## Nevada Division of Environmental Protection

# Proposed Plan for Cleanup of Groundwater

# Maryland Square PCE Site

### Las Vegas, Nevada

The **Nevada Division of Environmental Protection (NDEP)** is the lead agency providing regulatory oversight for the investigation and cleanup of contaminated sites in Nevada. As part of the process for cleanup of large-scale sites, the NDEP prepares a **Proposed Plan**, consistent with the process followed by the U.S. Environmental Protection Agency (USEPA). This **Proposed Plan** describes the proposed cleanup of contaminated groundwater to protect people and the environment at the **Maryland Square Tetrachloroethylene (PCE) Site**, located in Clark County, Nevada (Figure 1).

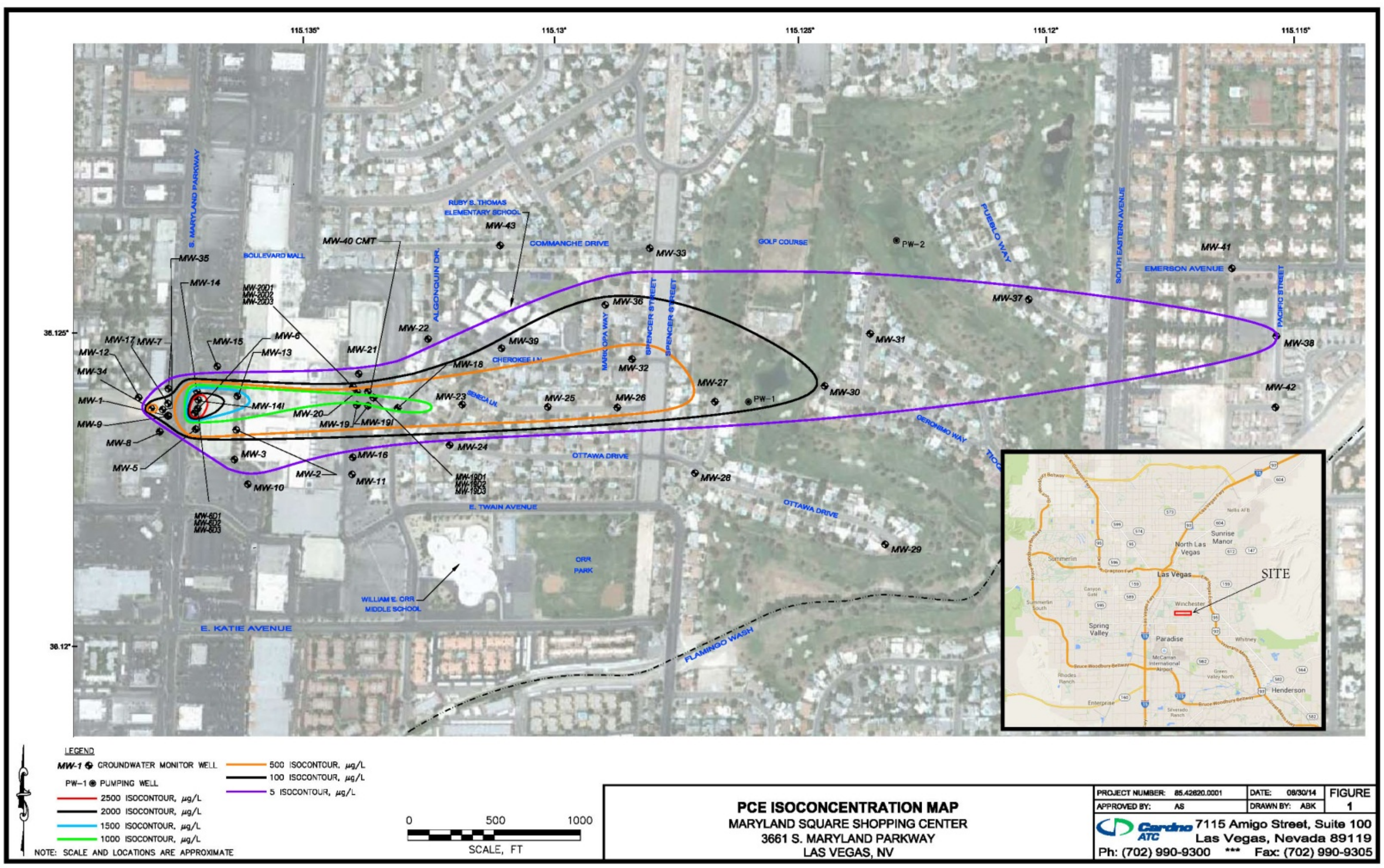
This **Proposed Plan** presents the **Preferred Alternative** for cleanup of contaminated groundwater at the **Maryland Square PCE Site** and summarizes other alternatives that were evaluated. The **Proposed Plan** also provides information on public participation, including a public meeting. Members of the public are encouraged to attend the public meeting and to review and comment on the remedy proposed for the cleanup of groundwater at the **Maryland Square PCE Site**.

## PROPOSED PLAN AT A GLANCE

### Statement of the Problem

A former dry cleaner in the former Maryland Square Shopping Center at 3661 S. Maryland Parkway operated from 1969 to 2000. PCE spilled inside the dry cleaners contaminated the soil and migrated into the shallow groundwater. After reaching groundwater, the PCE was transported offsite, forming what is known as a "plume" in the groundwater. This PCE plume extends approximately 6,000 feet downgradient from the source area at the former dry cleaner, and runs beneath the Boulevard Mall and a portion of the residential neighborhood east of the Mall (Figure 1).

**Figure 1. Location Map and Estimated Contours of the Maryland Square PCE Plume in Groundwater**

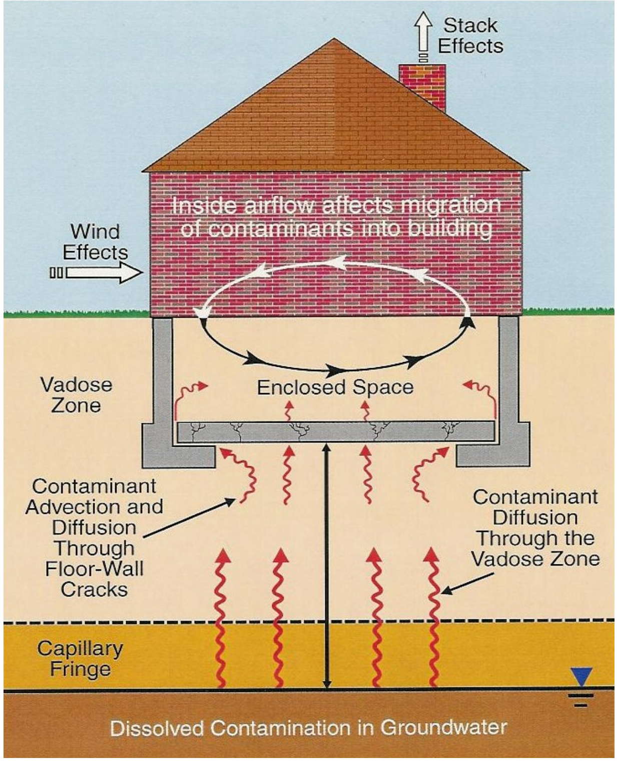


## PCE and Vapor Intrusion

PCE belongs to a group of chemicals known as "volatile organic compounds" (VOCs). As the PCE volatilizes (evaporates) from groundwater, the vapors fill pore spaces in the subsurface soil. PCE vapors in the soil can then migrate upward and into buildings. This process is known as "**vapor intrusion**" (Figure 2)

The health concern at the Maryland Square PCE Site is the migration of PCE vapors from the contaminated groundwater and up into homes overlying the PCE plume. These vapors can accumulate in the homes, where residents are exposed to PCE by inhalation of the contaminated indoor air. Testing of indoor air in the homes began in 2007, and mitigation systems have been offered to homeowners in cases where the concentrations of PCE exceed the NDEP's interim-action level for residential indoor air. Mitigation systems provide a short-term solution by intercepting the vapors before they can enter the home; however, the long-term solution is cleanup of the PCE-contaminated groundwater.

**Figure 2. The vapor intrusion process**




## Proposed Remedy for Cleanup of Groundwater

The NDEP proposes to prevent continued migration of the PCE-contaminated groundwater and to clean up the contamination using several types of remediation technologies. To prevent further migration of PCE into the neighborhood, the NDEP proposes construction of a groundwater extraction and treatment system (also known as a "pump and treat" system) for **hydraulic containment** of the PCE plume upgradient of the residential neighborhood. The main mass of PCE remains beneath Maryland Parkway and a portion of the western parking lot at the Boulevard Mall. To destroy this mass, other cleanup technologies, such as "air sparging and vapor extraction" (AS/VE) and "in situ chemical oxidation" (ISCO) with re-circulation wells, are proposed for treatment of PCE-contaminated groundwater near Maryland Parkway. Treatment of the PCE mass west of the Boulevard Mall should decrease the length of time required for extraction and treatment of groundwater on the eastern side of the mall property.

## Your Comments on the Plan

The NDEP is providing this **Proposed Plan**, along with a **Proposed Plan Fact Sheet**, for public review and comment, and to encourage public involvement. You may provide comments on this **Proposed Plan** verbally during the public meeting on **November 19, 2014** (6:00 pm at the Winchester Cultural Center) or in writing any time during the 90-day review period, from **October 15, 2014 through January 13, 2015**.

Although this is not a "Superfund" site, the NDEP is issuing this **Proposed Plan** as part of its community involvement program, consistent with requirements of the December 2010 Permanent Injunction issued by the US District Court and Section 117(a) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, commonly known as Superfund). This Plan is also consistent with Sections 300.430(f) and 300.435(c) of the National Oil and Hazardous Substances Pollution Contingency Plan and Nevada Administrative Code 445A.22755, which describe holding a meeting to obtain public input on a proposed cleanup.

This **Proposed Plan** summarizes information that can be found in greater detail in the case file and Administrative Record for the Site. The Administrative Record is available in hard copy in the Carson City office of the NDEP and on-line at: http://ndep.nv.gov/pce/maryland_square.htm

**What is PCE?** The contaminant of concern is perchloroethylene, also known as tetracholoroethylene, tetrachloroethene, perchloroethene, “perc”, or PCE. It is a colorless, nonflammable liquid that does not occur naturally. PCE is a solvent and degreaser used by dry cleaners to clean fabrics. PCE is also found in some common consumer products, such as glues and spot cleaners.

