CONESTOGA-ROVERS & ASSOCIATES
5900 Hollis Street, Suite A
Emeryville, California 94608
Telephone: (510) 420-0700 Fax: (510) 420-9170
www.CRAworld.com

TRANSMITTAL

DATE: October 3, 2014

REFERENCE NO.: 311642

PROJECT NAME: Chevron 91153
ACEH RO#0341

TO: Mr. Mark Detterman
Alameda County Environmental Health Services
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

RECEIVED
By Alameda County Environmental Health at 8:40 am, Oct 07, 2014

Please find enclosed:
- ☐ Draft
- ☐ Originals
- ☐ Prints
- ☒ Final
- ☐ Other

Sent via:
- ☐ Mail
- ☐ Overnight Courier
- ☐ Same Day Courier
- ☒ Other Alameda County FTP Upload and GeoTracker

QUANTITY	DESCRIPTION
1	Vapor Mitigation Plan

- ☐ As Requested
- ☐ For Your Use
- ☒ For Review and Comment
- ☐
- ☐

COMMENTS:
Please contact Nathan Lee at (925)849-1003 or nlee@craworld.com with any questions or comments regarding the contents of this report.

Copy to: Ms. Alexis Fischer (Chevron)
Mr. Mark Hom (Property Owner)

Completed by: Nathan Lee
[Please Print]

Signed: Nathan Lee

Filing: **Correspondence File**

Alexis Fischer
Project Manager
Marketing Business Unit

Chevron Environmental Management Company
6101 Bollinger Canyon Road
San Ramon, CA 94583
Tel (925) 790-6441
afischer@chevron.com

Alameda County Health Care Services
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577

Re: Chevron Service Station No. 91153
3135 Gibbons Drive (3126 Fernside Blvd)
Alameda, CA

I have reviewed the attached report titled *Vapor Mitigation Plan*.

The information in this report is accurate to the best of my knowledge and all local Agency/Regional Board guidelines have been followed. This report was prepared by Conestoga-Rovers & Associates, upon whose assistance and advice I have relied.

This letter is submitted pursuant to the requirements of California Water Code Section 13267(b)(1) and the regulating implementation entitled Appendix A pertaining thereto.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

Sincerely,

Alexis Fischer
Project Manager

Attachment: *Vapor Mitigation Plan*

VAPOR MITIGATION PLAN

FORMER CHEVRON STATION 91153
3135 GIBBONS DRIVE (3126 FERNSIDE BOULEVARD)
ALAMEDA, CALIFORNIA
ACEH CASE RO #0341

Prepared For:

Mr. Mark Detterman
Alameda County Environmental Health Services
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502 6577

Prepared by:
Conestoga-Rovers
& Associates

5900 Hollis Street, Suite A
Emeryville, California
U.S.A. 94608

Office: (510) 420-0700
Fax: (510) 420-9170

web:
http:\\www.CRAworld.com

OCTOBER 3, 2014
REF. NO. 311642 (35)
This report is printed on recycled paper.

VAPOR MITIGATION PLAN

FORMER CHEVRON STATION 91153
3135 GIBBONS DRIVE (3126 FERNSIDE BOULEVARD)
ALAMEDA, CALIFORNIA
ACEH CASE RO #0341

PROFESSIONAL GEOLOGIST
NATHAN S. LEE
No.8486
STATE OF CALIFORNIA

Nathan Lee

Nathan Lee PG 8486

Prepared by:
Conestoga-Rovers & Associates

5900 Hollis Street, Suite A
Emeryville, California
U.S.A. 94608

Office: (510) 420-0700
Fax: (510) 420-9170

web:
http:\\www.CRAworld.com

OCTOBER 3, 2014
Ref. No. 311642 (35)
This report is printed on recycled paper

TABLE OF CONTENTS

Page

LIST OF FIGURES
(Following Text)

LIST OF APPENDICES

1.0 INTRODUCTION

Conestoga-Rovers & Associates (CRA) is submitting this *Vapor Mitigation Plan* on behalf of Chevron Environmental Management Company (EMC). In a letter dated August 29, 2014 (Appendix A), Alameda County Environmental Health Services (ACEH) requested a *Vapor Mitigation Evaluation/Interim Remediation Plan*. As discussed with ACEH in a telephone conversation on September 10, 2014 and in a meeting with ACEH, EMC and CRA on July 18, 2014, the *Vapor Mitigation Evaluation/Interim Remediation Plan* will consist of a vapor mitigation plan for the garage slab on grade foundation. Based on the results outlined in CRA's *Subsurface and Crawl Space, Indoor and Ambient Air Investigation Report* dated April 18, 2012 and *Crawl Space, Indoor, Ambient Air and Sub-Slab Soil Gas Investigation Report* dated December 20, 2013 there is not a vapor intrusion risk to the onsite structure. Although sub-surface vapor intrusion risk is not present, a vapor intrusion coating system will be applied to the garage floor. The vapor intrusion coating system will prevent any potential future vapor risks that may occur if an unforeseen change of conditions were to happen. Presented below are the site background, vapor mitigation plan, and CRA's conclusions and recommendations.

2.0 SITE BACKGROUND

2.1 SITE DESCRIPTION

The site is located on a triangularly-shaped lot at the intersections of Gibbons Drive, Fernside Boulevard, and High Street in Alameda, California (Figure 1). A former service station operated until June 1986. A residence was built on the property in 1989 (Figure 2). Surrounding area use is residential and commercial.

2.2 PREVIOUS ENVIRONMENTAL WORK

Environmental investigations began in 1986 with the underground storage tank (UST) removals. Since 1986, a total of twelve confirmation samples, twenty six soil borings, ten groundwater monitoring wells (well C-2 has been destroyed), one extraction trench/well, one temporary well, and fifty one temporary soil vapor probes have been installed. Groundwater has been monitored since 1986. Remediation conducted has included an excavation during UST removal and during the foundation construction for the house, a groundwater pump and treat system, oxygen releasing compound (ORC) and hydrogen peroxide injections, groundwater extraction events, and since 1995 weekly to quarterly light non-aqueous phase liquid (LNAPL) removal by bailing and sorbent socks. Two well surveys and preferential pathway studies have also been conducted. A summary of previous environmental investigation and remediation is included in Appendix B.

2.3 SITE GEOLOGY

Soil beneath the site consists primarily of sand with some silt and clay to the total depth explored of approximately 23 feet below grade (fbg).

2.4 SITE HYDROGEOLOGY

The site is approximately 8 feet above mean sea level. Depth to water in wells ranges from approximately 0 to 6.5 fbg. Groundwater beneath the site is designated as an existing or potential drinking water resource by the Regional Water Quality Control Board – San Francisco Bay Region (RWQCB-SF).[1] Groundwater flow direction is typically east-southeast toward the Oakland Alameda Estuary. The estuary is the closest surface water and is approximately 550 feet downgradient. Since 2010, LNAPL has been measured in well C-1, ranging in thickness from 0.01 to 0.25 foot.

