Aquifer, and if so, what the estimated travel time(s) would be. Data from WRD's Lomita Well #1 indicates that there is a downward vertical hydraulic gradient (i.e., between the Gage and Silverado Aquifers) near Lomita Well #5 (WRD 2021b); however, there are a number of data gaps that reduce the certainty of assessing the risk of contamination, including:

- There is limited information outside of the SCPs to determine local groundwater flow directions of the Gage Aquifer and Silverado Aquifer within the Project Area. Regionally, groundwater flow direction is influenced by the WCBBP (west of the Project Area) and by the Dominguez Barrier Wall (east of the Project Area); however, how these influences affect local groundwater flow are uncertain in the Project Area.
- There are a limited number of deep monitoring wells and geological cross-sections within the region which leads to uncertainty as to whether the regional aquitard is laterally extensive across the Project Area. If there are areas where the aquitard does not exist (i.e., areas where the Gage and Silverado Aquifers merge) or areas of higher hydraulic conductivity, there is potential for the cVOCs to preferentially migrate vertically into the Silverado Aquifer.
- The limited number of deep monitoring wells (i.e., wells screened across the Silverado Aquifer) also means there is the potential that historical and/or future contaminant source(s) and/or pathways may not have been identified to date.
- The effects of pumping on the hydraulic gradient between the Gage Aquifer and Silverado Aquifer is currently unknown but may influence the lateral and vertical migration of cVOCs within the capture zone of Lomita Well #5.

5.2 Recommendations

Based on the data available, current CSM and evaluation results, the potential for cVOCs to migrate to within the capture zone of Lomita Well #5 exists, most notably if pumping rates at the production well increase, if there are areas where the aquitard between the RWTA and Silverado Aquifer does not exist, and/or if remediation of the source area does not occur.

To monitor for potential future impacts to the City's only production well, the following recommendations are made:

- The CSM and evaluation should be updated as new data becomes available. It is recommended that the CSM be updated every two to three years as new data becomes available to confirm migration of the cVOCs (e.g., travel times or pathways) has not changed significantly.
- A monitoring well network (i.e., sentry wells), installed along the edge of Lomita Well #5's 5-year capture zone, is needed to confirm assumptions used herein, address existing data gaps within the current CSM, and protect the public water supply.
- The monitoring well network should consist of a minimum of one nested well which includes a piezometer in each target aquifer (e.g., the Gage Aquifer, Lynwood Aquifer, and Silverado Aquifer) to assess changes in water level elevations and water quality over time. The monitoring well(s) could also be used to evaluate hydrogeologic conditions near Lomita Well #5 (e.g., hydraulic gradients and hydraulic conductivity values).
- A suitable location for an additional production (water supply) well should be identified. A second production well would provide a contingency well in case of future adverse impacts to Lomita Well #5 and could also be used to supplement the City's current water supply.

6 References

Alta (Alta Environmental). 2012. Conceptual Groundwater Remedial Action Plan. Prepared for Hi-Shear Corporation. Project No. LAP-12-0698. February 2012.

Alta (Alta Environmental). 2013. Aquifer Test Report. Prepared for Hi-Shear Corporation. Project No. LAP-12-11931. June 2013.

Alta (Alta Environmental). 2016. Interim Offsite Assessment Report. Prepared for Hi-Shear Corporation. Project No. LAP-16-5857. Prepared September 2016.

Alta (Alta Environmental). 2017. Groundwater Remedial Implementation Report. Prepared for Hi-Shear Corporation. Project No. LAP-17-6606. Prepared September 2017.

Aziz, C.E., Smith, A.P., and Newell, C.J. 2000. BIOCHLOR Chlorinated Solvent Plume Database. Air Force Center for Environmental Excellence. Prepared June 2000.

Aziz, C.E., Newell, C.J., Gonzales, J.R., Haas, P., Clement, T.P., and Sun, Y. 2000. BIOCHLOR Natural Attenuation Decision Support System Users' Manual Version 1.0. USEPA, Office of Research and Development. EPA/600/R-00/008. January 2000.

BBJ & Ramboll (BBJ Group, LLC and Ramboll US Consulting, Inc.). 2021. Preliminary Site Conceptual Model Report. East Adjacent Property 1. 24751/24777 Crenshaw Boulevard. Torrance, California. Prepared for Esterline Technologies Corporation. Prepared September 2021.

BBL (BBL Environmental Services Inc.). 2000. Hi-Shear Torrance Site. Remediation Status Update.

BBL (BBL Environmental Services Inc.). 2001. Letter Transmittal re: Deep Soils and Groundwater Investigations Progress. BBLES Project No. 66205.08 #2. Prepared September 2001.

BBL (BBL Environmental Services Inc.). 2002. Deep Zone Soil Investigation. 2600 Skypark Drive, Torrance, California. Project No. 66205/10 #6. Prepared April 2002.

