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PERMEABLE REACTIVE BARRIER PRE-DESIGN INVESTIGATION WORK PLAN

Crown Chevrolet Cadillac Isuzu
7544 Dublin Boulevard
Dublin, California

Prepared for:

Crown Chevrolet
Dublin, California

Prepared by:

AMEC Environment & Infrastructure, Inc.
180 Grand Avenue, Suite 1100
Oakland, California 94612

August 2014

Project No. OD10160070

August 14, 2014

Ms. Dilan Roe
Site Cleanup Program Manager
Alameda County Environmental Health
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94501-6577

Subject: **Permeable Reactive Barrier Pre-Design Investigation Work Plan**
Crown Chevrolet Cadillac Isuzu
7544 Dublin Boulevard
Dublin, California
Fuel Leak Case No. RO0003014

Dear Ms. Roe:

Enclosed please find the *Permeable Reactive Barrier Pre-Design Investigation Work Plan* for the Crown Chevrolet Cadillac Isuzu site at 7544 Dublin Boulevard, in Dublin, California (Fuel Leak Case No. RO0003014, GeoTracker Global ID T10000001616). This document was prepared by AMEC Environment & Infrastructure, Inc. (AMEC), on behalf of Crown Chevrolet Cadillac Isuzu.

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.

Please contact me at (925) 984-1426 or Avery Whitmarsh of AMEC at 510-663-4154 if you have any questions regarding this Work Plan.

Sincerely yours,

Terri Costello

Terri Costello
Betty J. Woolverton Trust

Attachment: Permeable Reactive Barrier Pre-Design Investigation Work Plan

cc: Tondria Hendrix, Zurich North American Insurance
Thomas L. Vormbrock, Rimkus Consulting Group, Inc.
Doug Bablitch, AMEC Environment & Infrastructure, Inc.

amec

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PRE-DESIGN INVESTIGATION WORK PLAN
Crown Chevrolet Cadillac Isuzu
7544 Dublin Boulevard
Dublin, California

August 14, 2014
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This work plan was prepared by the staff of AMEC Environment & Infrastructure, Inc., under the supervision of the Geologist whose seal and signature appear hereon.

The findings, recommendations, specifications, or professional opinions are presented within the limits described by the client, in accordance with generally accepted professional engineering and geologic practice. No warranty is expressed or implied.

PROFESSIONAL GEOLOGIST
AVERY WHITMARSH
No. 8541
STATE OF CALIFORNIA

Avery Whitmarsh, PG #8541
Senior Geologist

TABLE OF CONTENTS

Page

TABLE

FIGURES

APPENDIX

PERMEABLE REACTIVE BARRIER
PRE-DESIGN INVESTIGATION WORK PLAN

Crown Chevrolet Cadillac Isuzu
7544 Dublin Boulevard
Dublin, California

1.0 INTRODUCTION

AMEC Environment & Infrastructure, Inc. (AMEC), has prepared this *Permeable Reactive Barrier Pre-Design Investigation Work Plan* (Work Plan) on behalf of the Betty J. Woolverton Trust and Crown Chevrolet Cadillac Isuzu (collectively, Crown) for the property located at 7544 Dublin Boulevard, Dublin, California (the site; Figure 1). The Work Plan has been prepared at the request of Alameda County Environmental Health (ACEH). The purpose of the Work Plan is to collect site-specific information to support the final design of the proposed permeable reactive barrier (PRB) to be installed along the western edge of the property. Specifically, this work plan describes direct push boring and piezometer installation; soil and grab groundwater sampling; borehole dilution testing; and bench-scale testing of PRB treatment media.

The PRB and its preliminary design were proposed in the *Revised Draft Feasibility Study and Corrective Action Plan* which was submitted to ACEH on March 25, 2013 (AMEC, 2013b) and acknowledged by ACEH in a letter to Crown dated August 16, 2013 (ACEH, 2013). The Final Feasibility Study and Corrective Action Plan (FS/CAP) was submitted to ACEH on May 1, 2014 (AMEC, 2014a).

2.0 OBJECTIVES

The purpose of the proposed investigation is to collect site-specific information to support the final design of the proposed PRB, which is planned to be installed along the western edge of the property. In order to finalize the design of the PRB, the goal of this investigation is to acquire the additional data required to complete the characterization of the subsurface hydrogeology at the site. Additionally, bench-scale column testing of available ZVI products will be conducted using impacted groundwater collected from the site. The goal of the column testing is to determine which ZVI product exhibits the maximum treatment capacity for the site groundwater conditions.

3.0 BACKGROUND

The site was developed in 1968 as Crown Chevrolet, a car dealership with auto body shops, on land that appears to have been previously used for agricultural purposes. Operations as a car dealership and auto body shop continued from 1968 through 2013. The buildings are still present, but no operations are being conducted at the site at this time.

Multiple environmental investigations have been conducted at the site to address regulatory concerns as well as in support of transactional and potential redevelopment activities, and monitoring of site groundwater monitoring wells is ongoing.

Groundwater is first encountered at the site between approximately 9 and 15 feet below ground surface and generally flows from the west to the east. Volatile organic compounds (VOCs), primarily tetrachloroethene (PCE) and trichloroethene (TCE), have been detected above their respective Environmental Screening Levels (ESLs), published by the California Regional Water Quality Control Board, San Francisco Bay Region (Regional Water Board, 2013) in shallow groundwater and soil vapor throughout the northern portion of the site. Degradation byproducts (e.g., cis-1,2-dichloroethene) are also present in groundwater and vapor, but at lower concentrations relative to PCE and TCE and below their respective ESLs, with the exception of vinyl chloride detections in soil vapor above its ESL. Based on the results of the most recent investigation performed by AMEC, the source of PCE (and hence its degradation products) in groundwater is off site and hydraulically upgradient (AMEC, 2012).

Following the conclusion by AMEC that the source of PCE (and its degradation products) in groundwater is off site, ENGEO Incorporated (ENGEO) performed an off-site investigation in October 2012 (ENGEO, 2013) as part of due diligence program for a third party. Four grab groundwater samples (CG-3 through CG-6; Figure 2) were collected in Golden Gate Drive, upgradient of the site, and analyzed for VOCs and total petroleum hydrocarbons quantified as gasoline (TPHg). These samples were collected west of the sanitary sewer within the street to help identify whether the sanitary sewer may have been the source of PCE in groundwater. PCE and TCE were detected at concentrations similar to those at the western site boundary, confirming that the PCE source is upgradient of the site, but not providing clarity on whether or not the sewer line was a/the source of PCE in groundwater (Figure 4). TPHg was also detected; however, the analytical laboratory has indicated that this result is a false positive, likely representative of PCE. A complete summary of all analytical results detected above the laboratory reporting limit, including the ENGEO data and a discussion of the false positive TPHg detection, is presented in the *First Quarter 2013 Groundwater Monitoring Report* (AMEC, 2013a).

As detailed in the FS/CAP, redevelopment is currently planned for the site. Specifically, the site is tentatively planned for development of 314 apartments (a total of approximately 72,000 square feet in multi-unit structures) and 17,000 square feet of retail space at ground level along Dublin Boulevard.

The FS/CAP recommends the installation of a PRB for treatment of impacted groundwater migrating onto the site along portions of the western and northern property boundaries. The PRB is anticipated to use zero-valent iron (ZVI) as the reactive media. The purpose of the PRB is to provide a permeable treatment zone to facilitate reductive dechlorination of PCE-impacted groundwater that moves though the wall. Once the PRB is installed, concentrations of PCE at the downgradient side of the wall should decrease with time.

4.0 SOIL BORING FIELD INVESTIGATION

A field investigation is outlined in the following sections that will allow for characterization of site hydrogeology and design of the thickness, depth, width, and location of the PRB. The investigation will include up to 11 electrical conductivity (EC) probe borings for the collection of high-resolution data regarding lithology, 1 dual-tube direct push boring, 6 HydroPunch™-type borings for the collection of up to 9 depth-discrete grab groundwater samples, and installation of 3 piezometers. Following installation and development, the piezometers will be gauged, and one will be used for a borehole dilution test to quantify the groundwater flow velocity at the site.

As discussed in the FS/CAP, and based on recent discussions with the City of Dublin, the proposed PRB is intended to be located within the City of Dublin right-of-way. The north-south-trending portion of the proposed PRB will be located on land that is currently within the site boundaries, but will transfer to the City at the completion of site redevelopment activities. The borings along this portion of the proposed PRB are anticipated to be advanced within several feet of the planned PRB location. The east-west-trending portion of the proposed PRB is located within what is currently a City of Dublin right-of way. The borings along this portion of the proposed PRB will be advanced as close to the proposed PRB alignment as possible while remaining on site property; as a result, they may be up to 20 feet from the proposed PRB alignment.