3.0 VAPOR MITIGATION PLAN

The vapor intrusion coating system that will be used on the garage floor is, Retro-Coat ™ manufactured by Land Science Technologies in San Clemente, California. Retro-Coat ™ is a specially formulated concrete coating that has long-term chemical resistance and was developed especially to mitigate vapor intrusion into existing structures. Retro-Coat ™ reduces the permeation rates of constituents of concern (COC), thereby significantly reducing and essentially blocking the COC vapors from intruding into buildings. Data related to this product is presented in Appendix C. Retro-Coat ™ has been tested for effectiveness with tetrachloroethene and trichloroethene, which have higher diffusion coefficients than benzene and other petroleum hydrocarbons. Therefore, it is considered an effective barrier for petroleum hydrocarbons.

Prior to Retro-Coat's ™ application the garage's concrete floor will be made smooth by diamond sanding, shot blasting or similar methods. Any cracks or holes in the concrete will be sealed along with any utilities that come out through the garage floor. The two

1 Regional Water Quality Control Board – San Francisco Bay Region Groundwater Committee; June 1999, *East Bay Plain Groundwater Basin Beneficial Use Evaluation Report, Alameda and Contra Costa Counties, California; California.*

sub-slab vapor probes will also be removed and the voids filled with concrete, prior to the application.

The Retro-Coat™ application will consist of a 60 millimeters thick sealant that will incorporate silica sand for added durability. According Land Science Technologies, this sealant type is similar to what is used in airport hangars and should, based on normal residential garage use last indefinitely.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Upon approval from ACEH, and final approval from property owners, CRA will coordinate with the property owners to schedule a time that is most convenient in order to coordinate the Retro-Coat ™ application.

CRA will submit a report documenting the Retro-Coat ™ application, which will be submitted to ACEH approximately 90 days after the Retro-Coat ™ application, is complete.

Even though the use of Retro-Coat ™ is the preferred method of vapor mitigation, this method or any other mitigation measure will need to be approved by the property owners prior to implementation. On-going conversations with the property owners are taking place. If the preferred Retro-Coat ™ application method is not approved by the property owners, our alternative mitigation proposal will consist of a ventilation system using a fan to be installed in the garage.