CDM (Camp Dresser & McKee, Inc.). 1991. Report of Subsurface Soil Investigation at Hi-Shear Torrance Facility. Prepared May 1991.

CDWR (California Department of Water Resources). 1961. Planned Utilization of the Ground Water Basins of the Coastal Plain of Los Angeles County. Bulletin 104.

CDWR (California Department of Water Resources). 2021. California's Groundwater. Bulletin 118. Update 2020.

Domenico, P.A. 1987. An analytical model for multidimensional transport of a decaying contaminant species. Journal of Hydrology. Vol. 91, Issue 1-2, pp 49-59. May 1987.

Dudek. 2022. Water Master Plan. Summary Report. Prepared for City of Lomita. January 2022.

EEC (Environmental Engineering & Contracting, Inc.). 2008. Phase II Subsurface Site Investigation Report. Lisi Aerospace. EEC Job S1904.01T. September 2008.

ETIC. 2020. Well Installation and Semi-Annual Groundwater Monitoring Report. Pacific Shell Service Station / Former Mobil Service Station 18MRC. Prepared for ExxonMobil Oil Corporation and Hanukah, Inc. Project No. 20-018MRC. Prepared December 2020.

Feyen, L., Beven, K.J., Smedt, F.D., Freer, J. 2001. Stochastic capture zone delineation within the generalized likelihood uncertainty estimation methodology: Conditioning on head observations: Water Resources Research, v.37, no.3, p.625-638, doi: 10.1029/2000WR900351.

Fitts, C.R. 2013. Groundwater Science (Second Edition): Boston, Academic Press, 671 p.

GE&R (Genesis Engineering and Redevelopment). 2021a. On-Site Vertical Groundwater Investigation Report. On Behalf of Hi-Shear Corporation. Prepared August 2021.

GE&R (Genesis Engineering and Redevelopment). 2021b. Updated Site Conceptual Model. Skypark Commercial Properties. On Behalf of Hi-Shear Corporation. Prepared November 2021.

Geosyntec Consultants. 1995. Environmental Site Evaluation. Hi-Shear Corporation Facility. Torrance, California. Prepared September 1995.

Geosyntec Consultants. 2010. Tri-Annual Groundwater Monitoring Report, September 2009 – December 2009. Prepared for Hi-Shear Corporation. 2600 Skypark Drive, Torrance, California. Prepared January 2010.

Gibb, J.P., Barcelona, M.J., Richey, M.H. 1984. Effective Porosity of Geologic Materials. Champaign, Illinois. Print.

Hygienetics, Inc. 1991. Environmental Site Assessment. High-Shear Corporation. Fastener Division. Prepared for Chemical Bank, Chemical Realty Group. Prepared May 1991.

KEC (KEC Engineers, Inc.). 2015. City of Lomita Water Master Plan Update. Prepared September 2015.

MK Environmental Consulting, Inc. 2021. Preliminary Site Conceptual Model. 24702-24777 Crenshaw Boulevard, Torrance, CA. Submitted to Los Angeles Regional Water Quality Control Board. Project No. 20-118. Prepared September 2021.

Parsons. 2004. Principles and Practices of Enhanced Anaerobic Bioremediation of Chlorinated Solvents. AFCEE, NFEC, ESTCP 457 pp, August 2004

PIC (PIC Environmental Services). 2022. Groundwater Monitoring Report, Concerning commercial property at 2582 South Narbonne Avenue, Lomita, CA. Prepared January 2022.

SCS (SCE Engineers). 1991a. Preliminary Site Investigation. Former Underground Tank Area. Hi-Shear Corporation, Torrance, California. File No. 0191031.00. Prepared June 1991.

SCS (SCE Engineers). 1991b. Report for Soil Verification Borings. Former Underground Waste Oil Tank Area. Hi-Shear Corporation, Torrance, California. File No. 0191031.00. Prepared November 1991.

SCS (SCE Engineers). 1992. Monitoring Well Installation Report. Wells MW-5, MW-6, and MW-7. Hi-Shear Corporation, Torrance, California. File No. 0191031.00. Prepared May 1992.

SWRCB (State Water Resources Control Board). 2022. GeoTracker Data Management System. Available at: https://geotracker.waterboards.ca.gov/. Accessed 01 March 2022 to 15 April 2022.

Terraphase Engineering Inc. 2022a. Groundwater Removal Action Workplan. Skypark Commercial and Lomita Properties. Prepared for City of Torrance. Project No. S042.002.002. January 2022.

Terraphase Engineering Inc. 2022b. Removal Action Workplan for the East Adjacent Properties. Skypark Commercial Properties – East Adjacent Properties. Prepared for City of Torrance. Project No. S042.002.003. February 2022.

USEPA (United States Environmental Protection Agency). 2000. BIOCHLOR Natural Attenuation Decision Support System. User's Manual. Version 1.0. EPA/600/R-00/008. January 2000.