**Public Comment Period**

The public comment period runs for **90 days**, from **October 15, 2014** through **January 13, 2015**.

**Community Meeting**

A public meeting will be held on **November 19, 2014** at **6:00 pm** at the **Winchester Cultural Center**, 3130 McLeod Drive. The purpose of this meeting is to give the community the opportunity to ask questions and provide comment regarding the proposed cleanup program. In addition to the public meeting, the public is invited to send their comments via letters, faxes, and e-mails to the NDEP.

**Regulatory Authority**

This Proposed Plan was developed in accordance with Nevada Revised Statute 445A and in a manner consistent with Federal requirements under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or “Superfund”) and the National Contingency Plan by the USEPA.

**Contents of the Proposed Plan**



**Glossary of Some Technical Terms**

**AS/VE** means “air sparge and vapor extraction”
**CERCLA** means “Superfund”
**In situ** means “in place”
**ISCO** is “in situ chemical oxidation,” and involves injection of oxidant solutions into the ground to oxidize (and, thereby, destroy) contaminants
**µg/L** means “micrograms per liter” (also taken as “parts per billion” [ppb])
**µg/m3** means “micrograms per cubic meter” and is a measure of the concentration of a chemical vapor in air
**ROD** means “Record of Decision” which documents the selected remedy
**USEPA** means the “United States Environmental Protection Agency”
**VOC** means “volatile organic compound”

# I. SITE BACKGROUND

## Site Location and Description

The Maryland Square PCE Site includes contaminated soil and groundwater at the site of the former dry cleaners, as well as an offsite plume of PCE-contaminated groundwater. The dry-cleaning solvent, PCE, is also known as perc, perchloroethylene, perchloroethene or tetrachloroethene. The source of the PCE contamination was the former Al Phillips the Cleaner, which was located in the former Maryland Square Shopping Center at 3661 S. Maryland Parkway, Las Vegas, Nevada. The former shopping center was located on the northwest corner of Maryland Parkway and East Twain Avenue. This parcel (APN 162-15-602-004) lies across the street from the Boulevard Mall, Clark County, Nevada.

The dry cleaner operated at the Maryland Square site from 1969 through 2000. The exact dates of all spills are not known; however, at least one major spill in 1982 was estimated at 100 gallons of PCE, and some minor spills have been described by former workers at the former dry cleaners. The shopping center was demolished in mid-2006. Following cleanup of the source area by the excavation and removal of PCE-contaminated soils in the fall of 2011, the property was re-graded and is currently an empty dirt lot.

## Site Geology and Hydrogeology

The site is located in the Las Vegas Valley in southern Nevada. The Las Vegas Valley currently receives an average annual precipitation of only 4.16 inches. Shallow, non-potable groundwater is generally encountered at a depth of 12 to 25 feet across the length of the Maryland Square PCE plume. This shallow groundwater is of poor quality and is **not** used as a source of drinking water. The shallow groundwater in the area flows in an easterly direction, transporting the PCE eastward to form a cigar-shaped plume of contaminated groundwater that is approximately 6,000 feet long.

The Las Vegas Valley is filled with sediments eroded from the mountains surrounding the valley. The layers of sediments filling the basin were deposited on broad alluvial fans. Shallow groundwater flows through these layered sediments. Aquifer tests performed on the Mall property indicated that that the average rate of groundwater flow ranges from 2.1 to 4.2 feet per day. These tests also indicated that vertical permeability is nearly 100 times lower than the horizontal permeability at the site, which means that the contaminated groundwater flows horizontally more easily than vertically.

**Chemistry and Behavior of PCE:** The high density and low viscosity of PCE allow it to readily migrate through unsealed concrete, as noted in a guidance document issued by the Colorado Department of Public Health and Environment (CDPHE) for remediation of dry cleaner sites. "*The chemical properties of PCE are such that in liquid form it can readily migrate through unsealed concrete floors and concrete or asphalt parking lots. Thus, even if spills or leaks of the liquid PCE appear to be "captured or contained" by a hard surface, the chemical is actually moving into, and rather quickly through, the hard floor or pavement and entering the environment. The same properties that allow PCE to migrate through concrete floors also allow PCE to migrate rapidly through soil and rock once it is in the natural environment*" (Dry Cleaner Remediation Guidance Document, CDPHE 2006).

## Chemistry of Shallow Groundwater

The contaminant plume contains PCE with only trace amounts (generally less than 1%) of the degradation (breakdown) products, trichloroethylene (TCE), cis-1,2-dichloroethylene (DCE), and vinyl chloride (VC). Slightly greater percentages of TCE have been measured in some wells just east of the source area.

Conditions in the shallow groundwater indicate an aerobic (oxygenated) environment, with high concentrations of sulfate. These conditions do not promote natural biodegradation of the PCE. Additionally TCE, DCE and VC have not been detected in wells at the eastern end of the plume. The small amount of organic matter in the soils (typical of soils in desert environments), does not significantly slow the migration of the PCE in groundwater. Together, these factors have allowed the PCE plume to migrate more than a mile offsite, even though the bulk of contaminant mass appears to still reside near Maryland Parkway, just downgradient from the source area at the former dry cleaners.

## Deep Groundwater in the Las Vegas Valley

Municipal sources of drinking water come from pumping of the deep aquifer and from Lake Mead. Wells pumping the deep aquifer typically withdraw water from depths of hundreds of feet. Drilling on mall property indicated the base of the PCE plume is only about 80 feet deep. Municipal wells and drinking water are routinely monitored, and there is **no** evidence that the PCE has caused widespread contamination of the deep aquifer.

## PCE in Soil Gas

Samples of soil gas collected at multiple depths at several locations across the plume showed concentrations of PCE as high as 170,000 micrograms per cubic meter ($\mu g/m^3$) on mall property and as much as 46,000 $\mu g/m^3$ in shallow soil gas within the residential neighborhood. The NDEP performed vapor-transport monitoring using the data from soil-gas samples. The results from NDEP's modeling, along with toxicity information from the USEPA, prompted the NDEP to offer indoor air sampling to residents whose homes were potentially affected by PCE vapors emanating from groundwater.

## PCE in Indoor Air

Based on data collected in more than 97 homes, elevated concentrations of PCE vapors in indoor air appear restricted to homes overlying or adjacent to the 100 µg/L boundary for PCE in groundwater. Annual indoor air sampling is being offered to owners of these homes. If PCE concentrations measured in any home exceed the NDEP's interim-action level of 32 $\mu g/m^3$, a mitigation system is offered at no charge to the home owner.

**What are the Uses and Effects of PCE?**
The contaminant of concern is perchloroethylene, also known as tetracholoroethylene, tetrachloroethene, "perc", or PCE. It is a colorless, nonflammable liquid that does not occur naturally. PCE is a solvent/degreaser used by dry cleaners to clean fabrics, and is also found in some common household products, such a glues, spot cleaners, brake parts cleaners, and some spray polishes.
In December, 2012, the USEPA revised its hazard summary for PCE. See: http://www.epa.gov/ttn/atw/hlthef/tet-ethy.html

# II. HISTORY OF SITE INVESTIGATIONS

The following text provides a brief chronology of the investigations conducted for the Maryland Square PCE Site. The complete administrative record is available for review by the public at the Carson City offices of the NDEP and on-line at http://ndep.nv.gov/pce/maryland_square.htm .

**November 29, 2000**

The PCE found at the site of the former dry cleaner was first reported to NDEP's spill reporting hotline on November 29, 2000. The historical release was discovered during a routine environmental site assessment performed as part of a property transaction. Results from the investigation were submitted to the NDEP on July 21, 2001. After reviewing the report, NDEP determined that more investigation was required to evaluate whether the PCE had migrated offsite.

**2001 to 2004**

In 2001, the property owner began investigation of soil and groundwater at the site of the former dry cleaner. A 2002 report provided data showing PCE-contaminated soils below the concrete slab of the former dry cleaning shop. Additional monitoring wells provided data for groundwater directly downgradient (east) of the dry cleaners.

A report released in May, documented the highest concentration of PCE in a new well (MW-13) downgradient from the dry cleaners and east of S. Maryland Pkwy. This 2003 report concluded that "*Based on the information provided in this report and previous reports, it appears that the source of the PCE contamination originates at the Al Phillips The Cleaners, Inc.'s dry cleaning facility*." Wells installed in 2003 and 2004, failed to find the eastern boundary of the plume.

**2005 to 2008**

In March, 2005, five new monitoring wells were installed in the Paradise Palms neighborhood, and results were provided in a July 2005 report. This 2005 report presented the first data showing that the PCE plume had migrated more than 2,000 feet east of the source area and extended beneath the residential neighborhood east of Boulevard Mall. The NDEP then required the responsible party to submit a Corrective Action Plan for the cleanup of soil and groundwater. In April 2006, more wells were installed farther to the east. Groundwater samples from these new wells indicated that the Maryland Square PCE plume was atypically long, compared with other PCE sites in Las Vegas. By the end of 2006, it was apparent that the PCE plume extended at least several thousand feet downgradient from the source area.

In early 2007, a detailed investigation of source area soils was completed, along with an initial assessment of PCE vapors in soil gas overlying the PCE plume in groundwater. Based on data for groundwater and soil gas and the results from the NDEP's modeling of the PCE concentrations in soil gas samples, the NDEP determined that action was needed to further evaluate the potential for intrusion of PCE vapors into the homes overlying the PCE-contaminated groundwater.

The NDEP moved forward with a plan to perform indoor air sampling of homes in the Paradise Palms neighborhood. In August 2007, the NDEP mailed notification letters and information packets to approximately 150 residents and property owners, and a press release was issued. Staff from the NDEP met with residents in their homes for personal meetings to answer questions, provide information, and obtain permission to sample the indoor air at the residence.

With permission of the residents, contractors working for the NDEP collected samples of indoor air from homes, following general USEPA guidelines for sampling indoor air at vapor intrusion sites. The NDEP sent sample results to each resident whose home was sampled. Representatives from the NDEP met with all interested homeowners to discuss their sample results and answer their questions. Ultimately, indoor air was tested in 97 homes and two schools. Home mitigation systems were installed in 14 homes in 2008, at no cost to the home owners.