FIGURES

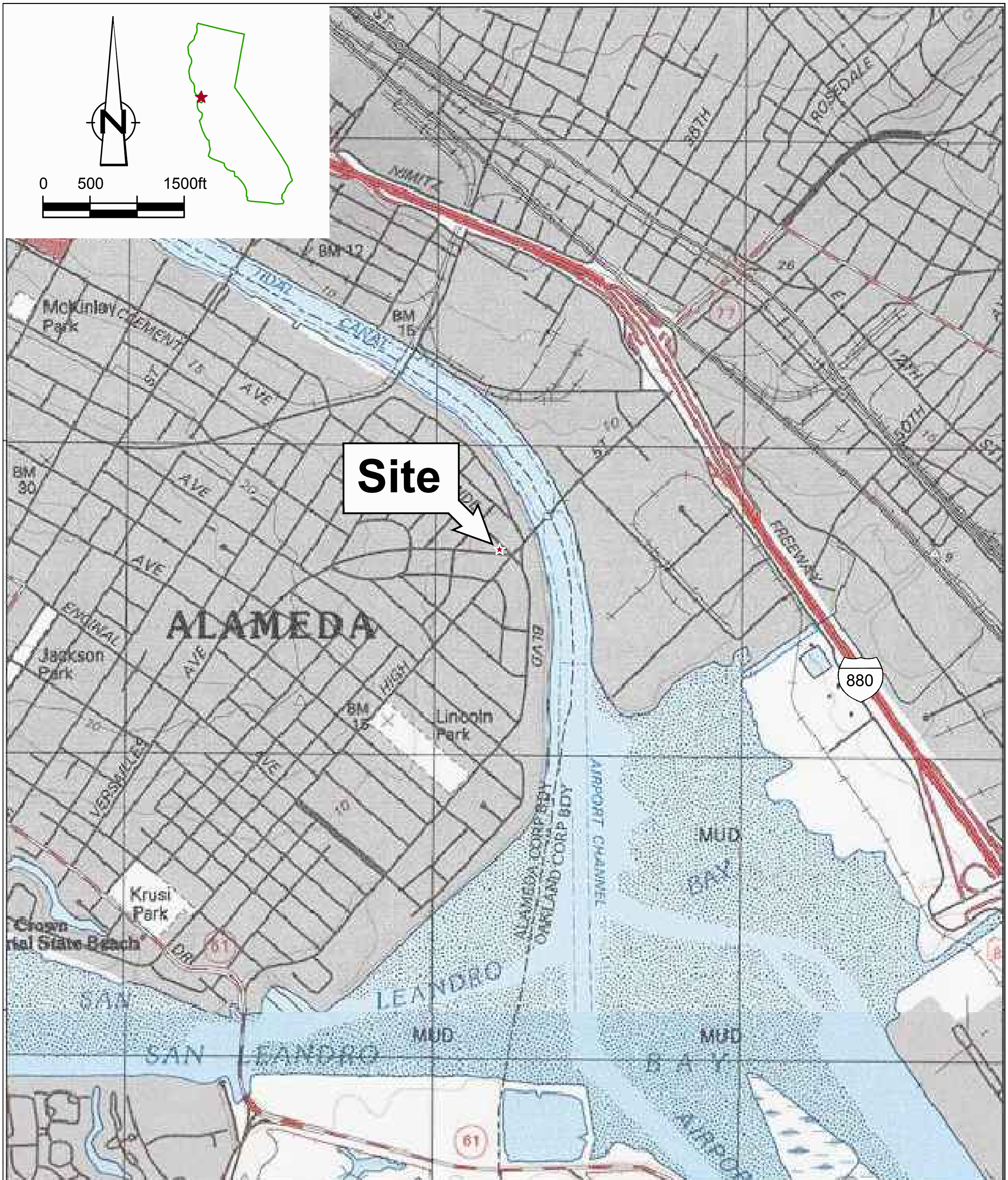

Figure 1

VICINITY MAP
FORMER CHEVRON SERVICE STATION 91153
3135 GIBBONS DRIVE (3126 FERNSIDE BLVD)
Alameda, California

311642-2014(035)GN-EM001 SEP 30/2014

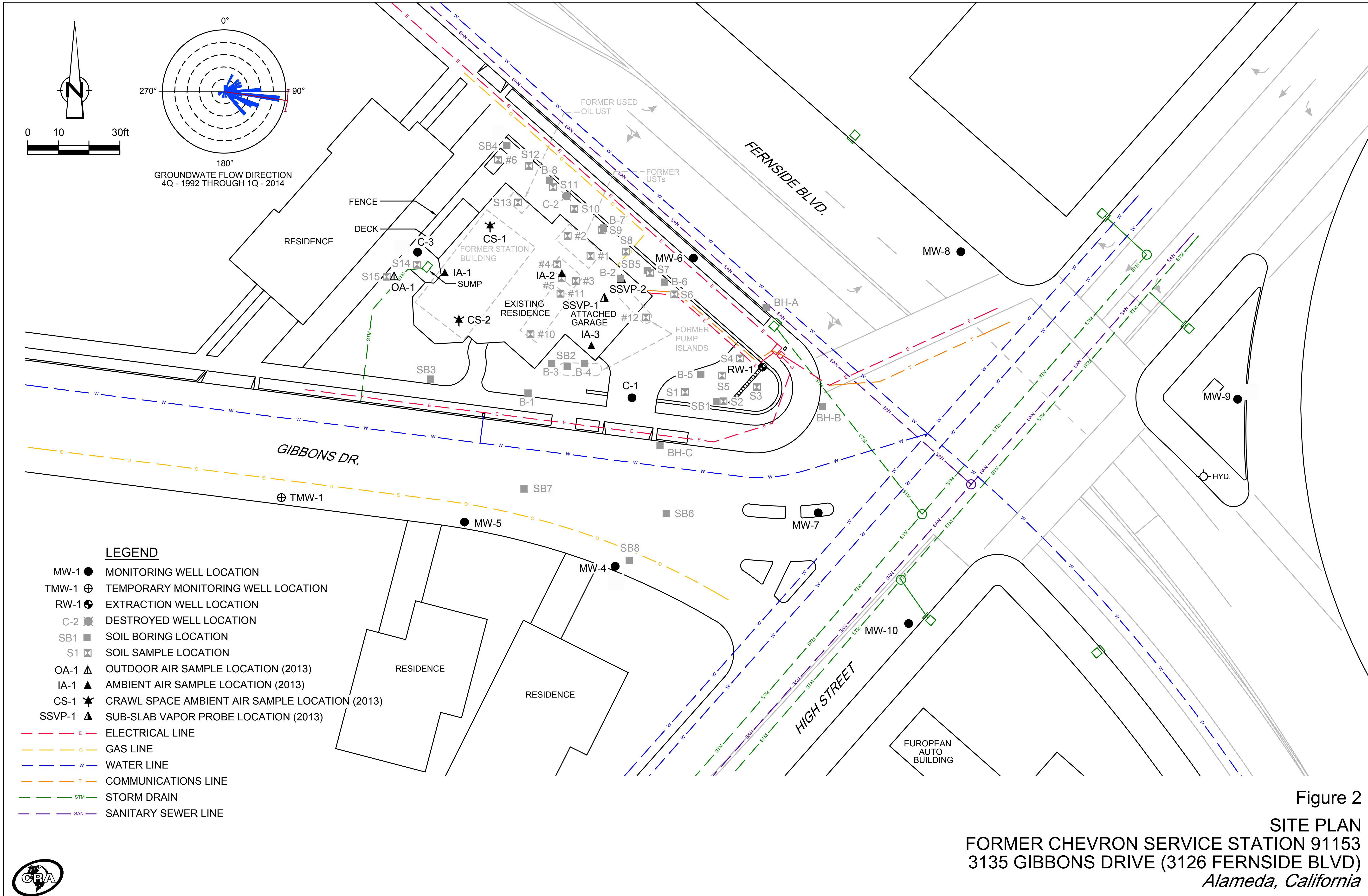

Figure 2

SITE PLAN
FORMER CHEVRON SERVICE STATION 91153
3135 GIBBONS DRIVE (3126 FERNSIDE BLVD)
Alameda, California

311642-2014(035)GN-EM002 SEP 30/2014

APPENDIX A

REGULATORY CORRESPONDENCE

ALAMEDA COUNTY
HEALTH CARE SERVICES
AGENCY
ALEX BRISCOE, Agency Director

ENVIRONMENTAL HEALTH SERVICES
ENVIRONMENTAL PROTECTION
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577
(510) 567-6700
FAX (510) 337-9335

August 29, 2014

NOTICE TO COMPLY

Ms. Alexis Fischer
Chevron Environmental Management Co.
6101 Bollinger Canyon Road
San Ramon, CA 94583
(sent via electronic mail to
AFischer@chevron.com)

Mr. Mark Hom and Anna Cheng
3135 Gibbons Drive
Alameda, CA, 94501-1749
(sent via electronic mail to
mark@galvinhom.com)

JL and Jane Bolton
Address Unknown

John Thompson
Address Unknown

Shirley & Ruben Cohen
Address Unknown

Gary & Jerri Fenstermaker
Address Unknown

Claire Cepollina & Fred Martini
Address Unknown

Subject: Notice to Comply: Request for Vapor Mitigation Evaluation / Interim Remediation Plan; Fuel Leak Case No. RO0000341; (Global ID # T0600100330); Chevron #9-1153, (3126 Fernside Blvd), 3135 Gibbons Drive, Alameda, CA 94501

Dear Ms. Fischer, Mr. Hom, and Ms. Cheng:

Alameda County Environmental Health Department (ACEH) staff has reviewed the case file and submittals that are due to ACEH for the subject site for compliance purposes. On March 24, 2014 a directive letter was sent requesting the submittal of a vapor mitigation evaluation; Interim Remedial Action Plan (IRAP) by April 27, 2014. On April 24, 2014 ACEH and Chevron representatives meet and agreed upon an extension of the due date to match the submittal date of the requested Site Conceptual Model (SCM) of June 27, 2014. On June 26, 2014, an additional extension request was requested and agreed with in order to allow a complete Data Gap Work Plan, SCM, and IRAP.

On July 10, 2014, ACEH received the *Focused Conceptual Site Model*, without the attendant Data Gap Work Plan or IRAP. To date ACEH has not received the Data Gap Work Plan or IRAP. Each of these reports remains overdue; you are out of compliance with this agency's directives. This site is occupied by a residential single family home occupied by a family. Site conditions and potential human health risk to the occupants due to vapor intrusion to indoor air warrant immediate responses. The referenced report states that a meeting is scheduled with Chevron's experts to evaluate site data and recommend appropriate vapor mitigation controls, but has provided no date. ACEH was made aware of this planned meeting in March 2014, and based on the lack of detail there does not appear to be a date for the meeting.

In order to regain compliance please submit the documents in accordance with the schedule below. Failure to do so will result in the issuance of a Notice of Violation.

COMPLIANCE SCHEDULE

Please upload technical reports to the ACEH ftp site (Attention: Mark Detterman), and to the State Water Resources Control Board's Geotracker website, in accordance with the specified file naming convention below, according to the following schedule:

- **October 3, 2014 –** Data Gap Investigation Plan and IRAP
  File to be named: RO341_WP_R_yyyy-mm-dd
- **60 Days After Data Gap Work Plan Approval** – Soil & Groundwater Investigation
  File to be named: RO341_SWI_R_yyyy-mm-dd
- **60 Days After Soil & Groundwater Investigation Review** – Feasibility Study / Corrective Action Plan; File to be named: RO341_FEASSTUD_R_yyyy-mm-dd

These reports are being requested pursuant to California Health and Safety Code Section 25296.10. 23 CCR Sections 2652 through 2654, and 2721 through 2728 outline the responsibilities of a responsible party in response to an unauthorized release from a petroleum UST system, and require your compliance with this request.

Online case files are available for review at the following website: http://www.acgov.org/aceh/index.htm.

If you have any questions, please call me at (510) 567-6876 or send me an electronic mail message at mark.detterman@acgov.org.