The drilling will be performed by a California C57-licensed drilling contractor under the supervision of AMEC field personnel. A decontaminated hand auger may be used to advance the first 5 feet of the boring in order to clear for subsurface utilities.

The following sections discuss details of the proposed investigation activities.

4.1 PRE-FIELD ACTIVITIES

Prior to conducting the field work, AMEC will obtain soil boring and well installation permits from the Zone 7 Water Agency. Additionally, at least two business days prior to sampling, the anticipated boundaries of the areas to be sampled will be marked with white paint and

Underground Service Alert (USA) will be contacted, as required by law, to identify public utilities that may be in the vicinity of the proposed borings. Finally, AMEC will contract with a private utility locator to clear boring locations for underground utilities.

AMEC will update the site specific Health and Safety Plan (HASP) prior to field work. The HASP will identify site-specific hazards and mitigation measures. All contractors will participate in a daily health and safety meeting led by AMEC field staff and comply with the AMEC HASP at a minimum.

4.2 ELECTRIC CONDUCTIVITY PROBE BORINGS

EC probe borings will be advanced at a minimum of 7, but up to 11, locations (see Table 1 and Figures 2 and 3). Table 1 identifies which borings will be advanced initially and which are optional. The decision to advance some or all of the optional EC borings will be based on the lithology encountered in the initial borings and the speed at which the investigation is progressing.

At each EC boring location, an EC probe will be advanced to approximately 35 feet below ground surface (bgs) using direct-push drilling technology to displace the soil (i.e., no soil is recovered). The EC probe continuously measures electrical conductivity, which is a physical property of the soil matrix and is primarily controlled by the clay mineral content. Soil with relatively high clay mineral content is generally more electrically conductive than soil with low clay mineral content (for example, a sand or gravel with less than 5 percent fines would have a low electrical conductivity). Because the EC probe electrodes are in direct contact with soil as the tool is advanced through the subsurface, the resulting log will aid in identification of coarse-grained and fine-grained sediments at a higher resolution than can be readily discerned during visual logging of soil extracted from the borehole. AMEC will use this information to confirm the minimum design depth for the PRB that ensures it will be “keyed” into clay soil.

4.3 DUAL-TUBE SOIL BORING

One soil boring will be advanced to 35 feet bgs adjacent to one of the EC probes, using dual-tube direct-push drilling technology with an outside diameter of at least 3.25 inches. The soil boring will be advanced in order to collect a continuous core of soil for comparison to the EC logs. The dual-tube boring is currently planned to be advanced adjacent to boring PRB-04, in an area where logs prepared by different consultants for historical borings located close to each other have indicated significant variation (Table 1).

The recovered soil will be described by an AMEC field geologist under the supervision of an AMEC California-licensed Professional Geologist, using the visual-manual procedures of the ASTM International Standard D 2488 for guidance, which is based on the Unified Soil Classification System (USCS). The recovered soils will be generally screened for the presence of VOCs using a photoionization detector (PID). The PID readings will be recorded on the lithologic log for each boring, along with field observations of the presence of any staining or odor.

4.4 DEPTH-DISCRETE GRAB GROUNDWATER SAMPLING

Following completion of the EC probe borings, HydroPunch borings will be advanced using direct-push drilling technology in close proximity to, and upgradient (i.e., west) of, six of the EC probe borings for the collection of depth-discrete grab groundwater samples. The grab groundwater samples will be collected to provide an assessment of expected concentrations of VOCs within and beneath the PRB (Table 1).

HydroPunch technology allows for collection of up to two depth-discrete grab groundwater samples from the same borehole. Using the HydroPunch tool, one grab groundwater sample will be collected from three of the borings (currently planned for PRB-01, P-01, and P-03), and two grab groundwater samples will be collected from three borings (PRB-02, PRB-03, and P-02). One grab groundwater sample will be collected from each boring from a zone of higher assumed hydraulic conductivity (lower electrical conductivity) as identified by the EC probe. The sample will be collected from the first water-bearing zone, within the vertical range of the proposed PRB (approximately 10 to 20 feet bgs). A second grab groundwater sample will be collected from three borings (currently planned for PRB-02, PRB-03, and P-02) from within the fine-grained soils near or below the anticipated bottom depth of the PRB (approximately 20 to 25 feet bgs), if it is possible to extract sufficient groundwater for sample collection. The target sampling intervals will be determined in the field based on data from the EC probe borings. Table 1 provides a summary of the proposed EC borings and groundwater sampling program. Each HydroPunch boring will be located near and identified with a similar designation as an EC boring (e.g., PRB-01HP).

Beginning with the shallowest planned groundwater sample interval, the HydroPunch sampling system will be advanced to the bottom of the target interval where a grab groundwater sample will be collected. Once the target depth is reached, the outer casing of the HydroPunch will be retracted to expose the target interval (anticipated to be approximately 6 inches) to the HydroPunch screen and the surrounding formation. If a second groundwater sample is planned to be collected from a deeper zone, the HydroPunch sampler will be removed from the borehole, decontaminated, and reinserted into the same borehole in order to advance to the next target interval. This methodology is acceptable because the HydroPunch casing will seal off the first water-bearing zone during the collection of the second sample (i.e., there is no opportunity for cross-contamination).

Prior to collection of the groundwater sample at each target interval, the HydroPunch casing will be purged to decrease turbidity in the sample (if there is insufficient groundwater flow, a sample may be collected without purging). Purging will be performed using a peristaltic pump, inertial lift pump, or new, disposable, polyethylene bailer. Following purging, a grab groundwater sample will be collected from each boring using a peristaltic pump, inertial lift pump, or a bailer. A bailer will only be used for groundwater sampling if the groundwater is too deep to allow for use of a peristaltic pump or inertial lift tubing. The groundwater sample will be collected into laboratory-provided containers equipped with preservatives appropriate for the desired analyses. Each sample will be immediately labeled with a unique identifier and the sample collection time, and stored in an ice-chilled cooler pending transport to a California Department of Public Health−certified analytical laboratory under AMEC chain-of-custody procedures.

4.5 SOIL SAMPLING FOR PHYSICAL PROPERTIES

In order to provide additional information regarding the soil types that will be adjacent to the PRB, AMEC will collect bulk soil samples for grain-size analysis by ASTM D 422. The samples for grain-size analysis are planned to be collected from borings P-02 and PRB-04. One sample representative of the fine-grained soils and one sample representative of coarse-grained soils will be collected from each boring; however, the borings and target soil types may be modified in the field if different soil types are encountered that AMEC feels should be represented.

4.6 PIEZOMETER INSTALLATION, DEVELOPMENT AND GAUGING

Three piezometers will be installed, developed, and gauged in order to refine our understanding of the groundwater gradient in the northwest corner of the site, near the proposed PRB alignment. The approximate locations of the proposed piezometers (identified as P-01, P-02 and P-03) are shown on Figures 2 and 3. One of the piezometers will support the borehole dilution testing described below in Section 5.0.

4.6.1 Piezometer Installation

The groundwater piezometers will be constructed in accordance with the appropriate state (California Department of Water Resources, 1991) and Zone 7 Water Agency requirements. The piezometers will be installed using hollow-stem auger drilling technology, within an up-to-8.25-inch-diameter borehole. The piezometers will be constructed using up to 2-inch-diameter, schedule 40 polyvinyl chloride (PVC) blank casing and 5 feet of slotted (0.010-inch slots) screen, and will be screened within the first-encountered water-bearing zone. Based on previous depth-to-groundwater data, we anticipate that the piezometers will be installed to total depths of between 15 and 20 feet bgs; however, the actual depths and screened intervals will be determined in the field.

The annular space between the piezometer screen and surrounding formation will be backfilled with an appropriately sized sand filter pack. The filter pack sand in each piezometer will be placed such that the top of the filter pack sand is approximately 1 foot above the screened interval. Approximately 2 feet of bentonite chips will then be placed above the filter pack sand and will be allowed to hydrate in place. The remaining annular space above the hydrated bentonite chips will be sealed using neat cement or a cement/bentonite grout mixture. The piezometer will be completed at the surface using a flush-mounted, traffic-rated box set into concrete. A locking, watertight plug will be placed in the top of the casing at each piezometer.

4.6.2 Piezometer Development

At least 48 hours after installation, the piezometers will be developed using a combination of bailing, surging, and purging until the water is relatively visibly clear and field parameters (e.g., dissolved oxygen, oxidation/reduction potential, temperature, pH, and specific conductance) are relatively stable (Kraemer, C., et al., 2006, pp. 850-855). These parameters will be monitored during piezometer development and recorded on a piezometer development record, which will be included with the report documenting the field work.