**2009 to 2012**

On May 4, 2009, the NDEP filed a complaint in U.S. District Court against the former owners and operators of the facility. On December 27, 2010, U.S. District Court issued a Permanent Injunction against the former owners and operators of the facility. The injunction established the schedule for remediation of PCE-contaminated soil and groundwater at the site. It also decreed that groundwater monitoring should continue based on the schedule previously defined by the NDEP, and that testing of indoor air should be offered annually to potentially affected homeowners.

In the fall of 2011, source-area soil contaminated with PCE was excavated and properly disposed of offsite in a permitted waste-disposal facility. The floor of the source-area excavation, which extended down to the water table at about 18 feet deep, was treated with the chemical oxidant, potassium permanganate ($KMnO_4$) to promote chemical destruction of residual PCE prior to backfilling. The excavation was backfilled with clean soil and re-grading of the site was completed in late October, 2011.

**2013 and 2014**

The vertical extent of the PCE-contaminated groundwater was established by drilling deeper borings as deep as 120 feet on the Boulevard Mall property, directly downgradient from the former dry cleaners. Groundwater data collected from deep borings and wells indicated that concentrations of PCE taper off below about 70 feet, reaching largely nondetectable levels by about 80 feet. Data from samples collected at different depths indicate that the PCE plume is largely constrained to the upper 60 feet of groundwater. This shallow groundwater is not used for drinking water.

Pilot testing of several cleanup technologies was performed in the eastern parking lot of the Boulevard Mall, just upgradient of the residential neighborhood. The testing focused on injection of two types of oxidants: potassium permanganate and peroxide-activated ozone, for ISCO to clean up groundwater. Although results were initially promising, data collected from 3 to 12 months after the injections appeared to show that PCE-contaminated groundwater had been displaced into previously clean areas. These results suggested that any cleanup technology involving injection of treatment chemicals must be paired with groundwater withdrawal to minimize the displacement of contaminated groundwater.

By 2014, new wells delineated the eastern end of the plume, approximately 6,000 feet downgradient from the source at the former dry cleaners. The cigar-shaped plume of PCE-contaminated groundwater is from 400 to about 1,000 feet wide. The shape of the plume is consistent with a single source at the site of the former dry cleaners in the former Maryland Square Shopping Center. The plume terminates at the 5 microgram per liter (µg/L) boundary about 1,000 feet east of Eastern Avenue.

Determining the shape and size of a contaminant plume in groundwater is a methodical step-by-step process that requires installing a series of borings and monitoring wells. Samples of groundwater collected from the wells are analyzed to determine if the contaminant is present at that well location. This process is followed by the installation of additional wells in the direction of groundwater flow, until the extent of the plume is defined. The history of wells installed across the site is shown at: http://ndep.nv.gov/pce/graphic/2012_Map_Well_History.pdf .

## III. SCOPE AND ROLE OF RESPONSE ACTION

The remediation of groundwater follows the initial interim actions performed by the NDEP; these actions included testing of indoor air in residences overlying the contaminated groundwater and the installation of home mitigation systems in those homes found to be adversely affected by intrusion of PCE vapors. The proposed remediation of groundwater also follows cleanup of the source-area soils at the site of the former dry cleaners.

Cleanup of groundwater is needed to decrease concentrations of PCE in groundwater to a level that is protective of indoor air, at which point the home mitigation systems will no longer be needed to protect human health from contaminant vapors. Cleanup actions are also intended to prevent further degradation of groundwater quality.

## IV. SUMMARY OF SITE RISKS

Exposure to contaminants at the Maryland Square PCE Site occurs through inhalation of contaminant vapors that have accumulated in homes via the vapor intrusion pathway. The contaminant vapors emanate from the contaminated groundwater. PCE is the main chemical of concern at the site; however, degradation products and impurities in the original dry cleaning solvent may include TCE, DCE, and vinyl chloride.

The contaminant plume is contained in the shallow groundwater system, which is underlain by hundreds of feet of layered sediments, including a thick sequence of low-permeability clays. These layers provide a barrier to vertical migration of contaminated groundwater, which protects the drinking-water aquifer. Municipal drinking water is not affected by this contamination.

A screening-level human health risk assessment was performed for the Maryland Square PCE Site. The work was consistent with the Risk Assessment Guidance for Superfund (USEPA, 1989), and included four basic steps: (1) data evaluation and identification of contaminants of potential concern, (2) exposure assessment, (3) toxicity assessment, and (4) risk and hazard characterization.

The risk estimate used data from indoor air samples collected at houses in the residential neighborhood. The chemicals evaluated in the screening-level human health risk assessment included PCE, TCE, and vinyl chloride. Each house was evaluated as an individual "exposure unit," meaning that exposures were considered separately for each home, rather than averaging the risk.

In late 2012, the USEPA released the new toxicity assessment for PCE. The USEPA's new toxicity factors found that PCE is slightly less toxic from a carcinogenic perspective, but more toxic than previously believed for non-carcinogenic effects, which are mainly neurological effects. The greatest carcinogenic risk at the Maryland Square PCE Site was estimated to be 3 per 100,000 excess cancers due to long-term exposure to PCE by inhalation of contaminated indoor air. The greatest noncarcinogenic hazard index was estimated to be 2.6 times greater than acceptable levels.

Some private wells screened in the shallow groundwater system were indicated in some areas east of Eastern Avenue, according to online records in the Nevada Division of Water Resources database. For this reason, it was necessary to delineate the eastern end of the plume to the 5 µg/L drinking water standard for PCE. According to records at the Nevada Division of Water Resources, there are no private wells within the 5 µg/L boundary of the PCE plume.

# V. REMEDIAL ACTION OBJECTIVES

The overall objective of the groundwater cleanup is to protect human health and the environment by reducing concentrations of PCE in groundwater and minimizing exposure of receptors to affected media. This objective requires the development and implementation of suitable and effective cleanup technologies. Until the cleanup of groundwater is achieved, interim actions (i.e., home mitigation systems) will continue. To accomplish the overall objective, the following goals (Figure 3) have been established:

1. Protect human health by reducing inhalation exposure to PCE and daughter products emanating from groundwater and ensuring that concentrations of PCE in indoor air are less than the long-term goals of 9.4 $\mu g/m^3$ for PCE and 2.0 $\mu g/m^3$ for TCE.
2. Remediate shallow groundwater where PCE concentrations exceed the remediation standard for groundwater protective of indoor air (100 µg/L).
3. Execute appropriate action to ensure PCE does not exceed water quality standard of 5 µg/L as defined in NAC 445A.22735 in domestic water supply wells, and to protect water quality from further degradation.

# VI. SUMMARY OF REMEDIAL ALTERNATIVES

Remedies were developed to address shallow groundwater contaminated with the dry cleaning chemical, PCE. The NDEP evaluated five remedial alternatives.

**Alternative 1** – No Further Action Alternative

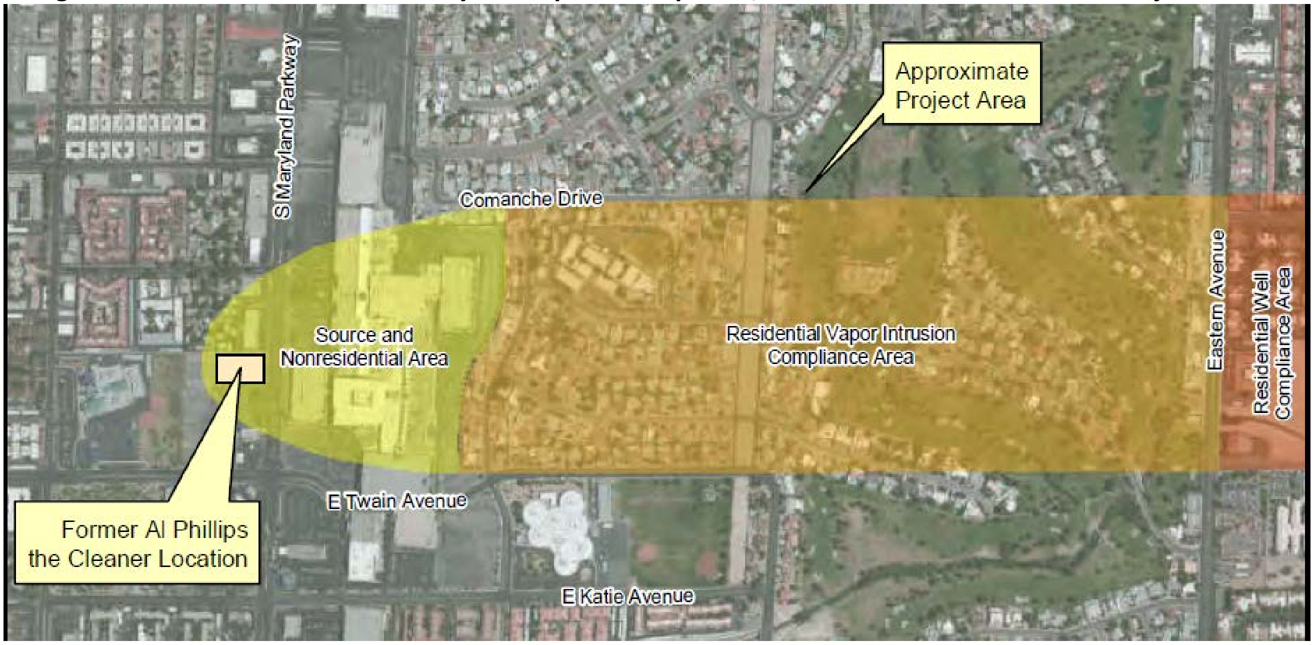
**Alternative 2** – Enhanced Bioremediation for In Situ Treatment of Target Areas

**Alternative 3** – Permeable Reactive Barrier (PRB) using Zero-Valent Iron (ZVI)

**Alternative 4** – In Situ Chemical Oxidation (ISCO) of Entire Plume

**Alternative 5 (Preferred Alternative)** – Groundwater Extraction and Treatment (Eastern Parking Lot), with Air Sparging and Vapor Extraction (AS/VE) and/or ISCO with Re-circulation of Groundwater or other technologies (Western Parking Lot)

**Figure 3. General areas of the Maryland Square PCE plume, as related to remedial action objectives**




## Common Elements

All of the alternatives require maintaining the protective elements already in place at the Site until groundwater cleanup levels are achieved. These common elements include long-term monitoring of groundwater and indoor air to monitor contaminant concentrations across the site. Another common element is the use of institutional controls to prevent installation of drinking water or irrigation wells within the footprint of the PCE plume. Additionally, all alternatives require maintenance of home mitigation systems (such as system adjustment and fan replacement), along with annual testing of indoor air for homes located on or within the estimated 100 µg/L boundary of the plume

All of the remedial alternatives would require a five-year review. The five-year reviews of the remedy would be conducted until the performance standards for groundwater and indoor air are achieved. If the indoor air goal is achieved but the remediation goal is not, the 100 µg/L goal for the concentration PCE in groundwater may be revised upward as long as protection of indoor air is well demonstrated and well documented.