Sincerely,

Digitally signed by Mark E. Detterman
DN: cn=Mark E. Detterman, o, ou, email, c=US
Date: 2014.08.29 17:34:16 -07'00'

Mark E. Detterman, PG, CEG
Senior Hazardous Materials Specialist

Enclosures: Attachment 1 – Responsible Party (ies) Legal Requirements / Obligations
Electronic Report Upload (ftp) Instructions

cc: Kiersten Hoey, Conestoga-Rovers & Assoc., 5900 Hollis Street, Suite A, Emeryville, CA 94608
(sent via electronic mail to khoey@craworld.com)

Brandon Wilken, Conestoga-Rovers & Assoc., 5900 Hollis Street, Suite A, Emeryville, CA 94608
(sent via electronic mail to bwilken@craworld.com)

Nathan Lee, Conestoga-Rovers & Assoc., 5900 Hollis Street, Suite A, Emeryville, CA 94608
(sent via electronic mail to nlee@craworld.com)

Dilan Roe, ACEH (sent via electronic mail to dilan.roe@acgov.org)
Mark Detterman, ACEH (sent via electronic mail to mark.detterman@acgov.org)
Electronic File, GeoTracker

Attachment 1

Responsible Party(ies) Legal Requirements / Obligations

REPORT REQUESTS

These reports are being requested pursuant to California Health and Safety Code Section 25296.10. 23 CCR Sections 2652 through 2654, and 2721 through 2728 outline the responsibilities of a responsible party in response to an unauthorized release from a petroleum UST system, and require your compliance with this request.

ELECTRONIC SUBMITTAL OF REPORTS

ACEH's Environmental Cleanup Oversight Programs (LOP and SLIC) require submission of reports in electronic form. The electronic copy replaces paper copies and is expected to be used for all public information requests, regulatory review, and compliance/enforcement activities. Instructions for submission of electronic documents to the Alameda County Environmental Cleanup Oversight Program FTP site are provided on the attached "Electronic Report Upload Instructions." Submission of reports to the Alameda County FTP site is an addition to existing requirements for electronic submittal of information to the State Water Resources Control Board (SWRCB) GeoTracker website. In September 2004, the SWRCB adopted regulations that require electronic submittal of information for all groundwater cleanup programs. For several years, responsible parties for cleanup of leaks from underground storage tanks (USTs) have been required to submit groundwater analytical data, surveyed locations of monitoring wells, and other data to the GeoTracker database over the Internet. Beginning July 1, 2005, these same reporting requirements were added to Spills, Leaks, Investigations, and Cleanup (SLIC) sites. Beginning July 1, 2005, electronic submittal of a complete copy of all reports for all sites is required in GeoTracker (in PDF format). Please visit the SWRCB website for more information on these requirements (http://www.waterboards.ca.gov/water_issues/programs/ust/electronic_submittal/).

PERJURY STATEMENT

All work plans, technical reports, or technical documents submitted to ACEH must be accompanied by a cover letter from the responsible party that states, at a minimum, the following: "I declare, under penalty of perjury, that the information and/or recommendations contained in the attached document or report is true and correct to the best of my knowledge." This letter must be signed by an officer or legally authorized representative of your company. Please include a cover letter satisfying these requirements with all future reports and technical documents submitted for this fuel leak case.

PROFESSIONAL CERTIFICATION & CONCLUSIONS/RECOMMENDATIONS

The California Business and Professions Code (Sections 6735, 6835, and 7835.1) requires that work plans and technical or implementation reports containing geologic or engineering evaluations and/or judgments be performed under the direction of an appropriately registered or certified professional. For your submittal to be considered a valid technical report, you are to present site specific data, data interpretations, and recommendations prepared by an appropriately licensed professional and include the professional registration stamp, signature, and statement of professional certification. Please ensure all that all technical reports submitted for this fuel leak case meet this requirement.

UNDERGROUND STORAGE TANK CLEANUP FUND

Please note that delays in investigation, later reports, or enforcement actions may result in your becoming ineligible to receive grant money from the state's Underground Storage Tank Cleanup Fund (Senate Bill 2004) to reimburse you for the cost of cleanup.

AGENCY OVERSIGHT

If it appears as though significant delays are occurring or reports are not submitted as requested, we will consider referring your case to the Regional Board or other appropriate agency, including the County District Attorney, for possible enforcement actions. California Health and Safety Code, Section 25299.76 authorizes enforcement including administrative action or monetary penalties of up to $10,000 per day for each day of violation.

Alameda County Environmental Cleanup Oversight Programs (LOP and SLIC)	**REVISION DATE:** May 15, 2014 **ISSUE DATE:** July 5, 2005 **PREVIOUS REVISIONS:** October 31, 2005; December 16, 2005; March 27, 2009; July 8, 2010, July 25, 2010
SECTION: Miscellaneous Administrative Topics & Procedures	**SUBJECT:** Electronic Report Upload (ftp) Instructions

The Alameda County Environmental Cleanup Oversight Programs (LOP and SLIC) require submission of all reports in electronic form to the county's ftp site. Paper copies of reports will no longer be accepted. The electronic copy replaces the paper copy and will be used for all public information requests, regulatory review, and compliance/enforcement activities.

REQUIREMENTS

- **Please do not submit reports as attachments to electronic mail.**
- Entire report including cover letter must be submitted to the ftp site as **a single portable document format (PDF) with no password protection**.
- It is **preferable** that reports be converted to PDF format from their original format, (e.g., Microsoft Word) rather than scanned.
- **Signature pages and perjury statements must be included and have either original or electronic signature.**
- **Do not password protect the document**. Once indexed and inserted into the correct electronic case file, the document will be secured in compliance with the County's current security standards and a password. **Documents with password protection will not be accepted**.
- Each page in the PDF document should be rotated in the direction that will make it easiest to read on a computer monitor.
- Reports must be named and saved using the following naming convention:

  RO#_Report Name_Year-Month-Date (e.g., RO#5555_WorkPlan_2005-06-14)

Submission Instructions

1) Obtain User Name and Password
   a) Contact the Alameda County Environmental Health Department to obtain a User Name and Password to upload files to the ftp site.
      i) Send an e-mail to deh.loptoxic@acgov.org
   b) In the subject line of your request, be sure to include **"ftp PASSWORD REQUEST"** and in the body of your request, include the **Contact Information, Site Addresses**, and the **Case Numbers (RO# available in Geotracker) you will be posting for**.

2) Upload Files to the ftp Site
   a) Using Internet Explorer (IE4+), go to ftp://alcoftp1.acgov.org
      (i) Note: Netscape, Safari, and Firefox browsers will not open the FTP site as they are NOT being supported at this time.
   b) Click on Page located on the Command bar on upper right side of window, and then scroll down to Open FTP Site in Windows Explorer.
   c) Enter your User Name and Password. (Note: Both are Case Sensitive.)
   d) Open "My Computer" on your computer and navigate to the file(s) you wish to upload to the ftp site.
   e) With both "My Computer" and the ftp site open in separate windows, drag and drop the file(s) from "My Computer" to the ftp window.