4.6.3 Piezometer Gauging

At least 48 hours after development and prior to designing the PRB, AMEC will gauge the depth to water within the new piezometers and the existing monitoring wells installed in the shallow water-bearing zone in order to refine our understanding of the direction of the groundwater gradient in the northwest corner of the site. This information will be used to determine if there is a northerly component to the groundwater flow direction and if it is necessary to install a portion of the PRB along the northern site boundary.

Prior to collecting depth-to-groundwater measurements, the well cap will be removed from each well and the water level allowed to equilibrate. Equilibration will be considered complete when two depth-to-groundwater measurements collected within several minutes of each other at one well or piezometer are equivalent. The depth-to-groundwater measurements will be made to an accuracy of 0.01 foot with an electric sounder and recorded on a field record.

4.7 DECONTAMINATION

All reusable sampling equipment will be decontaminated prior to sampling and between use at each boring using a steam cleaner and/or Liquinox rinse, followed by a final rinse of distilled or deionized water. Additionally, as possible, borings will be advanced in the anticipated lower concentration areas before the anticipated higher concentration areas, to reduce the risk of possible cross-contamination between boring locations.

4.8 BORING DESTRUCTION

Following completion of the sampling activities, each direct-push boring (i.e., the EC probe, dual-tube, and HydroPunch borings) will be backfilled with Type I/II neat cement grout using a tremie hose or pipe, so that the boring is sealed from total depth to ground surface. If a

HydroPunch grab groundwater sample is scheduled to be collected on the same day that the adjacent EC boring is installed, AMEC will collect the grab groundwater sample prior to destruction of the adjacent EC boring in order to avoid possible impacts from the cement grout before it has cured.

4.9 INVESTIGATION-DERIVED WASTE

Investigation-derived waste (IDW), including drill cuttings, purge water, and equipment wash water, will be stored at the site in appropriately-labeled 55-gallon drums pending disposal by Crown Chevrolet. To assist in the disposal, AMEC will collect one composite sample from soil cuttings generated during the investigation and one sample from each drum of purge water or equipment wash water generated during the investigation, if required by the disposal facility. Each IDW sample will be submitted for analysis as described below in Section 4.11.

4.10 SURVEY OF INVESTIGATION POINTS AND PIEZOMETERS

Following completion of field investigation activities, AMEC will contract with a California Licensed Land Surveyor to record the location of the EC probe borings, the HydroPunch borings and the installed piezometers. The ground surface at each boring will be surveyed to a vertical accuracy of 0.01 foot and a horizontal accuracy of 0.1 foot.

4.11 LABORATORY ANALYTICAL METHODS AND QUALITY ASSURANCE

The grab groundwater samples will be submitted to a California Department of Public Health−certified analytical laboratory under chain-of-custody procedures. The collected samples will be analyzed for the presence of VOCs and TPHg using U.S. Environmental Protection Agency (U.S. EPA) Method 8260B.

A blind field duplicate grab groundwater sample will be collected from at least one of the borings during the sampling event and analyzed for the same suite of constituents as the primary samples. Additionally, one equipment blank will be collected on each day of groundwater sampling by decanting laboratory-provided deionized water through the decontaminated HydroPunch sampler and into laboratory-provided sample containers. A laboratory-provided trip blank sample will be included in each cooler used to transport samples to the laboratory.

The soil samples for physical properties analysis will be submitted to Cooper Testing Laboratory in Palo Alto, California for grain size analysis by ASTM D422, including hydrometer analysis for differentiation of the fine sediments.

The IDW samples will be analyzed for VOCs using U.S. EPA Method 8260B and for Title 22 (CAM 17) Metals by U.S. EPA Methods 6020B and 7470/7471.

5.0 BOREHOLE DILUTION TEST

Following installation and development of the piezometers and prior to the designing the PRB, a borehole dilution test (also known as a single point tracer test) will be performed in one of the newly installed piezometers in order to provide an independent measurement of groundwater velocity in the vicinity of the proposed PRB. Groundwater velocity is one of the most important design parameters for the proposed PRB, but has not yet been directly measured at the site. The piezometer to be used for the borehole dilution testing will be determined based on the lithology encountered by the EC borings and during piezometer installation; the test will be performed in the piezometer screened through the coarsest-grained soil encountered during the investigation.

Prior to performing the dilution test, AMEC will secure any necessary permits from the Zone 7 Water Agency. The borehole dilution test will begin at least 48 hours following piezometer development. The test will use a recirculation pumping system, which includes an above-ground pump connected to extraction tubing positioned in the piezometer at the bottom of the test interval and injection tubing positioned at the top of the test interval. The test will consist of injection of sodium bromide (NaBr) salt solution into the piezometer during recirculation pumping to mix the NaBr solution in the piezometer. The initial target concentration of bromide ion (Br^-), the tracer for the solution, is 250 milligrams per liter (mg/L); the concentration of the Br^- ion within the test interval will be monitored using a bromide ion–specific probe either placed inside the piezometer within the test interval, or positioned above ground in line with the recirculation pumping system. The bromide ion is considered a conservative tracer because it is relatively nonreactive and stable in typical groundwater conditions. The rate of dilution of the tracer in the piezometer will be used to calculate the ambient groundwater flow through the monitoring well in the test interval. The ambient flow through the well will in turn be used to infer the steady-state groundwater pore velocity through the water-bearing formation surrounding the piezometer screen (Hall, 1993; Halevy et al., 1967).

Additional detail regarding procedures and equipment required to perform the borehole dilution test is included in Appendix A.

6.0 BENCH-SCALE COLUMN TESTING OF ZVI PRODUCTS

Bench-scale column testing will be performed in order to evaluate the treatment capacity and potential longevity of two available ZVI products for treatment of the site groundwater. The bench-scale column testing will be conducted using impacted groundwater collected from the site. Bench-scale column testing will be used to estimate degradation rates (half life) of PCE and its degradation products using different ZVI products and evaluate the effects of inorganic groundwater chemistry (such as mineral precipitation). The column testing procedures described in the following sections are based on the Interstate Technology Regulatory Council (ITRC) guidance for the procedure (ITRC, 2011).

Two commercially available ZVI products will be tested in order to compare the performance and to be able to confirm if each would satisfy the design goals of the PRB. AMEC has selected ZVI from Peerless Metal Powders & Abrasive of Detroit, Michigan (Peerless) and ZVI from Connelly-GPM Inc. of Chicago, Illinois (Connelly) for comparison.

6.1 ZVI Column Testing Procedure

The testing apparatus will consist of a Plexiglas™ cylinder, up to 2 inches in diameter and approximately 2 feet in length, with at least three sampling ports positioned along the length of the cylinder. The ends will be closed except for an inlet port at one end and an outlet port at the other end. Approximately 10 pounds of granular iron (ZVI) will be requested from each vendor. Each test will consist of a batch of 100% ZVI packed into the cylinder in order to achieve a target porosity of approximately than 50%. In addition to the two ZVI columns, a reference column containing 100% uniform, clean (no fines) sand will be included to offer additional quality assurance/quality control.

The water used for the bench scale testing will be collected from the site monitoring well MW-01. The concentration of PCE in groundwater collected from MW-01 during October 2013 was 150 micrograms per liter (µg/L), and the concentration of TCE was 1.9 µg/L. Up to 120 liters of water will be collected following purging, using the same methodology used to collect groundwater samples during quarterly sampling (AMEC, 2014b). The water may be collected during one of the quarterly sampling events (following sampling) or during a separate event. Prior to use during the column test, the extracted groundwater will be spiked with additional PCE to approximately 2,000 µg/L, a 10-fold increase in the concentration. Approximately 40 liters of spiked groundwater will be pumped through each ZVI-filled cylinder in an up-flow configuration (i.e., the water will enter the vertical cylinder at the bottom and exit at the top) and at a constant rate to achieve the target flow velocity for each test. The target flow rate will be selected based on estimated half-life degradation rate for PCE such that low concentrations are observed in the column sample port and/or effluent port.

Steady-state conditions will be considered to be achieved when the concentration-versus-distance profile for the target analytes (PCE and its degradation products) has stabilized. The ITRC document indicates that stabilization is generally achieved in 40 to 50 column pore volumes. Samples will be collected using a syringe from the ports along the column approximately every 5 to 15 column pore volumes, and sampling will continue until steady state is reached or until 50 pore volumes of throughput, whichever is achieved first.