# VII. EVALUATION OF REMEDIAL ALTERNATIVES

The evaluation of each alternative is used as a method to compare and contrast the remedial alternatives and assess the advantages and disadvantages of each by looking at a number of important factors. The expectations for remedy selection are listed in the ***Code of Federal Regulations*** at ***40 CFR § 300.430 (a)(1)(iii).***

**Threshold criteria** are requirements that each alternative must meet in order to be eligible for further evaluation and selection. **Primary balancing criteria** are used to weigh major trade-offs among alternatives. In the final balancing of trade-offs between alternatives, the **modifying criterion** (community acceptance) is of equal importance to the **primary balancing criteria**. In this Proposed Plan, each remedial alternative was evaluated according to the threshold and primary balancing criteria. Community acceptance will be evaluated after public comments are received on this Proposed Plan.

## Threshold Criteria

(1) ***Overall Protection of Human Health and the Environment*** – this criterion addresses how the alternative achieves and maintains protection of human health and the environment

(2) ***Compliance with Cleanup Standards*** – this criterion addresses how the alternative performs relative to water management objectives, requirements and water quality laws

## Primary Balancing Criteria

(3) ***Long-term Effectiveness and Permanence*** – this criterion addresses the long-term effectiveness of alternatives in maintaining protection of human health and the environment and their relative permanence. It is an assessment of how the system will perform years into the future.

(4) ***Reduction in Toxicity, Mobility, and Volume through Treatment*** – this criterion addresses the ability of the alternative to permanently or significantly reduce toxicity, mobility or volume of contaminants. It addresses the type and quantity of treatment residuals remaining at the site, and the degree to which treatment reduces the inherent hazards posed by principal threats at the site

(5) ***Short-term Effectiveness*** –this criterion addresses the impacts of the alternative during construction and implementation, until the project's initial objectives and goals are met. The criterion is also used as a measure of how quickly an alternative can meet remedial action objectives.

(6) ***Implementability*** – this criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of services and materials, including technical difficulties and unknowns associated with the construction and operation of a technology and the ability to monitor the effectiveness of the remedy

(7) ***Cost*** – this criterion addresses the capital and operations and maintenance costs of each alternative

## Modifying Criterion (evaluated after public comments are received)

(8) ***Community Acceptance*** – this criterion is evaluated after public comments are received. All comments received during the 60-day review period and at the public meeting (to be held during the review period), will be addressed and included in the "Responsiveness Summary" in the Record of Decision (ROD), which will document the selected remedy.

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### Alternative 1: No Further Action

*Estimated Cost: $0*
*Estimated Annual Cost: $0*
*Estimated Present Worth Cost: $0*
*Estimated Time to Completion: hundreds of years*

**Description of Alternative 1.** Under this alternative, no further actions would be taken to prevent exposure to the contaminated air and groundwater at the Site. Additionally, no action would be taken to clean up the groundwater.

**Threshold Criteria.** This alternative fails to meet the ***threshold criteria*** of protecting human health and achieving action levels for PCE in groundwater. This alternative was developed and retained as a baseline scenario to which the other alternatives may be compared. If concentrations of PCE in groundwater are not reduced and if migration of contaminated groundwater is not limited, then operation of home-mitigation systems must continue for the life of the plume, or residents will continue to be exposed via vapor intrusion. Untreated, the PCE plume at this site could persist for centuries.

The contaminated groundwater is currently posing a potential health risk to residents in the neighborhood, and the greatest mass of PCE still remains in groundwater upgradient of the neighborhood. A stable or expanding plume, along with the continued migration of PCE-contaminated groundwater into the neighborhood, has the potential to continue or extend vapor exposure risk to residential receptors. For these reasons, the alternative of "no further action" is not acceptable at this site. The remaining four alternatives were evaluated against threshold and primary balancing criteria.

## Threshold Criteria

**Overall Protection of Human Health and the Environment**

- Likelihood that the Alternative will Adequately Protect Human Health and the Environment

**Achievement of Action Levels**

- Likelihood that the Alternative will Achieve Cleanup Goals for all Media

## Primary Balancing Criteria

**Long-Term Effectiveness and Permanence**

- Expected Magnitude of Residual Risk
- Adequacy and Reliability of Controls

**Reduction of Toxicity, Mobility or Volume through Treatment**

- Treatment Process Used and Materials Treated
- Estimated Amount of Hazardous Materials Treated or Destroyed
- Expected Reduction in Toxicity, Mobility or Volume
- Degree to which Treatment is Irreversible
- Type and Quantity of Residual Contaminants Remaining after Treatment

**Short-Term Effectiveness**

- Protection of Community during Remedial Actions
- Protection of Workers during Remedial Actions
- Effects to the Environment
- Estimated Time until Remedial Action Objectives are Achieved

**Implementability**

- Ability to Construct and Operate the Technology
- Reliability of the Technology
- Ease of Undertaking other Technologies
- Ability to Monitor Effectiveness of Remedy
- Availability of Offsite Treatment & Disposal
- Availability of Equipment & Operators

**Cost**

- Estimated Capital Costs
- Estimated Annual O&M Costs
- Estimated Present-Worth Costs

## Modifying Criterion

**Community Acceptance**

- Features of the Remedial Alternative that the Community Supports
- Features of the Remedial Alternative about which the Community has Reservations
- Elements of the Remedial Alternative the Community Strongly Opposes

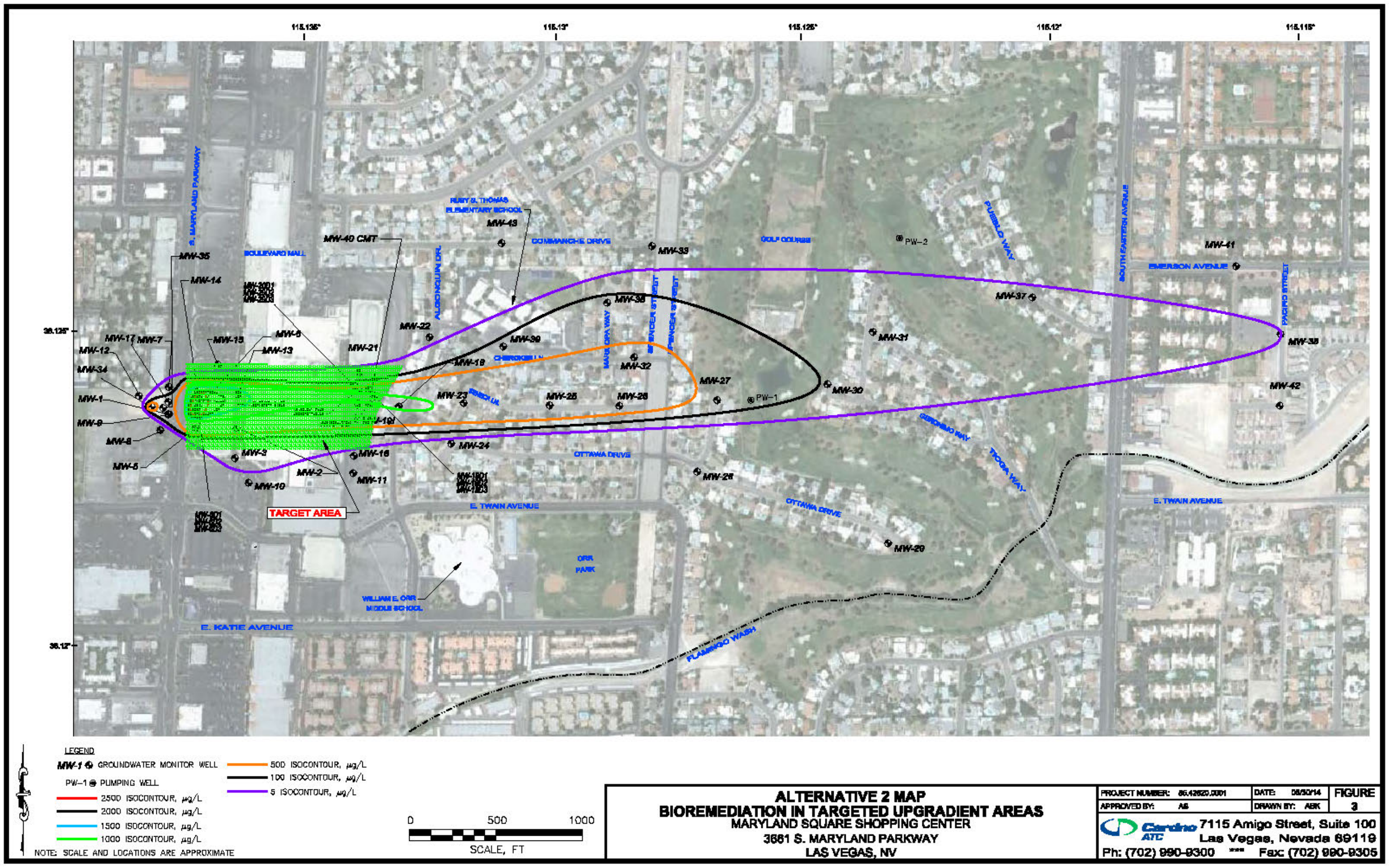
## Alternative 2: Enhanced Bioremediation for In Situ Treatment of Target Areas

*Estimated First-Year Cost: $600,000*
*Estimated Annual Cost: $450,000*
*Estimated Present Worth: $3,100,000to $5,300,000*
*Estimated Time to Completion: 10+ years*

**Description of Alternative 2**

Enhanced Bioremediation involves the establishment (and maintenance) of suitable geochemical conditions in groundwater necessary to sustain populations of bacteria that perform dechlorination of PCE under anaerobic conditions. (Such conditions may also establish abiotic dechlorination on mineral surfaces.) Anaerobic dechlorination by microbes is a step-wise process that progressively strips chlorine atoms from the carbon framework of PCE ($C_2Cl_4$) to form TCE ($C_2Cl_3H$), then DCE ($C_2Cl_2H_2$), then vinyl chloride ($C_2Cl_1H_3$), then ethene ($C_2CH_4$), and ultimately, carbon dioxide ($CO_2$). Figure 4 shows the treatment area for the in situ treatment using enhanced bioremediation.