3) Send E-mail Notifications to the Environmental Cleanup Oversight Programs
   a) Send email to deh.loptoxic@acgov.org notify us that you have placed a report on our ftp site.
   b) Copy your Caseworker on the e-mail. Your Caseworker's e-mail address is the entire first name then a period and entire last name @acgov.org. (e.g., firstname.lastname@acgov.org)
   c) The subject line of the e-mail must start with the RO# followed by **Report Upload**. (e.g., Subject: RO1234 Report Upload) If site is a new case without an RO#, use the street address instead.
   d) If your document meets the above requirements and you follow the submission instructions, you will receive a notification by email indicating that your document was successfully uploaded to the ftp site.

APPENDIX B

SUMMARY OF ENVIRONMENTAL INVESTIGATION AND REMEDIATION

SUMMARY OF ENVIRONMENTAL INVESTIGATION AND REMEDIATION
Former Chevron Service Station 91153
3135 Gibbons Drive (3126 Fernside Boulevard)
Alameda, California

1986 UST Removal and Excavation

The underground storage tanks (USTs) were removed and an unreported volume of soil was excavated from the former UST pit and product line trenches. Excavated soil was aerated onsite and used as backfill. Additional information is available in Blaine Tech Services, Inc.'s June 19, 1986 *Field Sampling* report and Weiss Associates' (Weiss) December 20, 1994 *Comprehensive Site Evaluation and Proposed Future Action Plan*.

1986 Well Installation

Wells C-1 through C-3 were installed onsite. Additional information is available in Emcon Associates' September 18, 1986 *Well Installation Memorandum*.

1987 Area Well Survey

In August 1987, Pacific Environmental Group, Inc. (PEG) conducted a well survey and indentified wells within approximately 0.5 mile of the site. The majority of these wells were used for groundwater monitoring or cathodic protection and some were used for irrigation. None of the wells were listed as municipal drinking water supply wells. Additional information is available in PEG's August 12, 1987 *Well Survey Report*.

1989 House Construction and Destruction of Monitoring Well C-2

According to Weiss' December 20, 1994 *Comprehensive Site Evaluation and Proposed Future Action Plan*, a majority of the soil beneath the planned residence footprint was removed for construction in early 1989. Groundwater monitoring well C-2 was apparently destroyed during construction prior to May 1989. Additional information is available in Weiss' December 20, 1994 *Comprehensive Site Evaluation and Proposed Future Action Plan*.

1987 and 1989 Soil Vapor Survey

Soil vapor surveys were conducted to quantify vapor intrusion to indoor air risks for onsite residents. Based on vapor concentrations from samples collected from the southeastern portion of the site, a vapor barrier was recommended for any structures. Additional information is available in EA Engineering's August 19, 1987 *Risk Assessment* and June 9, 1989 *Soil vapor Contaminant Assessment Report of Investigation*.

1989 Subsurface Investigation

In July 1989, EA collected soil samples from between 0.5 and 9.5 feet below grade (fbg) in five shallow onsite borings and three shallow offsite borings (SB1 through SB8). The highest concentrations of total petroleum hydrocarbons as gasoline (TPHg) and benzene, toluene, ethylbenzene and xylenes (BTEX) were found in the areas east of the UST complex and pump islands. Additional information is available in Weiss' December 20, 1994 *Comprehensive Site Evaluation and Proposed Future Action Plan*.

1991 Groundwater Treatment

A groundwater pump and treat system was installed and operated by EA from 1991 to 1994. The system extracted groundwater from a recovery trench and extraction well RW-1. Additional information is available in Weiss' December 20, 1994 *Comprehensive Site Evaluation and Proposed Future Action Plan*.

1992 Well Installations

Offsite wells MW-4 through MW-6 were installed to further delineate the lateral extent of dissolved hydrocarbons. Additional information is available in Groundwater Technology Inc.'s (GTI) July 16, 1992 *Environmental Assessment Report*.

1993 Offsite Groundwater Sampling

Weiss collected groundwater samples from temporary offsite borings BH-A, BH-B, and BH-C, located crossgradient and downgradient of the groundwater extraction trench. Additional information is available in Weiss' December 20, 1994 *Comprehensive Site Evaluation and Proposed Future Action Plan*.

1993 Monitoring Well Installation

On November 11, 1993 GTI installed groundwater monitoring well MW-7 and temporary monitoring well TMW-1 to further characterize the distribution of hydrocarbons in soil and groundwater upgradient and downgradient of the site. Additional information is available in GTI's January 31, 1994 *Additional Environmental Assessment Report*.

1994 Site Evaluation and Proposed Further Action

At Chevron's request, Weiss prepared a site evaluation to summarize all investigative and remedial actions performed to date and to outline a recommended future action plan. Additional information is available in WA's December 20, 1994 *Site Evaluation and Proposed Further Action Plan*.

1995 Well Installations

Wells MW-8 through MW-10 were installed to further delineate the downgradient extent of hydrocarbons in groundwater. Additional information is available in GTI's October 31, 1995 *Additional Site Assessment Report*.

1996 Evaluation for Potential Migration Pathway via Buried Utility Pipelines

Fluor Daniel GTI (FD-GTI) compiled utility location and depth information to analyze the potential for offsite migration of dissolved hydrocarbons in utility trenches. The report concluded that several utilities penetrated groundwater, but that these utilities were not acting as preferential pathways. The report states that the buried utilities were installed in materials similar to native soil and were unlikely to result in preferential flow. In addition, monitoring well data near the utilities was not consistent with preferential flow. Additional information is available in FD-GTI's May 15, 1996 *Evaluation for Potential Migration Pathway via Buried Utility Pipelines*.

1996 Geophysical Investigation for Buried Underground Storage Tanks

FD-GTI performed a geophysical survey of approximately 70 feet of sidewalk along Gibbons Boulevard and near monitoring well C-1. Both ground penetrating radar and vertical magnetic gradiometer were used. No buried underground storage tanks were identified within the survey areas. Additional information is available in FD-GTI's July 8, 1996 *Geophysical Investigation for Buried Underground Storage Tanks*.

1997 Shallow Soil Investigation

Shallow soil samples S-1 through S-15 were collected along the north, west, and east property boundaries to assess lead concentrations in onsite soil. Additional information is available in Gettler-Ryan's (G-R) October 22, 1997 *Soil Sampling Report*.

1997 ORC and Peroxide Injection

Oxygen releasing compound (ORC) was placed in well MW-6 and MW-7 and hydrogen peroxide was injected in well MW-1 to remediate light non-aqueous phase liquids. Additional information is available in ChevronTexaco Energy Research and Technology Company's (Chevron ETC) May 2003 *Risk-Based Corrective Action Evaluation of Vapor Intrusion to Indoor Air from Soil Vapor*,

1998 Bio-Parameter Evaluation

Three samples collected during the third quarter 1998 groundwater monitoring event were analyzed for bio-parameter data to evaluate biodegradation processes. The report concluded that not enough parameters indicated biodegradation was occurring. However, the report states that the recently added ORC and hydrogen peroxide would potentially increase bioremediation. Additional information is available in Chevron's September 29, 1998 *Bio-Remediation Evaluation Letter*.