USEPA (United States Environmental Protection Agency). 2002. BIOCHLOR Natural Attenuation Decision Support System Addendum. User's Manual. Version 2.2. March 2002.

USGS (United States Geological Survey). 2002. Geologic, Hydrologic, and Water-Quality Data From Multiple-Well Monitoring Sites in the Central and West Coast Basins, Los Angeles County, California, 1995-2000. Open-File Report 01-277. Prepared in cooperation with the Water Replenishment District of Southern California. Available at https://pubs.usgs.gov/of/2001/ofr01277/ofr01277.pdf

USGS (United States Geological Survey). 2003. Geohydrology, Geochemistry, and Ground-Water Simulation-Optimization of the Central and West Coast Basins, Los Angeles County, California. USGS Water-Resources Investigations Report 03-4065. Prepared in cooperation with the Water Replenishment District of Southern California.

Wiedemeier, T., Swanson, M.A., Moutoux, D.E., Gordon, E.K., Wilson, J.T., Wilson, B.H., Kampbell, J.E., Hansen, P., Hass, P., and Chapelle, F. 1996. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater. Air Force Center for Environmental Excellence. November 1996.

Wiedemeier, T.H., Rifai, H.S., Newell, C.J., and Wilson, J.W. 1999. Natural Attenuation of Fuels and Chlorinated Solvents, John Wiley & Sones, New York.

Winefield and Associates, Inc. 2010. Site Conceptual Model. Lisi Aerospace. 2600 Skypark Drive. Torrance, California. Report No. LAP-09-176. Prepared March 2010.

WRD (Water Replenishment District). 2021a. West Coast Basin Watermaster. July 1, 2020 – June 30, 2021. Prepared by the Administrative Body WRD. Prepared December 2021. Available at https://www.wrd.org/sites/pr/files/WCB%202021%20Watermaster%20Report%20Web.pdf

WRD (Water Replenishment District). 2021b. Regional Groundwater Monitoring Report. Water Year 2019-2020. Central and West Coast Basins. Los Angeles County, California. Prepared March 2021. Available at https://www.wrd.org/sites/pr/files/2020%20RGWMR%20Final_2.pdf

WRD (Water Replenishment District). 2022. Engineering Survey and Report. Prepared March 2022. Available at https://www.wrd.org/sites/pr/files/WRD%202022%20ESR%20-%20March%20v1%20%28FINAL%29.pdf

Appendix A
Model Input Parameters

Table A1 BIOCHLOR Model Input Parameters

Data Type	Model Parameter	Units	Value	Data Source
Model Domain	*Source Area Dimensions* Width Length Thickness	 ft ft ft	 280 2,000 190	
	Simulation Time Steady State Run	 years	 100	
Hydrogeology	Hydraulic Gradient (i)	ft/ft	0.0021	Alta (2017) and GE&R (2021)
	Hydraulic Conductivity (K)	cm/sec	$1.80x10^{-2}$	USGA (2003) and Alta (2013)
	Effective Porosity (n_e)	-	0.25	Gibb et al. (1984)
	Seepage Velocity (v)	ft/year	156.4	Calculated as $v=(Ki)/n_e$
Dispersion	*Dispersivity* Plume Length (X) Longitudinal (α_x) Transverse (α_y) Vertical (α_z)	 ft - - -	 2000 200 60 10	 GE&R (2021) Xu-Eckstein 0.3 x α_x 0.05 x α_x
Adsorption	Retardation Factor (R)	-	1.88	Average based on Foc and K_{oc} values
	Soil Bulk Density	kg/L	1.7	Estimated value
	Soil Fraction Organic Carbon (Foc)	-	0.001	Default value
	Organic Carbon Partition Coefficient (K_{OC}) Tetrachloroethene Trichloroethene Cis-1,2 DCE Vinyl Chloride	 L/kg L/kg L/kg L/kg	 426 130 125 29.6	Default values in BIOCHLOR model applied.
Biotransformation	*Biodegradation Rates (half-lives)* Tetrachloroethene Trichloroethene Cis-1,2 DCE Vinyl Chloride	 yr^{-1} yr^{-1} yr^{-1} yr^{-1}	 0.07 0.693 13.86 1.733	Estimated from Wiedemeier et al. 1999) and adjusted during calibration.

Data Type	Model Parameter	Units	Value	Data Source
Source Data	*Source Area Concentrations*			
	PCE	µg/L	220	Analytical data reported in Hygienetics (1991), adjusted to calibrate model.
	TCE	µg/L	70,000	
	Cis-1,2 DCE	µg/L	20	
	VC	µg/L	0	
Field Data	*Based on Available Monitoring Data*			
	PCE	µg/L	Varies from well to well.	Analytical data from November 2019 reported in GE&R (2021a).
	TCE	µg/L		
	Cis-1,2 DCE	µg/L		
	VC	µg/L		