**Figure 4. Map showing treatment area for Alternative 2, Enhanced Bioremediation**




To stimulate and enhance microbial activity, microorganisms and amendments are injected into groundwater. Amendments can also be injected where the bacteria necessary to degrade the contaminants are present but conditions do not favor their growth. Microorganisms can be injected when the bacteria necessary to degrade the contaminants do not occur naturally at a site or occur at too low of a population to be effective. This remedy would consist of drilling injection wells in selected treatment areas and injecting amendments and anaerobic bacteria to actively dechlorinate and degrade the PCE “in situ” in the groundwater.

**Threshold Criteria**. At sites where geochemical and lithologic characteristics are suitable, enhanced bioremediation has successfully remediated PCE to achieve action levels and protect human health.

**Long-term Effectiveness and Permanence**. The long-term effectiveness of this family of technologies is suspect because anaerobic conditions are not naturally present at the site, and such conditions would be difficult to induce and sustain. Implementation of this alternative would require creating and maintaining strongly reducing conditions in the groundwater so that dechlorinating microorganisms could thrive. Addition of a bacterial culture would likely be required to avoid long lag periods before such microbial populations could develop sufficiently. Bioreactors would have to deal with sulfide toxicity, whereby the waste products of the microorganisms eventually become toxic to the microbes themselves. This can eliminate or reduce all microbial activity or cause these microbes to be replaced by other bacteria that will not dechlorinate PCE.

**Reduction of Toxicity, Mobility or Volume**. A potential problem with anaerobic biodegradation is that the daughter products of PCE degradation (TCE, DCE, and vinyl chloride), are more toxic than PCE; therefore, this technology has the potential to increase toxicity due to incomplete degradation, even if the mass of PCE decreases. Additionally, sulfate reduction produces sulfide, which is toxic to the dechlorinating bacteria. The high concentrations of naturally occurring sulfate (as much as 3,700 mg/L) could possibly result in partial dechlorination of PCE. Partial biodegradation could produce increased concentrations of TCE, DCE or vinyl chloride in the groundwater.

**Short-term Effectiveness**. It is unknown if treatment could even temporarily create conditions that are sufficiently reducing to fully dechlorinate the PCE. As noted above, incomplete biotic dechlorination of PCE produces more-toxic compounds, such as TCE. Even if it were possible to overcome naturally occurring electron acceptors (including dissolved oxygen, nitrate, sulfate, and ferric iron) and create reducing conditions in groundwater, such reducing conditions would be difficult to maintain. As upgradient groundwater flowed into the treatment zone, the geochemistry in the treatment area would revert back to conditions that are not favorable for anaerobic biotic dechlorination.

**Implementation.** Enhanced bioremediation in targeted areas upgradient of the residential neighborhood would theoretically achieve threshold criteria; however, the geochemistry of shallow groundwater at the Maryland Square PCE Site is not conducive to biodegradation via anaerobic dechlorination. It is unknown if treatment could even temporarily create sufficiently reducing conditions to fully dechlorinate the PCE. Therefore, it is questionable that enhanced bioremediation could adequately protect human health or achieve cleanup levels for PCE in groundwater.

**Cost**. Cost for this type of technology is based on size and mass of the PCE plume; however, implementation may be logistically infeasible and costs may be more than $5,000,000.

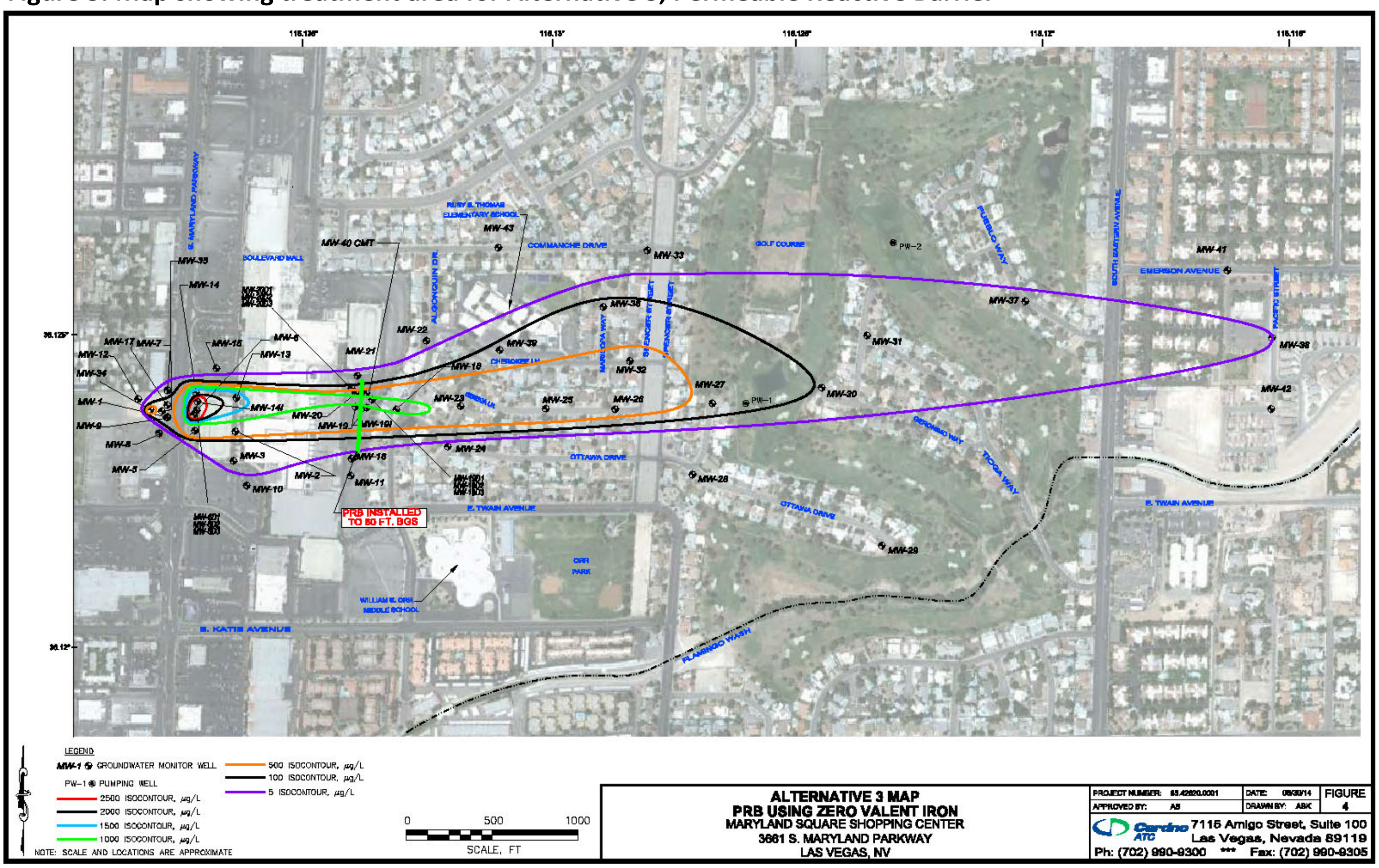
## Alternative 3: Permeable Reactive Barrier (PRB) using Zero-Valent Iron (ZVI)

*Estimated First-Year Cost: $1,500,000*
*Estimated Annual Cost: $600,000*
*Estimated Present Worth: $4,600,000 to $7,600,000*
*Estimated Time to Completion: 10+ years*

### Description of Alternative 3

A PRB is a constructed zone of reactive material that extends below the water table to passively intercept and treat contaminated groundwater. PRBs can be installed as permanent or semi-permanent units. The most commonly used PRB configuration is that of a continuous trench in which the treatment material is backfilled. The trench is perpendicular to and intersects the groundwater plume (Figure 5).

**Figure 5. Map showing treatment area for Alternative 3, Permeable Reactive Barrier**



Installation of PRBs at depths greater than 60 feet can be challenging. At the Maryland Square PCE Site, a north-south trench in the eastern parking lot of the Mall would need to extend to a depth of at least 80 feet below the ground surface. The primary determinant of degradation rate is the specific surface area of the PRB, or the surface area of iron per unit volume of pore water. The use of a passive PRB requires comprehensive hydrologic characterization, so that the design can be based on a thorough understanding of the heterogeneity of subsurface soils.

**Threshold Criteria**. PRBs using ZVI have been shown to be effective in intercepting and treating chlorinated VOC plumes at some sites, achieving action levels and protecting human health. Properly designed PRBs are permeable barriers that should have little effect on groundwater flow patterns. A PRB employing ZVI installed upgradient of the residential neighborhood would allow groundwater to flow into the neighborhood, but without dissolved-phase PCE. In the presence of ZVI (granular iron or iron filings) chlorinated solvents like PCE degrade to nontoxic end products. This abiotic process involves corrosion (oxidation) of ZVI and reduction of dissolved chlorinated VOCs. The process induces highly reducing conditions that cause substitution of chlorine atoms by hydrogen in the structure of chlorinated solvent. Under ideal geochemical conditions, once installed, such systems should require little maintenance and, unlike biological anaerobic dechlorination, abiotic dechlorination of PCE tends to produce complete transformation to nontoxic products such as acetylene.

**Long-term Effectiveness and Permanence**. Use of PRBs with ZVI has been shown to be effective in intercepting and treating chlorinated VOC plumes at some sites. A PRB employing ZVI installed upgradient of the residential neighborhood would theoretically achieve threshold criteria; however, the site conditions are likely to preclude effective long-term functioning of this technology. Under the geochemical conditions at the Maryland Square PCE Site the ZVI could be subject to premature passivation (i.e., loss of its catalytic properties) due to the naturally high concentrations of total dissolved solids and sulfate in site groundwater. The concentrations of naturally occurring constituents are in ranges known to diminish the longevity of ZVI-based PRBs, due to mineral precipitation and other surface-coating reactions . It is not known how quickly the ZVI in the PRB would suffer passivation and breakthrough. Before passivation occurred, PCE could be at least partially dechlorinated by ZVI-mediated reactions.