1999 Hydrogen Peroxide Injection

In July 1999, Cambria Environmental Technology, Inc. (Cambria) injected a hydrogen peroxide solution into well C-1 to oxidize residual hydrocarbons. Additional information is available in Cambria's July 12, 1999 *Hydrogen Peroxide Injection* report.

2001 to 2002 Groundwater Batch Extraction Events

Five groundwater batch extraction events were conducted. These events were discontinued because of inconvenience to the resident. Additional Information available in Chevron ETC's May 2003 *Risk-Based Corrective Action Evaluation of Vapor Intrusion to Indoor Air from Soil Vapor*.

2002-2003 Vapor Intrusion Study and Risk-Based Correction Action Evaluation of Vapor Intrusion to Indoor Air from Soil Vapor

Borings SV-1 through SV-7 were hand-augered along the edges of the current building and soil-vapor samples were collected from temporary probes. These data were used to evaluate potential indoor air risks to onsite residents. Data was compared to the United States Environmental Protection Agency's established target risk levels for adults and children. The report concludes that vapor intrusion risks from soil vapor intrusion to indoor air were below the established guidelines. Additional information is available in Chevron ETC's May 2003 *Risk-Based Corrective Action Evaluation of Vapor Intrusion to Indoor Air from Soil Vapor*.

2010 Preferential Pathway and Well Survey

In 2010, Conestoga-Rovers & Associates (CRA) completed another preferential pathway analysis and well survey. CRA located electric, natural gas, water, communication, storm drain sewer, and sanitary sewer lines near the site. Although some of these utilities periodically intersect the groundwater table, hydrocarbon concentrations in monitoring wells indicate that utilities are not acting as significant pathways for hydrocarbon migration. This is consistent with previous assessments. The closest water supply wells are over 1,000 feet from the site. These wells are either upgradient or located in Oakland across the Oakland Alameda Estuary. The wells identified in the survey are not at risk from hydrocarbons originating from the site. Additional information is available in CRA's September 30, 2010 *Preferential Pathway Study and Well Survey Report*.

2011 Subsurface and Crawl Space and Indoor Ambient Air Investigation

In 2011, Conestoga-Rovers & Associates (CRA) collected 2 indoor ambient air samples from inside the residence, 2 ambient air samples from within the crawl space, and 1 outdoor ambient air sample. Also 8 soil borings B-1 through B-8 were advanced onsite. Additional information is available in CRA's April 18, 2012 *Subsurface and Crawl Space, Indoor and Ambient Air Investigation Report*.

2013 Crawl Space, Indoor Ambient Air and Sub-Slab Soil Gas Investigation

In 2013 -Rovers & Associates (CRA) installed 2 sub-slab vapor probes and collected 2 sub-slab vapor probe samples, 2 indoor ambient air samples from inside the residence, 2 ambient air samples from within the crawl space, and 1 outdoor ambient air sample. Additional information is available in CRA's December 20, 2013 *Crawl Space, Indoor Ambient Air and Sub-slab Soil Gas Investigation Report*.

APPENDIX C

VAPOR INTRUSION BARRIER BROCHURE

A New Methodology for Chemical Resistance Testing of a Retrofit Vapor Intrusion Barrier

Ben Mork, Ph.D.; Ryan Ferguson, M.S.
Land Science Technologies, 1011 Calle Sombra, San Clemente, CA

Abstract

Chemical resistance of the Retro-Coat™ barrier system was tested against the VOCs perchloroethene (PCE), and trichloroethene (TCE). A custom apparatus and testing methodology were developed to mimic conditions that are directly relevant to vapor intrusion. The testing was run for approximately 150 days and permeation rates were determined for each contaminant at challenge concentrations of approximately 25, 125, 250, and 500 ppmV. The VI-specific barrier was determined to be highly chemically resistant to these VOCs, exhibiting diffusion coefficients of 7.6 x 10^{-14}m ^{2}/s and 8.2 x 10^{-14} m^2/s for PCE and TCE respectively, thus validating efficacy of the Retro-Coat barrier as a preventative measure against vapor intrusion for existing structures on contaminated land.

Introduction

Vapor Intrusion (VI) is the process by which toxic vapors from contaminated soil and groundwater can migrate into the indoor air of a building, thus presenting a risk to the health of building occupants. The risks of VI to human health can be significant in structures built upon sites contaminated with volatile organic chemicals (VOCs) such as perchloroethene (PCE) or benzene. For new structures built on contaminated land, there are a variety of strategies and technologies available to mitigate future vapor intrusion into structures. For example, the Geo-Seal® membrane is a multi-ply chemically resistant barrier that is installed prior to pouring the concrete slab foundation. Active and passive ventilation systems are also widely used to mitigate vapor intrusion beneath buidings and are usually installed during construction.

There are many VI mitigation options that can be incorporated into the construction phase of a new building, however there are limited options available for existing structures that have a vapor intrusion problem or a potential risk of vapor intrusion. For the countless existing “sick” or at-risk structures in need of a vapor intrusion mitigation solution, Land Science Technologies, Inc. (San Clemente, CA) has developed a VI-specific floor coating system called Retro-Coat™. This material has been explicitly developed and tested for its ability to seal concrete-slab floors in existing structures against VOCs, thus significantly lowering the risk of VI to the indoor air quality.

Although there are existing standardized test methods to quantify the transport of water vapors through barriers (e.g., ASTM E-96), these methods are inaccurate for estimation of VOC vapor transmission at levels relevant to vapor intrusion mitigation (e.g. ppmV levels). In order to demonstrate the efficacy of this new floor coating system, a new method and testing apparatus were developed. This is the only method to date that closely models the condition of contaminant vapor intrusion. The practice of active sampling, the chamber design, and the constant clean-air exchange above the barrier sample ensure that a conservative and accurate measure of contaminant diffusion through the barrier is obtained. In consideration of reported diffusion coefficients from this and other studies, it is very important that these criteria are addressed correctly in the experimental design and procedure.

An extensive five month study was performed to quantify the chemical resistance of Retro-Coat toward two toxic and volatile chemicals that are commonly encountered as soil and groundwater contaminants: perchloroethene (PCE) and trichloroethene (TCE). Historically, these chlorinated solvents have been widely used as dry-cleaning and degreasing agents, respectively. The study design involved testing multiple contaminant concentrations, starting from a high level (500 ppmV) and sequentially testing lower concentrations in order to establish a relationship between concentration and permeation rate. This "high to low" methodology is a conservative approach that ensures the permeation of contaminant is at a steady-state condition and that diffusion rates will not be underestimated. An overview of the new, custom-developed testing methodology is reported in this paper, along with the resulting chemical resistance data and contaminant diffusion coefficients determined for the Retro-Coat barrier material.