The samples collected from the column ports will be analyzed for some or all of the following constituents at an appropriately certified analytical laboratory (the testing may not be performed in California):

- VOCs by U.S. EPA Method 8260B;
- Aluminum, barium, boron, calcium, iron, potassium, magnesium, manganese, molybdenum, sodium, strontium, and silicon by U.S. EPA Method 6010 or 6020 (depending on reporting limit needs);
- Chloride, nitrate, nitrite, sulfate, phosphate, and phosphorus, by U.S. EPA Method 9056A;
- Alkalinity (carbonate, bicarbonate, and hydroxide) by Standard Method (SM) 2320B;
- Ammonia as N by U.S. EPA Method 350.1;
- Hardness by SM 2340B;
- Ion balance (% difference calculation performed by laboratory);
- Anion and cation sum (tabulated by laboratory);
- Dissolved organic carbon (DOC) and total organic carbon (TOC) by Method 9060;
- Total dissolved solids (TDS) by U.S. EPA 160.1;
- Reactive silica (SM 4500-SiO2 C); and
- Saturated pH and Langelier Index at 20 degrees Celsius and 4 degrees Celsius (calculation by laboratory based on pH measurement by U.S. EPA Method 9040C).

Periodic measurements of pH, specific conductivity, dissolved oxygen, ORP, Eh, and temperature will be made using calibrated bench instruments during the testing procedure. Additionally, the ambient temperature will be monitored and recorded throughout the experimental period.

6.2 EVALUATION OF COLUMN TEST RESULTS

The degradation rates for the target chemicals will be reported in half-lives (a half-life is the time required for the concentration of the chemical to decrease by one-half). The half-life can be used to confirm that the PRB design will achieve sufficient residence time to achieve the desired reduction in chemical concentrations.

The results from the column tests will also provide information on the production of degradation products and, similarly, their calculated half-lives. This analysis will confirm that the PRB design is sufficient to treat the degradation products in addition to PCE.

Analysis of inorganic groundwater chemistry provides important information about the type and magnitude of mineral precipitation. Based on the differences in inorganic water quality between the inlet and outlet of the testing apparatus, the test results should provide insight into the potential for mineralization to affect long term performance of the PRB.

7.0 DESIGN OF PRB

Following completion of the investigation activities, including the soil borings, grab groundwater sampling, piezometer gauging, borehole dilution test, and ZVI column testing, AMEC will perform an evaluation of the data and design the PRB so that it is adequately placed laterally and is keyed vertically into low permeability soils beneath the first (VOC-impacted) water-bearing zone.

The EC probe boring data and soil observations will be used to confirm the lithology that will be encountered by the PRB and evaluate the appropriate bottom depth of the PRB. This data will be incorporated into the existing cross-section that is oriented along the anticipated PRB alignment; the cross section will be included in a *PRB Basis of Design Report*.

The results for VOCs in grab groundwater samples will be used to delineate the vertical and lateral extents of the PCE plume in the first water-bearing zone, to confirm the range of concentrations that the PRB will intercept, and to design the appropriate length and bottom depth of the PRB.

The results of the borehole dilution test (used to determine the groundwater velocity), and the results of the bench-scale testing of different brands of ZVI will be used to confirm the thickness of the PRB and sand/iron ratio.

8.0 REPORTING AND SCHEDULE

The results of the PRB pre-design investigation, as well as a detailed design and proposed PRB installation methods will be summarized in a forthcoming *PRB Basis of Design Report*. The *PRB Basis of Design Report* will also detail the materials to be used, required permits, extents of excavation, and the procedures for handling soil and groundwater during installation of the PRB.

We anticipate that field work for the pre-PRB investigation can commence within approximately 1 month of approval of this work plan by ACEH and that activities detailed in this work plan, including the borehole dilution test and ZVI column testing, will take approximately 3 months to complete. We estimate that the *PRB Basis of Design Report* will be submitted to ACEH approximately 4 months following completion of investigation work.

9.0 REFERENCES

Alameda County Environmental Health, 2013, Fuel Leak Case No. RO0003014 and GeoTracker Global ID T10000001616, Crown Chevrolet Cadillac Isuzu, 7544 Dublin Boulevard and 6707 Golden Gate Drive, Dublin, CA 94568, August 16.

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AMEC, 2013a, First Quarter 2013 Groundwater Monitoring Report Crown Chevrolet Cadillac Isuzu, 7544 Dublin Boulevard and 6707 Golden Gate Drive, Dublin, California, March 25.

AMEC, 2013b, Revised Draft Feasibility Study and Corrective Action Plan, Crown Chevrolet Cadillac Isuzu, 7544 Dublin Boulevard and 6707 Golden Gate Drive, Dublin, California, March 25.

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TABLE

TABLE 1

PROPOSED INVESTIGATION BORINGS AND GROUNDWATER SAMPLES
Crown Chevrolet Cadillac Isuzu
7544 Dublin Boulevard
Dublin, California

Boring ID	Proposed Activities	Location of Boring and Rationale	Type of Sampling and Rationale
PRB-01	• EC boring [1] • HydroPunch sampling [2]	PRB-01 will be located approximately 45 feet south of the south end of the proposed PRB to provide additional information about the geology and groundwater quality south of the proposed PRB.	One grab groundwater sample will be collected from saturated, coarse-grained soils in the first water-bearing zone, to confirm that the plume does not extend this far south.
P-01	• EC boring • HydroPunch sampling • Soil logging [3] • Piezometer [4]	P-01 will be located approximately 12 feet south of the south end of the proposed PRB to provide additional information about the geology and groundwater quality just south of the proposed PRB. The piezometer will be used to refine our understanding of the groundwater gradient.	One grab groundwater sample will be collected from saturated, coarse-grained soils in the first water-bearing zone, to confirm the lateral delineation of the plume.
Optional EC Boring A	(Optional) [5]	Located near the south end of the proposed PRB, this boring would provide higher-resolution data for the final PRB design.	None planned
Optional EC Boring B	(Optional)	Located between historical borings SB-42 and SB-43, this boring would provide higher-resolution data for the final PRB design.	None planned
PRB-02	• EC boring • HydroPunch sampling	PRB-02 will be located between historical borings SB-42 and SB-43 to provide higher-resolution data for the final PRB design.	One grab groundwater sample will be collected from saturated, coarse-grained soils from a depth between approximately 10 and 20 feet bgs in order to confirm the range of concentrations that will be treated by the PRB. A second, deeper grab groundwater sample will be collected, if possible, at or below the bottom of the proposed PRB, to confirm vertical extent of the PCE plume.
PRB-03	• EC boring • HydroPunch sampling	PRB-03 will be located near the center of the PRB, where the highest PCE concentrations have been detected.	One grab groundwater sample will be collected from saturated, coarse-grained soils from a depth between approximately 10 and 20 feet bgs in order to confirm the range of concentrations that will be treated by the PRB. A second, deeper grab groundwater sample will be collected, if possible, at or below the bottom of the proposed PRB, to confirm vertical extent of the PCE plume.
PRB-04	• EC boring • Soil logging • Soil properties [6]	PRB-04 will be located near historical boring NM-B-34. A companion Dual-tube soil boring will help reconcile the variation in logging of soils by different consultants (boring NM-B-34 was logged as containing a greater amount of sand than nearby borings were logged).	A dual-tube soil boring is currently planned adjacent to PRB-04 to help reconcile the variation in logging of soils by different consultants and to calibrate the EC boring interpretation. Two soil samples for physical properties will be collected, one from saturated coarse-grained soils and one from saturated fine-grained soils. Both samples will be collected from depths between approximately 10 and 20 feet bgs.
Optional EC Boring C	(Optional)	Located between P-02 and historical boring SB-45, this boring would provide higher-resolution data for the final PRB design.	None planned