The high concentrations of naturally occurring sulfate also have the potential to enhance the growth of sulfate-reducing bacteria that feed off of the hydrogen released during iron corrosion. Excessive growth of sulfate reducers can cause biofouling, which in turn can cause preferential flow through the barrier and reduce the hydraulic residence time. Certain sulfate-reducing bacteria can partially dechlorinate PCE to cis-1,2 DCE at the leading edge of the barrier. Increasing the concentration of cis-1,2 DCE (which is degraded more slowly than PCE), coupled with the decreased residence times, can result in breakthrough of PCE and its daughter products. Depending on the severity of the biofouling, groundwater flow may eventually bypass the PRB.

Long-term effectiveness and permanence are questionable for the reasons discussed above. It is questionable if this technology could provide long-term effectiveness due to site geochemistry, which could likely lead to failure of the remedy in the longer term, even if initial results showed decreased concentrations of PCE downgradient of the PRB.

**Reduction of Toxicity, Mobility or Volume**. Abiotic dechlorination would reduce the mass of PCE without generating degradation products such as TCE. However, stimulation of biotic dechlorination could produce the degradation products, TCE and vinyl chloride, which are more toxic than PCE. So, if partial biotic dechlorination occurs upgradient of the neighborhood, this could actually make exposure problems worse. The ZVI could be initially successful in achieving full abiotic dechlorination of the PCE; however, the PRB could be clogged by precipitated minerals and partial dechlorination by biotic dechlorination could lead to bio-fouling, as well as production of TCE and vinyl chloride.

**Short-term Effectiveness**. Short-term effects include the disruption of the eastern parking lot at the Mall and noise and dust related to excavation and placement of the PRB. The location of the PRB would be next to the residential neighborhood, so the noise and dust during construction could be disruptive.

**Implementation.** It may be logistically difficult to implement this remedy. Although it may be possible to install a PRB to the base of the plume (at least 80 feet deep on the eastern side of the Mall), specialized excavation equipment would likely be required. Implementation of this remedy, if possible, would be difficult.

**Cost**. This alternative has a high initial cost, but typically has lower operational and maintenance costs than more active, mechanical alternatives, such as air sparging and vapor extraction.

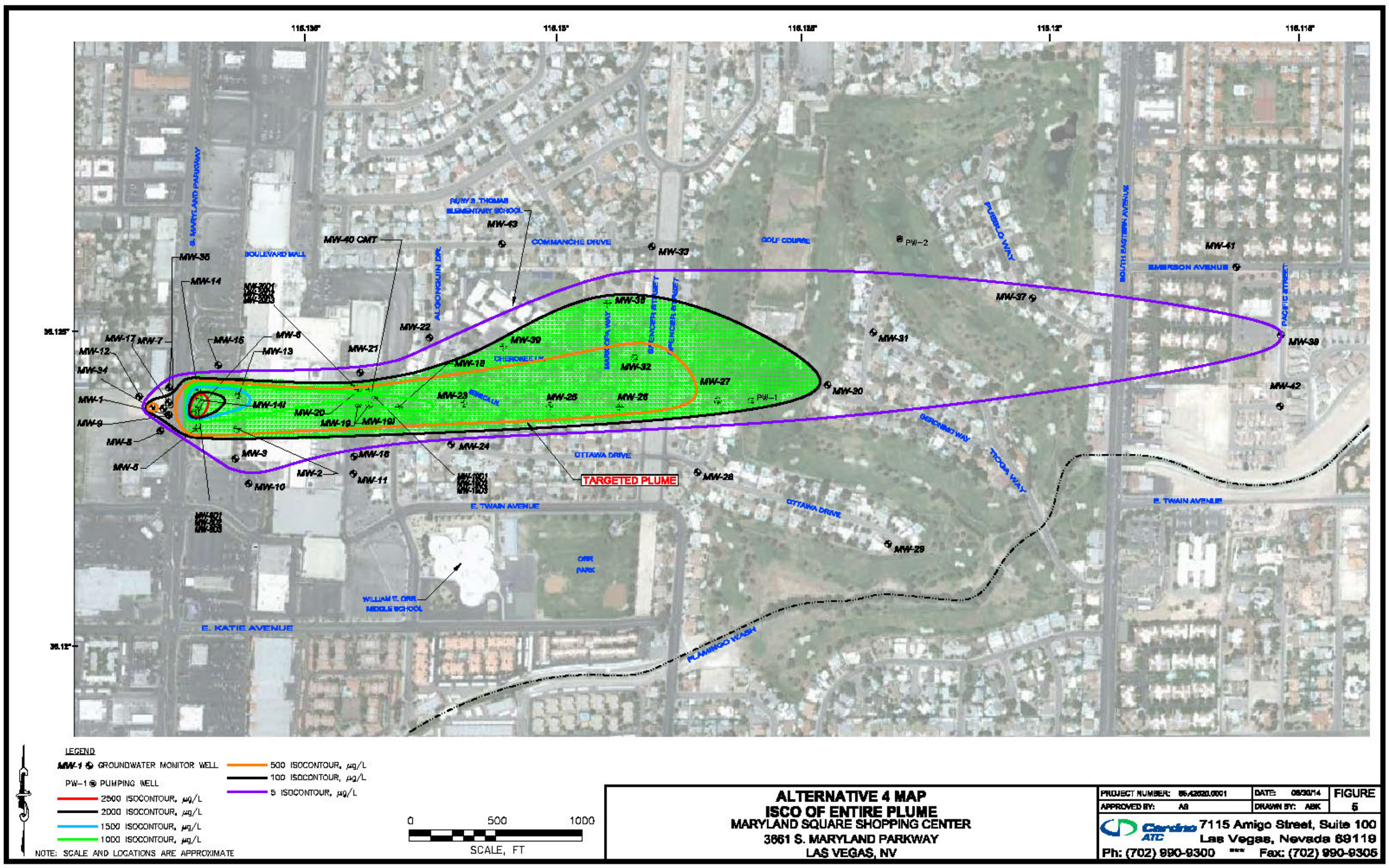
## Alternative 4: In Situ Chemical Oxidation (ISCO) of Entire Plume

*Estimated First-Year Cost: $1,100,000*
*Estimated Annual Cost: $700,000*
*Estimated Present Worth: $5,800,000 to $8,700,000*
*Estimated Time to Completion: 10+ years*

### Description of Alternative 4

A chemical oxidation reaction involves the breaking of chemical bonds. ISCO is a class of remediation technologies in which PCE and other contaminants are degraded in place by oxidants delivered to the subsurface. Successful implementation of this technology requires an effective means for dispersing the oxidizing chemicals throughout the contaminated groundwater. Complete and rapid treatment may be inhibited by a lack of direct contact of oxidant and contaminant. This is especially true for highly heterogeneous soils with low-permeability lenses and layers. To employ ISCO across the entire plume would involve drilling numerous injection wells and thorough characterization of every treatment area. Oxidants could be mixed on site, but safety and access issues may affect the ability to conduct ISCO everywhere across the plume (Figure 6).

**Figure 6. Map showing Treatment Area for Alternative 4, In Situ Chemical Oxidation of Entire Plume**




**Threshold Criteria**. ISCO involves the injection of oxidant solutions into the subsurface, and has been successfully used for treating PCE in soils and groundwater at some sites. Under ideal conditions, ISCO technology has the potential to attain the threshold criteria of protecting human health and achieving action levels.

**Long-term Effectiveness and Permanence.** Initial results from ISCO pilot tests performed at the Maryland Square PCE Site showed large decreases (order of magnitude) in the concentration of PCE; however, data collected six and nine months after the pilot-test injection of 20,000 gallons of permanganate solution showed that concentrations of PCE in deep-screened wells increased from near nondetect (0.50 and 0.68 µg/L) to 710 to 160 µg/L PCE in one well, and near nondetect (0.66, 0.50 µg/L) to 25 to 62 µg/L in another deep well. Long-term effectiveness is difficult to assess because it is difficult to distinguish between destruction of PCE and displacement of PCE-contaminated groundwater.

**Reduction of Toxicity, Mobility or Volume.** Laboratory tests have demonstrated that chemical oxidants destroy PCE. However, in the field, it can be difficult to predict and direct the migration of oxidants and contaminants. The presence of heterogeneous soils and clay layers exacerbates the difficulty in controlling and predicting migration of contaminants and oxidants. Unless injection of oxidant solutions into groundwater is paired with extraction of groundwater, the potential for uncontrolled migration is too high to recommend use near a residential area. The issue of displacement also can make it difficult to accurately gauge the effectiveness of the ISCO treatment in reducing the toxicity, mobility or volume of the PCE. That is, it is difficult to determine if decreasing concentrations measured in some observation wells are the result of chemical destruction of the PCE or simply displacement of PCE-contaminated groundwater.

The injection of large amounts of water into a contaminated area will dilute the amount of contamination present. An issue that must be resolved when assessing treatment effectiveness is the role of displacement of contaminated water away from the injection points. Depending on sampling locations observed, post-injection declines might reflect the displacement of contaminated water rather than actual contaminant mass destruction. Any area where oxidants are injected needs to have a comprehensive monitoring well system in place. Monitoring should start before oxidant injection and continue at least a year after.

**Short-term Effectiveness**. Conducting ISCO within the residential area would likely encounter numerous problems related to infrastructure and access, as well as the noise and disruption of traffic flow throughout the neighborhood. There are also safety issues related to the chemical oxidant itself and the migration of the oxidizing solution into other areas. Although the data from the pilot test indicated that concentrations of PCE and its daughter products were almost completely destroyed by the oxidant, the effects of dilution and displacement after injecting the chemical oxidant were not calculated or evaluated in the Corrective Action Report for Groundwater.

**Implementability**. Each chemical oxidant type has specific drawbacks to implementation, such as issues related to potential decreases in permeability associated with manganese precipitation (for potassium permanganate) or potential volatilization from the exothermic reactions (associated with either persulfate or Fenton's reagent), any of which can cause issues for the residents. Additional concerns include the hazardous nature of the oxidants themselves, which could pose safety concerns for anyone who unknowingly comes into contact with them. Use of ISCO injections in the residential area is problematic due to widespread infrastructure. Access may also be an issue.

**Cost** could be relatively high. The Correction Action Report estimated that treatment of the portion of the plume upgradient of the neighborhood would be $3,000,000 to $5,000,000.