Experimental

Chemical Resistance Testing Apparatus: A labeled photograph of the custom-made vapor transmission testing apparatus is shown in Figure 1. The lower chamber is constructed from a 5 L glass round-bottom flask, and the top section consists of a 3-necked glass chamber. Both top and bottom chambers are open-ended to interface with an approximately 6" diameter circular sample of vapor barrier to be tested. The two chambers are separated by the tested barrier material and the system is secured and sealed by a ring clamp that compresses and seals the barrier between chambers with adjustable screws. Two independent chamber studies were run in parallel: one for each contaminant tested (PCE and TCE). All vapor experiments were run by Columbia Analytical Services (Simi Valley, CA)

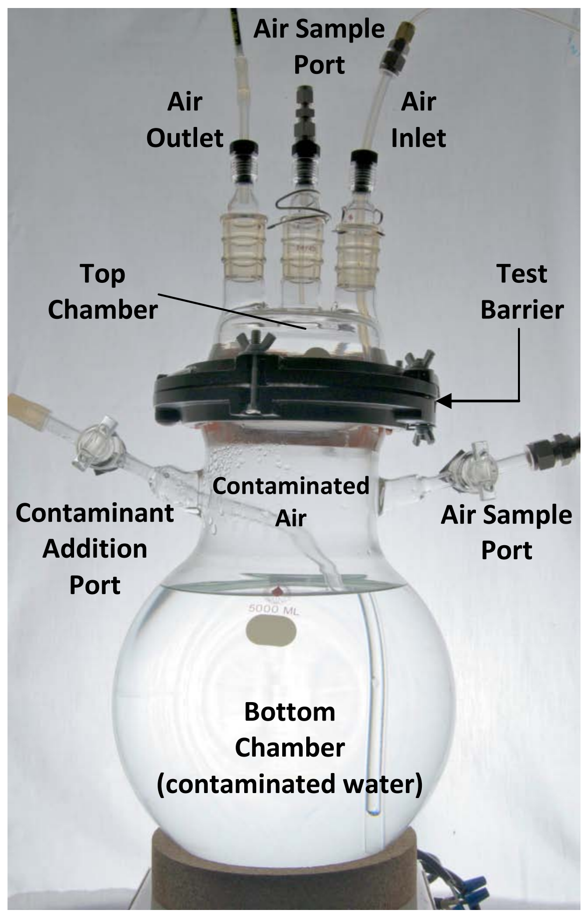

Figure 1. Chemical Resistance Testing Apparatus

Sample Preparation: A 20 mil (0.020 inch) thick sheet of the Retro-Coat barrier was prepared by layering 2 10-mil coatings on a 22"x42" glass surface with a 10-mil notched squeegee. After the material cured for one day, the barrier was carefully lifted off the glass. Six inch diameter circular samples of Retro-Coat were cut from the sheet. The thickness of each of the samples was tested at 13 points in a grid pattern. Two samples, one for each chamber, were selected with a target thickness of 20 mil.

Chemical Permeation Experiments: This experimental methodology establishes a contaminant vapor concentration in the lower chamber, then measures the transmission rate of that contaminant through the test sample into the upper chamber air, which is constantly exchanged at a fixed flow rate of 2.5 mL/min. This constant air exchange approximates the indoor air of a building being exchanged by an HVAC system. The permeation testing was run at a series of four target challenge concentrations for each contaminant: 500 ppmV, 250 ppmV, 125 ppmV, and 25 ppmV in the gas phase of the lower chambers. The vapor concentrations were established by spiking the water in the lower chamber with appropriate doses of contaminant followed by the natural equilibration of liquid and vapor phases. The sequence of tested concentrations was run in decreasing order from highest to lowest in order to ensure that for the final 3 concentrations the permeation rates started high and equilibrated down to their steady-state values. This is a conservative approach that ensures permeation and diffusion are not underestimated in the study results.

The bottom chambers were kept sealed for the duration of the experiments, in order to maintain desired contaminant levels for long durations. In order to emulate indoor air exchange as created by HVAC systems in typical buildings, the top chamber was continuously purged with high purity humidified air. The top chamber has a void volume of 400 mL. Humidified zero-air (HZA) was controlled by a mass flow controller (MFC) and continuously delivered to the upper chamber inlet port at 2.5 mL/min. The outlet port was vented to a chemical fume hood.

Analytical Measurements: Through the course of these studies, gas phase contaminant measurements were taken twice per day from both chambers for five days each week. The gas samples were taken by syringe and quantified by direct injection on an Agilent 5890 GC-ECD system.

Results and Discussion

Chemical resistance testing was carried out over four challenge concentration phases for each contaminant. A range of contaminant vapor concentrations from 500 ppmV down to 25 ppmV was targeted. Within each phase of the experiment after the challenge concentration stabilized near its target value, the top chamber vapor was monitored for four to eight weeks until its contaminant concentration had also stabilized. The total duration of these experiments was approximately 150 days, ensuring the data are representative of long term performance of the barrier. Actual challenge concentrations varied from the theoretical targets, but in general were very stable. Table 1 lists the targeted and actual vapor challenge concentrations for PCE and TCE for the individual test phases. Although in general the actual concentrations were slightly lower than targeted, the values were relatively stable over time and allowed for accurate calculation of permeation and diffusion rates.

Table 1. Targeted and actual challenge contaminant concentrations in lower chamber vapors

	Target [PCE] (ppmV)	Actual [PCE] (ppmV)	Target [TCE] (ppmV)	Actual [TCE] (ppmV)
Phase A	500	**444**	500	**446**
Phase B	250	**237**	250	**248**
Phase C	125	**95**	125	**103**
Phase D	25	**26**	25	**29**

Each testing phase was monitored until the permeating contaminant concentration in the upper chamber had stabilized for a 3-week period, at which time it was deemed to be at a steady-state condition. At that time, the next phase was initiated and the next challenge concentration was established in the lower chamber. As needed, contaminant was introduced to the water of the lower chamber by spiking (PCE or TCE in methanol) through the contaminant addition port (Figure 1) to establish close to target challenge concentrations.

Each contaminant data set resulted in time-averaged, steady-state contaminant concentrations for the lower chamber and the top chamber gases. The averaged contaminant concentrations for all phases of both experiments are listed in Table 2. Using these data and experimental apparatus parameters the chemical permeation rate, *J*, for each phase was calculated and also listed below.

Table 2. Contaminant data and calculated permeation rates for each phase in PCE and TCE experiments

	Challenge Concentration (ppmV)	Top Chamber Concentration (ppbV)	Permeation Rate (μg cm^{-2} s^{-1})
	PCE		
Phase A	444	12.8	4.64E-08
Phase B	237	6.61	1.96E-08
Phase C	95.2	1.86	6.43E-09
Phase D	26.3	0.536	1.83E-09
	TCE		
Phase A	446	16.4	4.41E-08
Phase B	248	4.00	9.95E-09
Phase C	104	3.76	1.07E-08
Phase D	29.1	1.90	5.29E-09

Using the data in Table 2, a plot of permeation rate vs. challenge concentration was constructed for each contaminant. These plots are shown in Figures 2 and 3.