TABLE 1

PROPOSED INVESTIGATION BORINGS AND GROUNDWATER SAMPLES

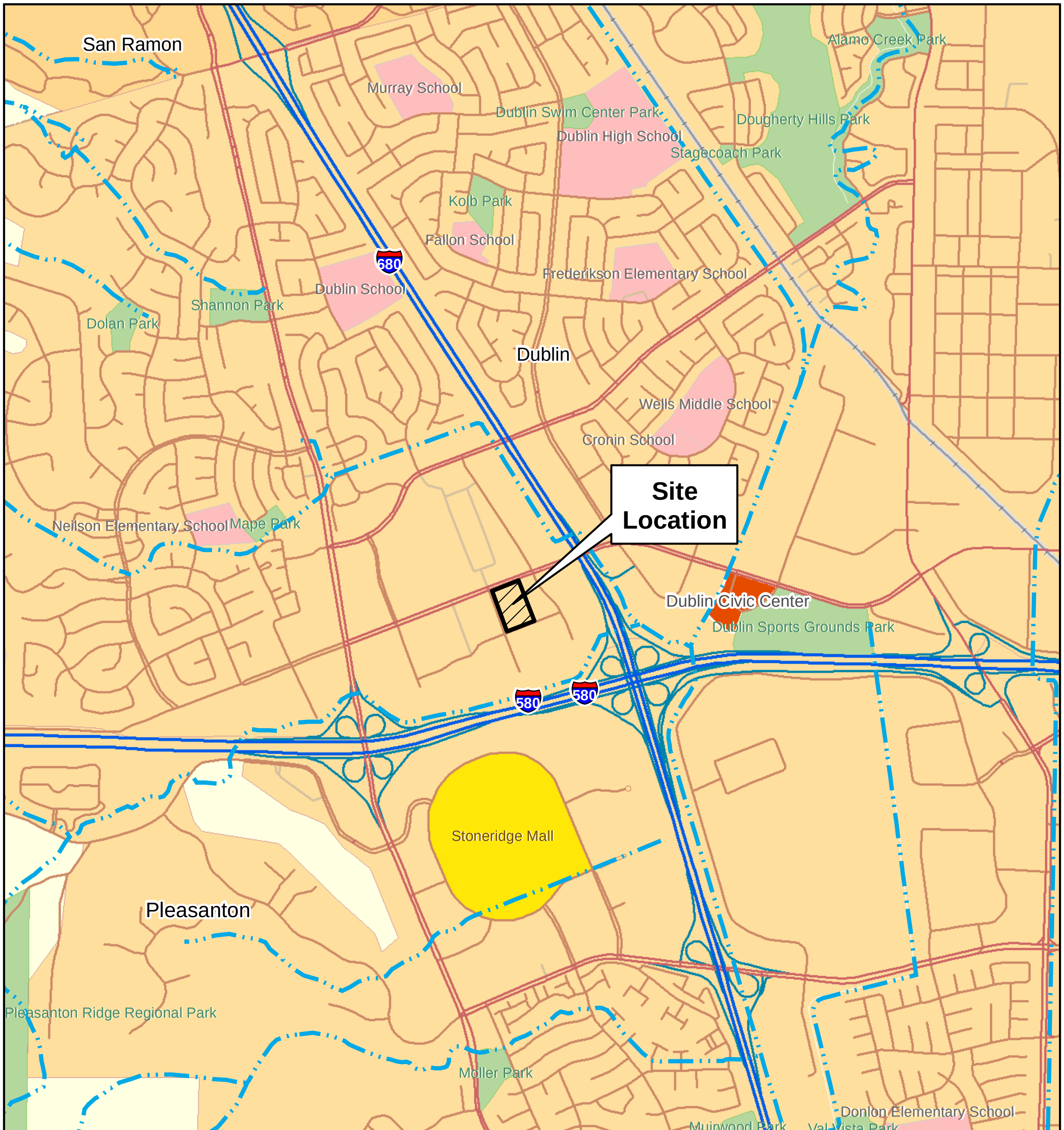
Crown Chevrolet Cadillac Isuzu
7544 Dublin Boulevard
Dublin, California

Boring ID	Proposed Activities	Location of Boring and Rationale	Type of Sampling and Rationale
P-02	• EC boring • HydroPunch sampling • Soil logging • Soil properties • Piezometer	P-02 will be located near the bend in the proposed PRB alignment to provide higher-resolution data for the final PRB design. The piezometer will be used to refine our understanding of the groundwater gradient.	One grab groundwater sample will be collected from saturated, coarse-grained soils from a depth between approximately 10 and 20 feet bgs in order to confirm the range of concentrations that will be treated by the PRB. A second, deeper grab groundwater sample will be collected, if possible, at or below the bottom of the proposed PRB, to confirm vertical extent of the PCE plume. Two soil samples for physical properties will be collected, one from saturated coarse-grained soils and one from saturated fine-grained soils. Both samples will be collected from depths between approximately 10 and 20 feet bgs.
Optional EC Boring D	(Optional)	Located at the north end of the proposed PRB, this boring would provide higher-resolution data for the final PRB design.	None planned
P-03	• EC boring • HydroPunch sampling • Soil logging • Piezometer	P-03 will be located approximately 35 feet east of the northeast end of the proposed PRB to provide additional information about the geology and groundwater quality just east of the proposed PRB. The piezometer will be used to refine our understanding of the groundwater gradient.	One grab groundwater sample will be collected from saturated, coarse-grained soils in the first water-bearing zone, to confirm the lateral delineation of the plume.

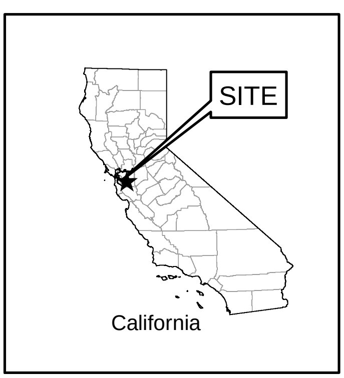
Notes
1. "EC Boring" indicates that one electrical conductivity boring will be advanced.
2. "HydroPunch sampling" indicates that up to two depth-discrete grab groundwater samples will be collected.
3. "Soil logging" indicates that a soil boring will be advanced using dual-tube direct push drilling technology or hollow-stem auger drilling technology with core barrel soil sampling in order to provide a continuous core of soil for lithologic interpretation.
4. "Piezometer" indicates that one piezometer will be installed in a boring advanced using hollow-stem auger drilling technology.
5. "(Optional)" indicates that an optional EC boring may be advanced.
6. "Soil properties" indicates that soil samples for physical properties analysis will be collected.

Abbreviations
EC = electrical conductivity
PCE = tetrachloroethene
PRB = permeable reactive barrier

FIGURES



Street map from ESRI, 2007.



0 2,000 4,000 Feet

N

SITE LOCATION MAP
Crown Chevrolet Cadillac Isuzu
7544 Dublin Boulevard
Dublin, California

By: GFS	Date: 04/07/2014	Project No. OD10160070
amec		Figure 1

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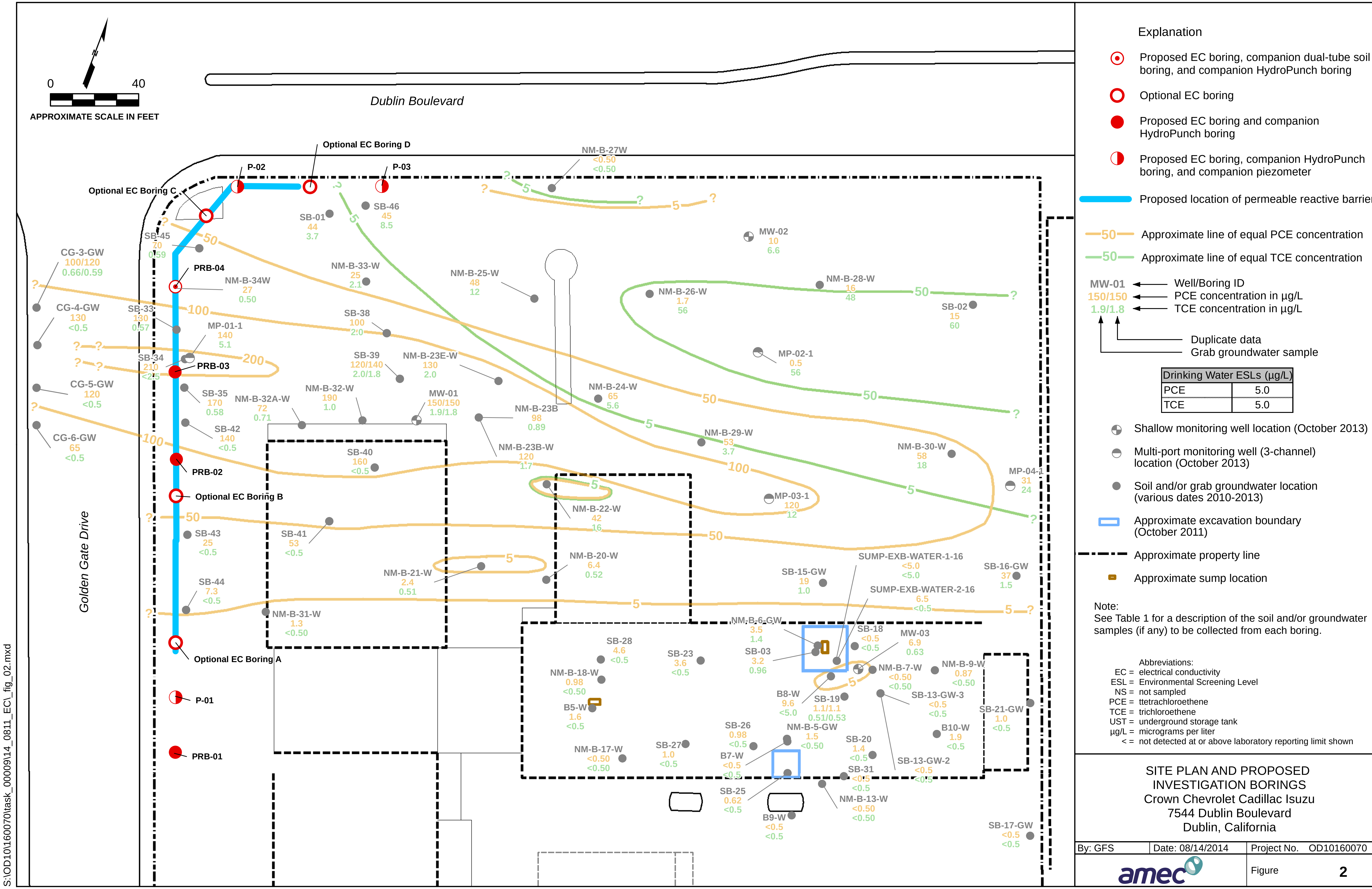