### Alternative 5 (Preferred Alternative): Groundwater Extraction and Treatment (East Parking Lot), with AS/VE and ISCO with Recirculation of Groundwater or Other Technologies (West Parking Lot)

*Estimated First-Year Cost: $1,700,000*
*Estimated Annual Cost: $650,000*
*Estimated Present Worth: $5,700,000 to $7,900,000*
*Estimated Time to Completion: 10+ years*

**Description of Alternative 5**

This alternative consists of two treatment areas: in the eastern part of the mall property, pumping wells will provide hydraulic containment that will greatly reduce the flow of PCE-contaminated groundwater into the residential neighborhood; in the western part of the mall property, one or more technologies will be used to destroy or remove contaminants in the main mass of the plume (Figure 7).

**Threshold Criteria**. A well-designed groundwater extraction and above-ground treatment is a proven technology that will also prevent continued migration of PCE-contaminated groundwater into the neighborhood. Other treatment technologies are being considered for treatment of contaminated groundwater underlying the western parking lot of the Mall, across the street from the former dry cleaners. These methods include AS/VE , ISCO with extraction wells for recirculation (to minimize displacement), or other technologies. The combination of containment and treatment is expected to achieve action levels within the residential neighborhood, thereby protecting human health and the environment. Treatment on the western side of the mall will be used to destroy the high mass remaining near the source area.

**Long-term Effectiveness and Permanence.** This remedy combines several technologies to maximize effectiveness and permanence of the cleanup. Destruction of the mass of PCE in groundwater beneath the western parking lot of the mall (just east of the former dry cleaners), combined with containment and aboveground treatment of extracted PCE-contaminated groundwater in the eastern parking lot, will permanently reduce the mass of PCE in groundwater.

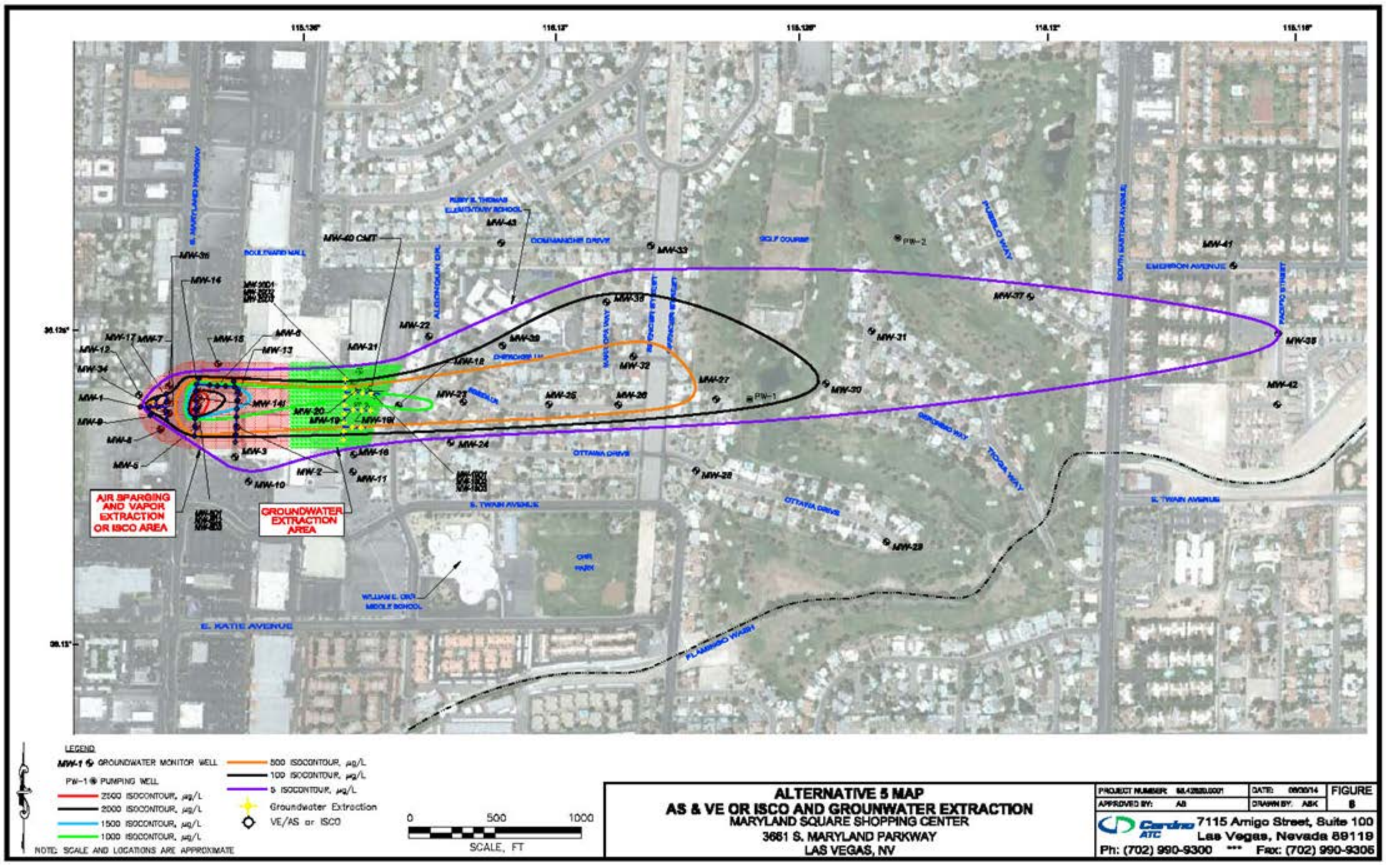
**Reduction of Toxicity, Mobility or Volume.** The pump-and-treat portion of the remedy will provide hydraulic containment of PCE-contaminated groundwater and reduce the mass of PCE flowing into the residential neighborhood. Aboveground treatment, AS/VE, and ISCO or other technology will reduce the volume (mass) of PCE in groundwater.

**Short-term Effectiveness**. The extraction wells will hydraulically contain the flow of PCE-contaminated groundwater.

**Implementability.** Design and installation of remedy components are easy to implement using widely available drilling technology. Detailed characterization of treatment areas would be required for any of the remedies; better characterization leads to better design and better effectiveness of the remedy.

**Cost:** Cost estimated for this alternative includes annual operating and maintenance expenses.

**Figure 7. Map showing treatment area for Alternative 5, the Preferred Alternative**




## VIII. PREFERRED ALTERNATIVE

**Alternative 5,** Groundwater Extraction and Treatment (Eastern Parking Lot), with AS/VE and ISCO with Recirculation of Groundwater (Western Parking Lot), is the **Preferred Alternative**. This alternative is recommended because it will achieve substantial risk reduction by reducing the mass of PCE near S. Maryland Parkway and preventing the continued flow of contaminated groundwater into the residential neighborhood (Figure 7).

The major elements of the **Preferred Alternative** include the following:

- Construction of a groundwater extraction and treatment (also known as "pump and treat") system for hydraulic containment of the PCE plume upgradient of the residential neighborhood.

- AS/VE or ISCO with directed recirculation of groundwater (that is, paired injection and extraction wells) in the area of highest concentrations on the western side of the Boulevard Mall. Other treatments may also be considered.
- Continued monitoring of groundwater across the site
- Indoor air monitoring of qualifying homes in the residential neighborhood between the Boulevard Mall on the west and the Las Vegas National Golf Course on the east

Maintenance of home mitigation systems (SSD systems) and installation of new mitigation systems in homes as needed, until such time that concentrations of PCE in the groundwater have declined to be sufficiently protective of residential indoor air via the vapor intrusion pathway

Remediation of groundwater using extraction and aboveground treatment ("pump and treat") remains a dependable technology for cleanup of deep (> 50 feet below ground surface) groundwater. Successful and cost-effective use of this technology requires (1) detailed characterization of the geology, hydrology, and chemistry; (2) removal of source terms, if possible; (3) initial design for plume containment and source remediation; (4) detailed monitoring of the remediation; (5) active ongoing reevaluation of the operating well field, including redesign as appropriate (dynamic management); (6) reinjection of treated groundwater to speed the flushing of contaminants. Techniques can dramatically reduce the time required to achieve cleanup goals and thus the cost of groundwater remediation.

This remedy combines at least two remedial technologies to achieve **containment** of the PCE-contaminated groundwater and to reduce the mass of contaminants through treatment. **Hydraulic containment** of the PCE plume upgradient of the residential neighborhood would be achieved by installing a line of pumping wells to prevent contaminated groundwater from continuing to flow into the neighborhood. A series of extraction wells would be designed to intercept the PCE-contaminated groundwater upgradient of the neighborhood. Groundwater would be extracted, treated aboveground to remove the contaminants, then re-injected as clean water to help reduce concentrations of PCE in the plume underlying the neighborhood. The reinjection should accelerate the time required to reduce concentrations of PCE to the point where home mitigation systems are no longer needed.

Another component of the remedy will be **treatment** of the main mass of contaminated groundwater which currently resides in an area just to the east of the former dry cleaner, in the western parking lot at the Boulevard Mall. This component may actually involve several different treatment technologies, such as AS/VE , ISCO with directed recirculation (designed to prevent pushing the contaminated groundwater into areas that are currently not contaminated) or other treatments. This component of the groundwater remedy may include any or all of the following:

- AS/VE, where vapor extraction is used to capture fugitive vapors released from the groundwater by the sparging of air into the groundwater
- In situ oxidation (ISCO), with concurrent groundwater extraction (i.e., directed recirculation) to minimize displacement of contaminated groundwater into areas or zones that are currently unaffected by the PCE plume.
- Other treatments proven effective at destroying PCE

<u>Pump and Treat (Groundwater Extraction and Aboveground Treatment)</u>

"Pump and treat" involves groundwater extraction and aboveground treatment of the extracted groundwater. This technology will require a more detailed assessment of the aquifer properties and the contaminant profile in the vicinity targeted for well placement. The aquifer tests performed on the Mall portion of the site suggested that the site is a candidate for this remediation technology. Assuming that the hydraulic properties are similar across the length and breadth of the plume, this site would be amenable to pump and treat. The design of an effective extraction system will require additional aquifer testing. Dewatering wells are common throughout the Las Vegas Valley, mainly for underground parking areas at some of the large hotels, so it should be possible to achieve drawdown and reasonable rates of extraction. Injection of cleaned groundwater into the "stagnant zone" downgradient of the pumping wells can be used to help dilute and flush out the PCE-contaminated groundwater under the residential neighborhood.