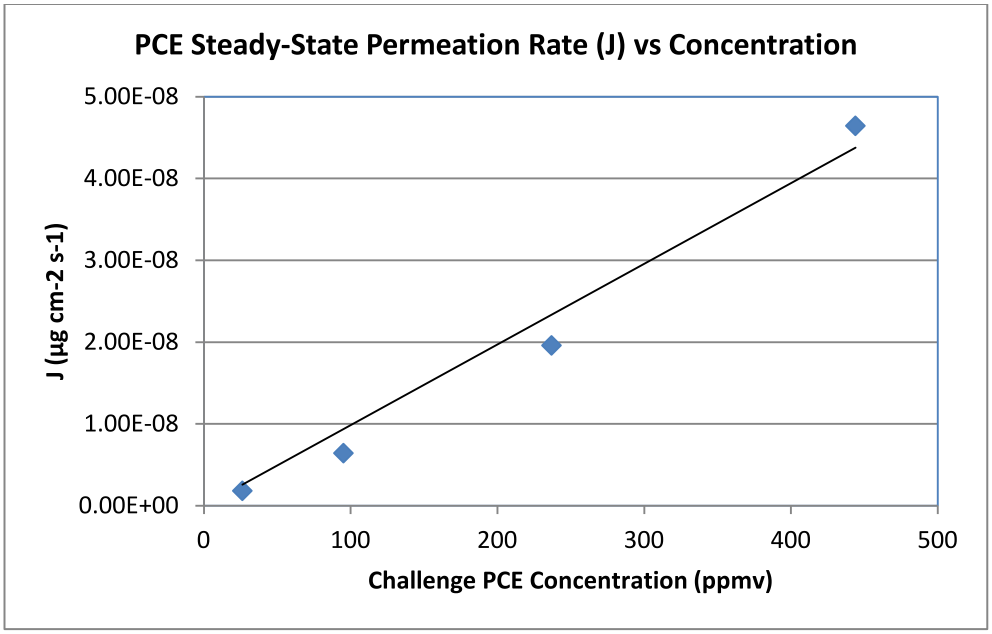

Figure 2. PCE permeation rate, *J*, vs. challenge concentration

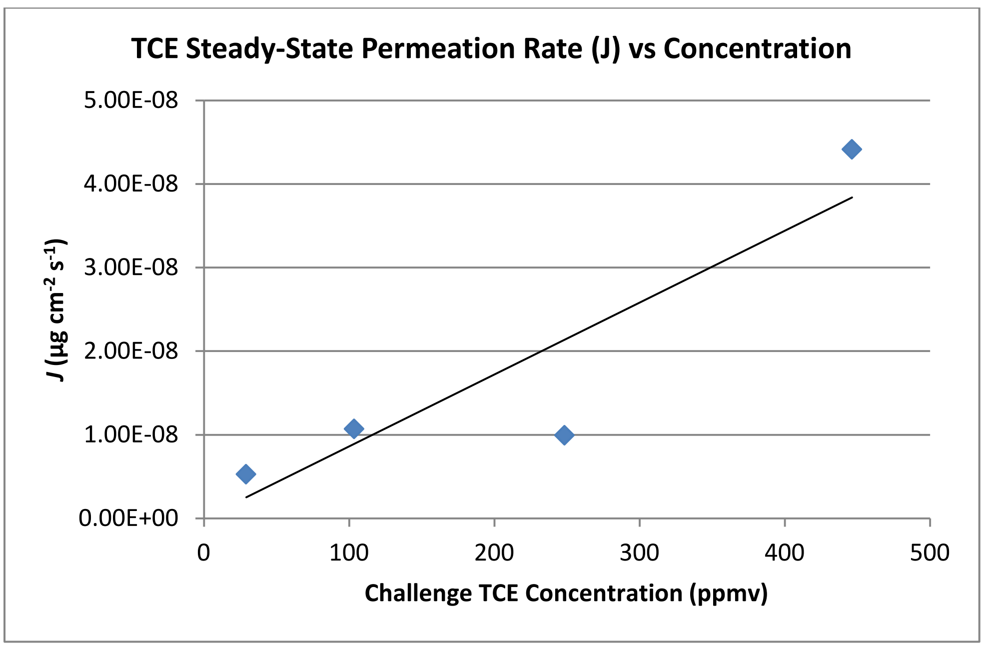

Figure 3. TCE permeation rate, J, vs. challenge concentration

Diffusion coefficients for each contaminant were calculated using the data in Table 2. and Fick's first law, which relates the chemical permeation rate (or diffusion flux), *J*, to the difference in contaminant concentration across the barrier (dC) and thickness of the barrier (dx, equation 1). For these calculations, dx = 20 mil, and dC is the difference in contaminant concentration across the membrane (challenge – permeate).

$$J = -D(dC/dx) \quad (1)$$

The experimentally-derived diffusion coefficients (D) for PCE and TCE in the Retro-Coat VI barrier are displayed in Table 3. These numbers indicate a very high degree of chemical resistance toward the tested VOCs. For comparison, Luber et. al reported diffusion coefficients of PCE and TCE in HDPE (high density polyethylene), material commonly used to line hazardous waste landfills, to be 7.8×10^{-11} m^2/s and 7.3×10^{-11} m^2/s respectively.[1,2] While these numbers were obtained using a different methodology (contaminated water rather than vapor) they are, nonetheless, three orders of magnitude larger than the diffusion coefficients determined for the Retro-Coat vapor intrusion barrier in this study.

Table 3. Sample thickness and diffusion coefficients

Contaminant	Retro-Coat Sample thickness in mil	Diffusion Coefficient (m^2/s)
PCE	20.48 ±3.06	**7.6×10^{-14}**
TCE	20.22 ±3.11	**8.2×10^{-14}**

Conclusions

New equipment and state of the art methods have been developed to test the chemical resistance of vapor intrusion barriers. The Retro-Coat vapor barrier was tested against the chemically aggressive chlorinated solvents PCE and TCE under a wide range of concentrations and found to be extremely chemically resistant. Diffusion coefficients of 7.6×10^{-14} and 8.2×10^{-14} m^2/s for PCE and TCE, respectively verify that this floor coating is very effective for blocking the flow of VOCs from contaminated sites into the building indoor air. This amount of protection corresponds to the coating providing a reduction factor of greater than one million fold for indoor air contamination compared with soil gas VOC levels.

This retrofit floor coating technology is the first of its type to be developed specifically for vapor intrusion mitigation. Its efficacy has been proven explicitly by technically rigorous vapor-phase contaminant diffusion studies that relate directly to common vapor intrusion scenarios. The test results reported here are conservative and very accurate, and should only be compared with diffusion coefficients derived under equally rigorous conditions. Future work in this area will include the study of other VOCs that are highly relevant to vapor intrusion problems, most notably benzene.

References

1. Luber, M., 1992, "*Diffusion of Chlorinated Organic Compounds Through Synthetic Landfill Liners*", Department of Earth Sciences, Waterloo Centre for Groundwater Research, University of Waterloo, (complete report not available), approx. 88 p. (Also described and referenced in Rowe et. al below)
2. Rowe, R.K., Hrapovic, L. and Kosaric, N., 1995, "Diffusion of Chloride and Dichloromethane Through an HDPE Geomembrane", *Geosynthetics International*, Vol. 2, No. 3, pp. 507-536.