0 40
APPROXIMATE SCALE IN FEET
Dublin Boulevard
Golden Gate Drive
Optional EC Boring D
Optional EC Boring C
Optional EC Boring B
Optional EC Boring A
P-01
P-02
P-03
PRB-01
PRB-02
PRB-03
PRB-04
Explanation
Proposed EC boring, companion dual-tube soil boring, and companion HydroPunch boring
Optional EC boring
Proposed EC boring and companion HydroPunch boring
Proposed EC boring, companion HydroPunch boring, and companion piezometer
Proposed location of permeable reactive barrier
Approximate line of equal PCE concentration
Approximate line of equal TCE concentration
MW-01 Well/Boring ID
150/150 PCE concentration in µg/L
1.9/1.8 TCE concentration in µg/L
Duplicate data
Grab groundwater sample
Drinking Water ESLs (µg/L)
PCE 5.0
TCE 5.0
Shallow monitoring well location (October 2013)
Multi-port monitoring well (3-channel) location (October 2013)
Soil and/or grab groundwater location (various dates 2010-2013)
Approximate excavation boundary (October 2011)
Approximate property line
Approximate sump location
Note:
See Table 1 for a description of the soil and/or groundwater samples (if any) to be collected from each boring.
Abbreviations:
EC = electrical conductivity
ESL = Environmental Screening Level
NS = not sampled
PCE = ttetrachloroethene
TCE = trichloroethene
UST = underground storage tank
µg/L = micrograms per liter
< = not detected at or above laboratory reporting limit shown
SITE PLAN AND PROPOSED INVESTIGATION BORINGS
Crown Chevrolet Cadillac Isuzu
7544 Dublin Boulevard
Dublin, California
By: GFS
Date: 08/14/2014
Project No. OD10160070
amec
Figure 2
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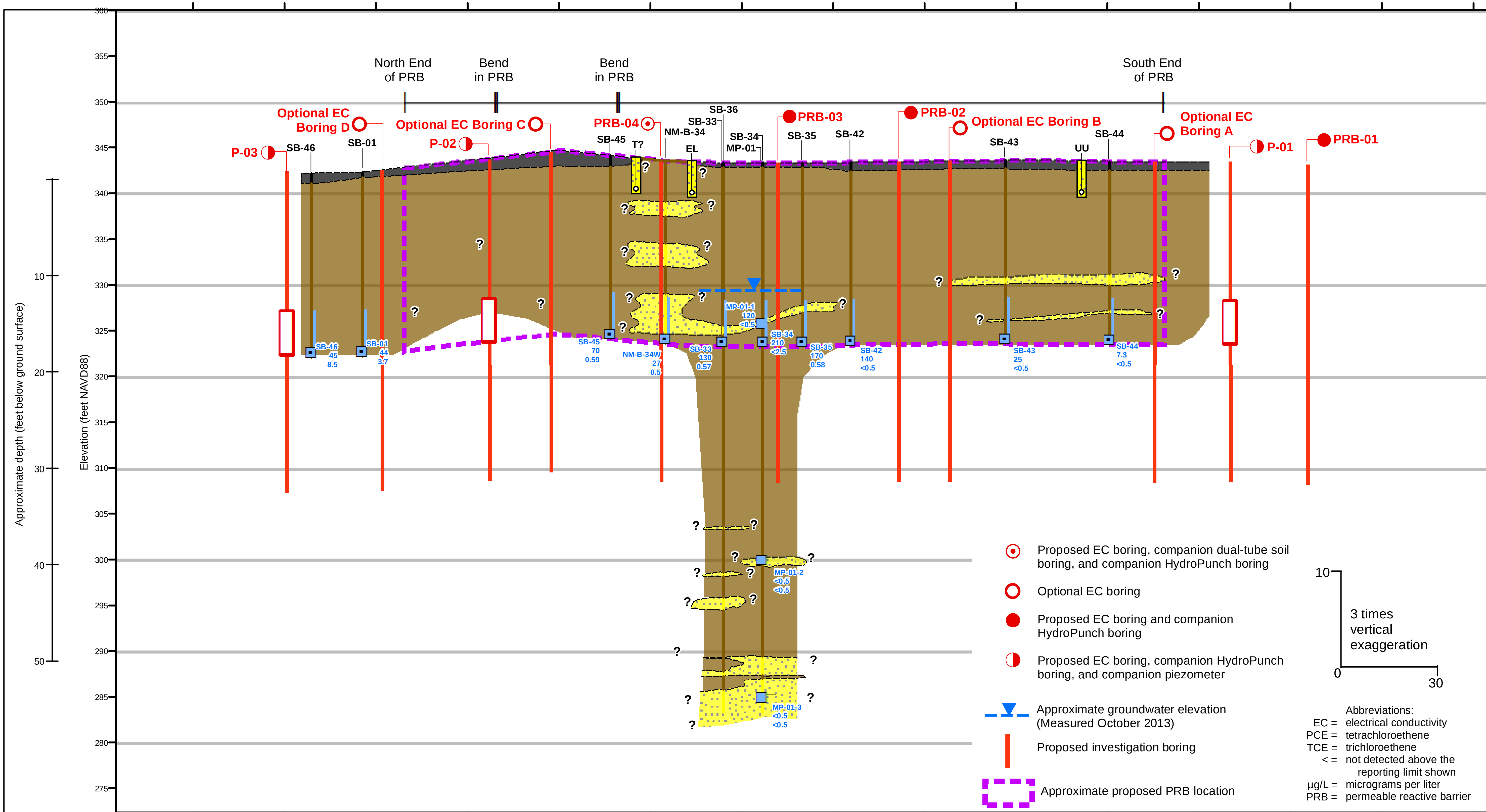

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Explanation

- Artificial fill
- Coarse-grained unit (e.g., sands, gravels, silty and clayey sands and gravels)
- Fine-grained unit (clays, silts)

EL ← Utility line type
EL = electric line
T? = suspected telecommunications line
UU = undifferentiated utility line
Approximate location of utility trench
Approximate location of utility line

Groundwater monitoring well sample
Grab groundwater sample (screen interval shown)
Proposed screen interval for piezometer

Results for PCE and TCE in groundwater
SB-43 ← Well/Boring ID
25 ← PCE concentration in µg/L
<0.5 ← TCE concentration in µg/L

Drinking Water ESLs (µg/L)	
PCE	5.0
TCE	5.0

Note:
See Table 1 for a description of the soil and/or groundwater samples (if any) to be collected from each boring.

CROSS SECTION ALONG PROPOSED PRB
Crown Chevrolet Cadillac Isuzu
7544 Dubliin Boulevard
Dublin, California

By: GFS | Date: 08/14/2014 | Project No. OD10160070

amec

Figure 3

APPENDIX A

Borehole Dilution Testing Procedure

TABLE OF CONTENTS

Page

TABLE

FIGURE

ATTACHMENTS

BOREHOLD DILUTION TESTING PROCEDURE

Crown Chevrolet Cadillac Isuzu
7544 Dublin Boulevard
Dublin, California

1.0 INTRODUCTION

The tracer dilution testing program will consist of injection of sodium bromide (NaBr) salt solution into a piezometer during recirculation pumping to mix the NaBr solution in the piezometer. The concentration of bromide ion (Br^-) within the piezometer test interval will be monitored as a tracer using bromide ion–specific probes. The bromide ion is considered a conservative tracer because it is relatively nonreactive and stable in typical groundwater conditions. The rate of dilution of the tracer in the piezometer will be used to calculate the ambient groundwater flow through the piezometer in the test interval. The ambient flow through the piezometer will in turn be used to infer the steady-state groundwater pore velocity through the water-bearing formation surrounding the piezometer screen (Hall, 1993; Halevy et al., 1967). The test equipment and procedures are in summarized in the subsections below.