Aboveground treatment can include air stripping, activated carbon adsorption, or other methods. The selection of pump and treat and the specific aboveground treatment needs to consider the concentration of contaminant in the extracted water, the pumping rate/volume of extracted water, permitting requirements, exhaust treatment requirements, and public acceptance including noise control concerns, site logistics, and cost. Those factors would be addressed during the preliminary design phase. Depending on the quality of the treated water, and any regulatory constraints, the treated water might be suitable for supplementing the irrigation demand at the Mall or golf course.

Air Sparging and Vapor Extraction

Air sparging is performed "in situ" and therefore offers the benefit of not bringing contaminated groundwater to the surface; however, this technology offers less direct plume control than the pump and treat alternative. For this reason, AS/VE is only being proposed for the western parking lot of the Mall, because this area is not adjacent to any residences. Sparging systems are simple in design, require little operation and maintenance (O&M), require a small footprint, and are relatively inexpensive. Vapor extraction is needed to capture the PCE vapors to prevent potential vapor intrusion or other health-related issues. Incorporating ozone injection along with AS/VE would result in PCE destruction; however, it complicates the system design, requires additional O&M (which can be significant due to the corrosive effects of ozone), and adds to the capital cost. The continued need for recovering the vapor would be assessed over the life cycle of the remediation.

Designing an AS/VE system will require that the vertical and cross-sectional profile of the PCE plume be well defined for optimum placement of the air sparge points. Pilot testing is conducted to determine the "effective" radius of influence of a sparge point and to define the initial and design operational parameters (i.e., number of sparge points, operating pressures and flow rates, etc.). Testing of soil-gas permeability should be performed to design a VE system that will capture the vapors created by the sparging action.

In Situ Chemical Oxidation with Directed Recirculation

Although the ISCO pilot testing conducted on the eastern side of the Mall property appeared to result in displacement of contaminated groundwater into previously clean areas or zones, that testing did not incorporate extraction or recirculation wells. Theoretically, extraction of a volume of groundwater equal to the volume of injectate should minimize the amount of displacement of contaminated groundwater.

Short-term effectiveness of potassium permanganate has been demonstrated by laboratory testing and longevity of permanganate has been shown by the pilot testing, suggesting that long-term effectiveness may be achievable.

Implementation and cost for this type of technology have not been thoroughly evaluated.

Summary of Preferred Alternative

Based on information currently available, the NDEP believes the **Preferred Alternative** meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria.

The NDEP expects the **Preferred Alternative** to satisfy the following statutory requirements of CERCLA §121(b): 1) be protective of human health and the environment; 2) comply with site action levels; 3) be cost-effective; 4) employ permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and 5) satisfy the preference for treatment as a principal element.

The Cleanup Process used by the USEPA follows a series of steps and documents, as outlined at: http://www.epa.gov/superfund/cleanup/ Additional information on the USEPA process can be found at: http://www2.epa.gov/cleanups The cleanup process followed by the NDEP is consistent with and similar to the USEPA process.

## IX. COMMUNITY PARTICIPATION

The Proposed Plan is a document used to facilitate public involvement in the remedy selection process. The document presents the lead agency's Preferred Alternative to address contamination at the site, presents alternatives that were evaluated, and explains the reasons the lead agency recommends the Preferred Alternative.

Comments on this Proposed Plan will be accepted by mail, e-mail or fax throughout the **90-day comment period**, from **October 15, 2014 through January 13, 2015**. Comments will be addressed in the "Responsiveness Summary," which is included in the Record of Decision (ROD). The final decision regarding the selected remedy is documented in the ROD after the lead agency has considered all comments from both the support agency and the public.

### Document Locations

The complete administrative record (as hard-copy files) is available in the Carson City office of the NDEP. Selected documents are also available as hard-copy files in the Las Vegas office of the NDEP. The entire Administrative Record, including all reports and correspondence, is available on-line (see link below).

**Bureau of Corrective Actions**
**Nevada Division of Environmental Protection**
**901 S. Stewart St, Suite 4001**
**Carson City, NV 89701**
**Phone (775) 687-4670**

**Bureau of Corrective Actions**
**Nevada Division of Environmental Protection**
**2030 E. Flamingo Rd, Suite 230**
**Las Vegas, NV 89119**
**Phone: (702) 486-2850**

### NDEP Website Link

View the Proposed Plan, Administrative Record, NDEP correspondence, and additional details and information for the Maryland Square PCE Site at: http://ndep.nv.gov/pce/maryland_square.htm

### Public Meeting

A public meeting will be held on **Wednesday, November 19, 2014** at **6:00 pm**, in the **Winchester Cultural Center**, which is located at 3130 McLeod Drive, Las Vegas, NV. Members of the public are encouraged to attend the public meeting, ask questions, and provide comments on the preferred remedy and other remedies evaluated for the cleanup of contaminated groundwater at the Site.

**Table 1. Comparative Analysis of Alternatives**

| Comparison Criteria | Alternative 1<br>No Further Action Alternative | Alternative 2<br>Biologically Enhanced In Situ Treatment (ISB) | Alternative 3<br>Permeable Reactive Barrier (PRB) using Zero-Valent Iron (ZVI) | Alternative 4<br>In Situ Chemical Oxidation (ISCO) of the Entire Plume | Alternative 5<br>Groundwater Extraction and Treatment (P&T) in East Parking Lot, with Air Sparging and Soil Vapor Extraction (AS/SVE) or ISCO with Recirculation Wells in West Parking Lot | Comparative Analysis Summary |
|---|---|---|---|---|---|---|
| **Threshold Criteria** | | | | | | |
| 1) Overall Protection of Human Health and the Envrionment | Fails | Likely Meets | Likely Fails | Likely Meets | Meets | Enhanced Bioremediation (Alt 2) is not compatible with site geochemistry. A PRB using ZVI (Alt 3) would be extremely difficult to implement to 80 ft bgs, as well as being subject to passivation due to groundwater geochemistry. ISCO (Alt 4) appears to destroy PCE, but migration is uncontrolled and displacement of contamination is a concern, along with safety issues. P&T (Alt 5) is believed to be the safest option next to homes, with ISCO and AS/VE retained for the western parking lot on mall property. |
| 2) Achieving Action Levels* | Fails | Likely Fails | Likely Fails | Likely Fails | Meets | Enhanced Bioremediation (Alt 2) and a PRB with ZVI (Alt 3) depend on reducing conditions and are not likely to perform successfully over the long term, so these remedies are not expected to achieve or maintain action levels. The performance of ISCO (Alt 4) is unknown because of the difficulty distinguishing between contaminant destruction and displacement of contaminated groundwater. ISCO with Recirculation and AS/VE in the western mall parking lot in concert with P&T (Alt 5) is likely to acheive action levels in a timely fashion. |
| **Primary Balancing Criteria** | | | | | | |
| 3) Long-Term Effectiveness | 0 | 2 | 1 | 3 | 4 | Enhanced Bioremediation (Alt 2) and a PRB using ZVI (Alt 3) are expected to have low long-term effectivness due to incompatibility with site geochemistry and the likely difficulty in maintaining reducing conditions. The long-term effectiveness of ISCO (Alt 4) is unknown because of the difficulting discerning between efficacy and displacement. P&T in east parking lot, combined with AS/VE and ISCO with Recirculation in the west parking lot (Alt 5), should remain effective over the long-term. |
| 4) Reduction of Toxicity, Mobility and Volume | 0 | 3 | 2 | 1 | 4 | Enhanced Bioremediation (Alt 2) and a PRB using ZVI (Alt 3) are expected to produce only a small decrease in contaminant volume, and may increase toxicity by production of more-toxic daughter products as a result of incomplete reductive dechlorination of PCE. ISCO remedies (Alt 4) may decrease volume and toxicity, but without active recirculation wells may increase mobility by displacing the contamination into previously clean area or depths. P&T, AS/VE, ISCO with Recirculation (Alt 5) should reduce mobility, toxicity and volume of contaminants |
| 5) Short-Term Impact | 0 | 2 | 1 | 0 | 3 | Short-term effectiveness evaluates the degree of disruption caused by remedy implementation, as well as the rapidity of achieving remediation goals. Enhanced Bioremediation (Alt 2) on Mall property would likely have minimal short-term disruption to the residential neighborhood, but may be slow in effectiveness. A PRB using ZVI (Alt 3) would have moderate negative short-term impact during construction and moderate to low effectiveness in the short term. ISCO on Mall property would have a low to moderate short-term impact, depending on the oxidant used; however, ISCO throughout the plume (Alt 4) would have a high negative impact on the neighborhood. P&T in the east parking lot, along with AS/VE and ISCO with Recirculation in the west parking lot (Alt 5) would likely have moderate negative short-term impact during construction and optimization, but hydraulic containment with reinjection of clean water may provide the fastest short-term effectiveness to achieve remediation goals in the neighborhood. |
| 6) Implementability | 0 | 3 | 1 | 0 | 3 | Implementing Enhanced Bioremediation (Alt 2) is theoretically easy but acheiving reducing conditions may be difficult. Installing a ZVI PRB (Alt 3) to 80 ft bgs would be difficult to highly impracticable. Implementing ISCO across the entire plume (Alt 4) would be relatively easy on mall property but difficult in the neighborhood due to necessity of drilling hundreds of injection points. Installing a series of P&T wells on the east side of mall property, along with AS/VE and ISCO with Recirculation on the west side of mall property(Alt 5) should be easy to implement, though optimal placement of screens would require more detailed characterization of lithology in the treatment areas. |
| 7) Cost | 0 | 4 | 3 | 1 | 2 | Costs for all alternatives are estimated. The highest costs are likely to be for a ZVI PRB (Alt 3), ISCO throughout the plume (Alt 4), and P&T with AS/VE and ISCO with Recirculation (Alt 5). |
| **Modifying Criterion** | | | | | | |
| 8) Community Acceptance | | | | | | Dependent on feedback from community members and other stakeholders |

Note: The action level for PCE in groundwater under the residential neighborhood, (100 µg/L) protective of indoor air is 20 times higher than the MCL (5 µg/L); the action level for PCE (9.4 µg/m3) and TCE (6 µg/m3) in indoor air reflect the latest risk information from the USEPA.

| | Worst Option | | | | Best Option |
|---|---|---|---|---|---|
| TOTALS = | 0 | 14 | 8 | 5 | 16 |