2.0 EQUIPMENT AND MATERIALS

The tracer dilution testing will require the following equipment and materials:

- Two TempHion™ (or equivalent) Br^- probes with recording dataloggers: one probe will be used to test for consistency in the piezometer; the other probe is included as backup field equipment and will be used to perform additional monitoring overnight, if required, if the dilution rate is very slow.
- A laptop with necessary software pre-loaded to display real-time probe measurements.
- Two peristaltic pumps: a primary peristaltic pump for recirculation pumping throughout the data collection period, and a secondary peristaltic pump for injection of the bromide solution.
- ¼-inch polyethylene tubing and soft silicone tubing.
- Small-diameter stainless steel or fiberglass connecting rods to form the test assembly support structure.
- Cable ties or silicone tape to attach the tubing and probe to the test assembly support structure.
- An injection and sampling manifold.
- Laboratory-prepared deionized water.
- Sodium bromide.
- An electronic water-level-sounding instruments (Solinst or equivalent) capable of measuring water levels to an accuracy of approximately 0.01 foot.

- A generator.
- Supplies to wash and rinse the equipment.
- 500-milliliter (mL) unpreserved polyethylene bottles to hold samples collected for laboratory analyses.
- Field forms to record field data measurements and other information.

3.0 TRACER DILUTION TESTING PROCEDURES

The tracer dilution testing procedures (including instrument calibration), test setup and tracer injection, and tracer monitoring are described in the following sections.

3.1 INSTRUMENT CALIBRATION

TempHion ion-specific electrodes (Br^- probes), manufactured by Instrumentation Northwest or similar, will be used to monitor the Br tracer concentration during the tests. The raw signal output for the Br^- probes, in millivolts (mV), is related to the logarithm of Br concentration (log [Br]) based on the following linear relationship:

$$mV = m \times \log[Br] + b$$

where *m* and *b* are the slope and intercept of a plot of *mV* versus log[*Br*], respectively, and are derived from the instrument calibration plot.

Each Br^- probe will be calibrated in accordance with the manufacturer's directions. The reservoirs of the Br^- probes will be filled about one day before calibration to submerge the reference electrodes. Calibration standards will be purchased from the manufacturer or prepared by field staff. Calibration standard concentrations will be verified by laboratory analyses of the standards using EPA Method 300.0. The slope and intercept of the calibration plot for each Br^- probe will be used to convert the mV readings to Br concentrations in milligrams per liter (mg/L) or parts per million (ppm).

3.2 TEST SETUP AND TRACER INJECTION

Tracer dilution testing procedures are described below:

- An initial water level measurement will be collected after the piezometer is opened and allowed to equilibrate.
- The total open depth of the piezometer will be sounded, and if sediment is on the sounder, the depth of the sediment will be noted.
- Thin metal or fiberglass rods will be connected into one length that can be inserted into the total depth of the piezometer. The connected rods will form the support structure of the test assembly. Two lengths of ¼-inch polyethylene tubing will be attached to the rods. One tube will end near the bottom of the zone targeted for testing but at least 0.5 foot above the sounded bottom of the piezometer or depth of sediment detected in the piezometer. The other tube will end approximately at the

top of the zone targeted for testing. The distance between the pump intake and discharge comprises the test interval for the test. A Br^- probe will be attached to the rod at the approximate midpoint of the test interval. The entire test assembly will be lowered into the piezometer. The tube ending at the bottom of the test interval (extraction end) will be connected to the intake of the primary peristaltic pump, and the tube ending at the top of the test interval (injection end) will be connected to the effluent of the main tubing of the injection/sampling manifold. Another length of ¼ inch polyethylene tubing will be used to connect the effluent of the primary peristaltic pump and the influent of the main tubing of the injection/sampling manifold, closing the recirculation loop. Additional information on the proposed setup, including the assembly of the injection/sampling manifold, is provided as Figure A1. Additional information on piezometer test intervals is provided in Table A1.

- The primary pump will be operated such that groundwater will be extracted from near the bottom of the piezometer screen and injected at a flow rate of approximately 800 milliliters per minute (mL/min). The primary pump will be operated for approximately 20 minutes before the test begins. During this period, a minimum of 100 mL of groundwater will be collected in a laboratory-supplied unpreserved 500 mL polyethylene bottle to analyze for the background bromide concentration in groundwater using EPA Method 300.0. In addition, the Br^- probes will begin logging during this period. After 20 minutes, the background bromide concentration will be measured and recorded on the attached field form (Attachment B) in both voltage (in mV) and the corresponding concentration (in mg/L or ppm).
- The tracer injection solutions will be made before the start of each test by mixing a measured quantity of NaBr salt into a measured quantity of lab-prepared deionized water. The proper weight of NaBr salt will be used to achieve an initial Br concentration of approximately 200 to 500 mg/L in the test interval, with a target initial concentration of 250 mg/L. The calculated mass of NaBr salt required to achieve this target initial concentration in the piezometer is listed in Table A1.
- The bromide solution will then be injected via the one-way valve of the injection/sampling manifold using the secondary peristaltic pump. The solution will be injected at a rate of approximately 50 mL/min so that the entire piezometer-specific volume of solution (Table A1) is injected during the time it takes to circulate one test volume. The time of injection will be recorded on the field form (Attachment A).
- Beginning immediately after the injection period, the Br^- probe readings will be recorded (in mV and mg/L) on a timed basis. There are no specific standards for time intervals, but the general timing for probe readings is as follows: once every minute for the first 10 minutes, once every 5 minutes until the end of the first hour, once every 10 minutes until the end of the second hour, and once every 15 minutes until the end of test. The Tracer Dilution Testing Field Form in included as Attachment A.
- Once every 60 minutes, no more than 100 mL of groundwater will be collected in a laboratory-supplied unpreserved sample container by opening the sample port on the injection/sampling manifold and pinching the silicone tubing on the injection end of the main tubing. The sample collection time, volume, and probe reading at the

time of collection will be recorded. These samples will be submitted to a laboratory for analysis using EPA Method 300.0, and the results will be used as a quality control measure to generate a calibration curve for comparison of laboratory and field data.

- When the Br^- probe readings reach the background concentration, or the change in bromide concentration approaches approximately 0.1 ppm between each measurement interval, the primary peristaltic pump will be turned off and the test assembly can be removed from the piezometer.

3.3 TRACER MONITORING

The probe datalogger will be programmed to record Br^- readings once every minute for the duration of each test (minimum of 8 hours, or when the change in bromide concentrations approaches an asymptote). If dilution rates are relatively low and the site is secure, the probe may be left in the piezometer overnight after turning off the pump and downloading the data accumulated. The probe will not be disturbed during a test once it has been set in the piezometer. At the end of the tracer dilution test, the concentration versus time data will be downloaded from the datalogger, and the probe will be removed from the piezometer.

All-new polyethylene and silicone tubing will be used for the test. All tracer test equipment, including support structure rods, the Br^- probe, and cables, will be cleaned before the start of the test using a three-stage soap and water rinse.

4.0 DATA EVALUATION AND ANALYSIS

Data will be evaluated using the simplifying assumptions that the water-bearing formation is homogeneous and isotropic through the test interval and that dilution of the tracer over time is dominated by horizontal groundwater flow through the piezometer (Hall, 1993).

4.1 CALCULATION OF GROUNDWATER VELOCITY

The rate of groundwater flow through the piezometer screen (Q) will be calculated directly from the tracer dilution rate using the assumptions outlined above. The tracer dilution rate is directly related to Q and inversely related to the volume of the test interval (V), as described below (Hall, 1993):

$$dC/dt = -\left(Q/V\right) \bullet C(t) \qquad (1)$$

where $C(t)$ is the tracer concentration at an elapsed time (t).

Assuming the tracer is well mixed within the test interval (i.e., the piezometer screen interval) to give the initial tracer concentration (C_0), Q can be obtained by integrating Equation 1 from time t = 0 to an elapsed time t, where C_0 decreases to a concentration C over the time interval of the test (t) as shown below (Hall, 1993):

$$Q = -\left(\frac{V}{t}\right)\ln\left(\frac{C}{C_0}\right) \qquad (2)$$

Q is obtained graphically by plotting the natural logarithm of the tracer concentration versus time (*ln C* vs. *t*). The initial concentration (C_0) can be calculated from the *y*-intercept of the plot, and Q/V can be obtained from the slope by rearranging Equation 2 as follows:

$$\ln(C) = -\left(\frac{Q}{V}\right)t + \ln(C_0) \qquad (3)$$

The groundwater pore velocity (v) through the formation of the test interval is calculated using Equation 4 by dividing flow through the piezometer (Q) by the cross-sectional area of the test interval (A; piezometer diameter multiplied by length of test interval), a correction factor (α; assumed to be equal to 2, based on Hall, 1993), and the effective porosity of the subsurface (n):

$$v = Q/(nA\alpha) \qquad (4)$$

Substituting Equation 3 into Equation 4 yields Equation 5:

$$v = \frac{-m\pi r}{2n\alpha} \qquad (5)$$

where m is the slope of the *ln C* versus t plot, and r is the radius of the piezometer.

4.2 CALCULATION OF GROUNDWATER FLUX

The flow rate through the piezometer (Q) may be used to calculate the groundwater flux (Qf) through the formation of the test interval using Equation 6, dividing by the cross-sectional area of the test interval (A) and an assumed correction for flow convergence at the piezometer (α), assumed to be equal to 2, based on Hall (1993):

$$Q_f = \frac{Q}{A\alpha} \qquad (6)$$

Substituting Equation 3 into Equation 6 yields Equation 7:

$$Q_f = -\frac{m\pi r}{2\alpha} \qquad (7)$$

where m is the slope of the *ln* C versus t plot, and r is the radius of the piezometer.

5.0 REFERENCES

Halevy, E., Moser, H., Zellhofer, O., and Zuber, A., 1967. Borehole dilution techniques: A critical review: in Proceedings of Isotopes in Hydrology Symposium, International Atomic Energy Agency, Vienna, pp. 531-564.

Hall, S.H., 1993. Single well tracer tests in aquifer characterization, Ground Water Monitoring and Remediation, vol. 13, no. 2, pp. 118-124.

TABLE

TABLE A1

PRELIMINARY CIRCULATION RATES AND MASS OF TRACER INJECTION

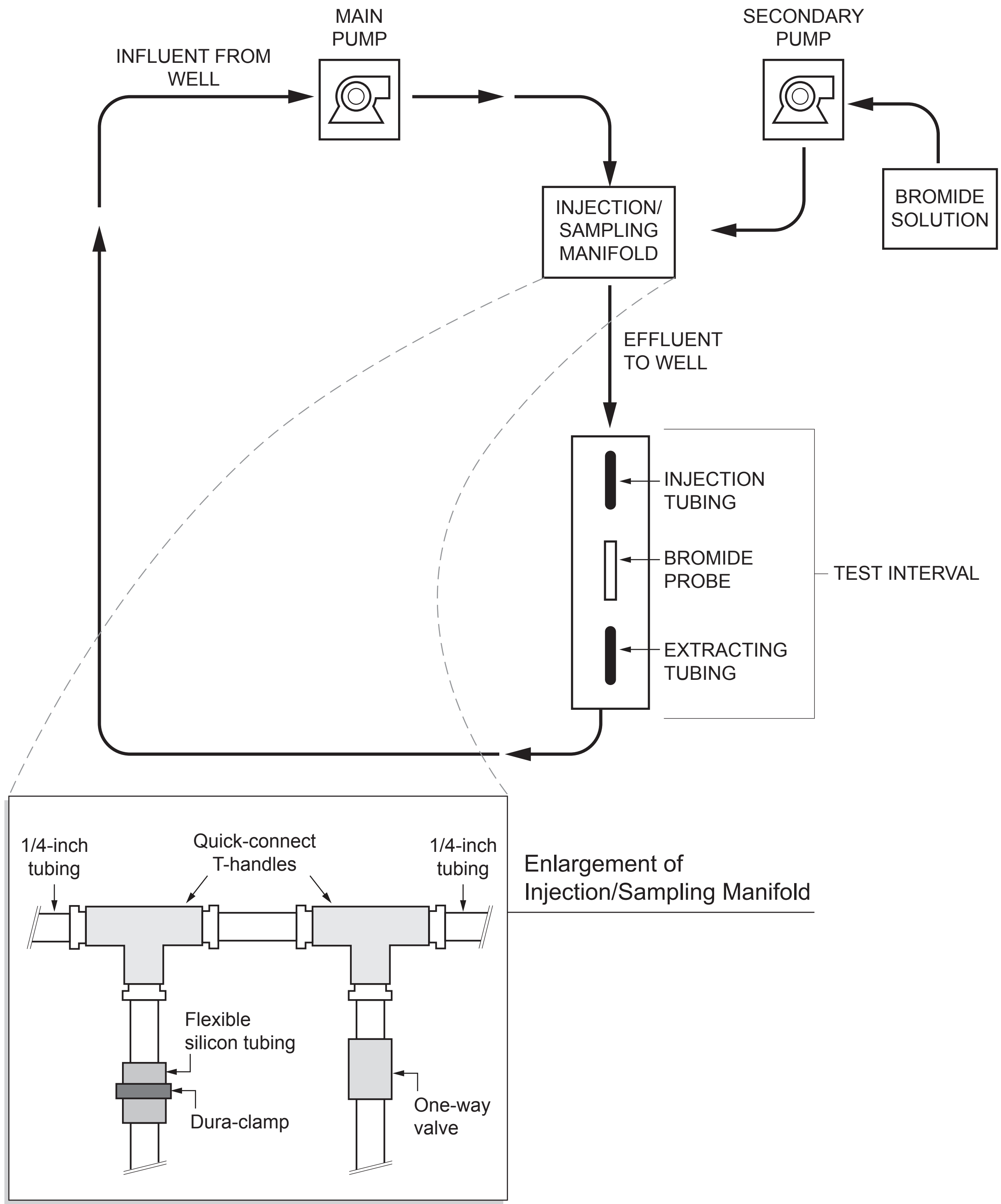
Crown Chevrolet Cadillac Isuzu
7544 Dublin Boulevard
Dublin, California

Approximate Piezometer Construction[1] and Testing Measurements	
Depth to Top of Screen (feet bmp)	15
Depth to Bottom of Screen (feet bmp)	20
Depth of Well (feet bmp)	21
Depth to Water (feet bmp)	15
Casing Diameter (inch)	2.07
Pump Intake Setting (feet bmp)	20
Return Flow Setting (feet bmp)	15
Length of Test Interval or Zone of Circulation (feet)	5
Probe Depth (feet bmp)	17.5
Volume in Test Interval (L)	3.3
Recirculation Pumping Rate (Lpm)	0.8
Time for Recirculation of one Test Interval at Recirculation Pumping Rate (minutes)	4.1
Volume of Injection Solution at an Injection Rate of 0.05 Lpm (L)	0.21
Mass of Sodium Bromide for Target Initial Concentration of 250 mg/L Br^- (grams) [2]	1.06

Notes
1. The piezometer construction is hypothetical, in order to estimate tracer requirements.
2. 1.29 grams of sodium bromide = 1 gram of the bromide ion.

Abbreviations
Br^- = bromide ion
feet bmp = feet below measuring point
ft MSL = feet above Mean Sea Level
L = liter
Lpm = liters per minute
mg/L = milligrams per liter

FIGURE



SCHEMATIC OF TRACER DILUTION TEST SETUP
Standard Procedures for Tracer Dilution Testing

By: GFS	Date: 03/21/2014	Project No.	OD10160070
amec		Figure	1

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ATTACHMENT A

Tracer Dilution Testing Field Form

Tracer Dilution Testing Field Form

Well ID: ________________________

Project and Task No.:________________

Project Name: Crown Chevrolet____________________

Date: ____

Br Dilution Starting Time:________________________

Circulation rate: ________________________________

Injection Rate: _________________________________

Injection Fluid Volume: ___________________________

Probe Serial Number: _____________________________

Total Depth (ft bmp): __________________________

Groundwater Depth (ft bmp):____________________

Pump Intake Depth (ft bmp):_____________________

Injection Depth (ft bmp):_______________________

Depth of Probe (ft bmp):_______________________

Well Diameter (inches):________________________

Volume of Test Interval (gal):_____________________

Time	Water Level (ft bmp)	Br (mg/L)	Br (mV)	Water Level (ft bmp)	Remarks (sample collection time, general observations)

Abbreviations
- ft = feet
- bmp = below measuring point
- gal= gallons