Appendix B

Technical Memorandum: Results of the Detailed Evaluation and Comparative Analysis of *Ex-Situ* Groundwater and Vapor Treatment Alternatives

FINAL TECHNICAL MEMORANDUM

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Re: Results of the Detailed Evaluation and Comparative Analysis of *Ex-Situ* Groundwater and Vapor Treatment Alternatives

Cc: John Hartley, United States Army Corps of Engineers

INTRODUCTION

T N & Associates, Inc. (TN&A) has prepared this technical memorandum to report the results of the screening, detailed evaluation, and comparative analysis of *ex-situ* groundwater and vapor treatment technologies as part of the *Final Feasibility Study Report, Pemaco Superfund Site, Maywood, California* (TN&A, 2004). This was performed to ensure the selection of *ex-situ* technologies capable of destroying and/or reducing site-specific contaminants to concentrations below discharge requirements. The results of this exercise are intended to provide representative process options for *ex-situ* treatment of groundwater and vapor for inclusion in the assembled remedial alternatives.

SCREENING PROCESS

A three-step screening process was developed to select the most efficient technologies for *ex-situ* treatment of groundwater and vapor. The first step involved the development of a list of remedial technologies and process options for *ex-situ* treatment of groundwater and vapor. Only technologies that were potentially applicable and/or technically feasible were included. The second step involved an initial screening of the *ex-situ* process options to eliminate technologies based on technical implementability, effectiveness, and cost. Based on site contaminants and contaminant concentrations, the most effective technologies for *ex-situ* groundwater treatment and *ex-situ* vapor treatment were retained for detailed evaluation (step three).

It should be noted that the disposal options for treated groundwater were integrated into this screening process.

The technologies and process options considered for *ex-situ* treatment of extracted groundwater are listed in Table 1.0 (and below); technologies and process options considered for *ex-situ* treatment of soil vapor are listed in Table 2.0 (and below). The bolded text on Tables 1.0 and 2.0 indicates options retained from the screening process. Notes explaining the rationale behind eliminating the remaining options are also presented in Tables 1.0 and 2.0.

The *ex-situ* treatment technologies that were retained during the screening process for *ex-situ* groundwater treatment are as follows:

- Liquid-Phase Granular Activated Carbon (GAC),
- Air Stripping, and
- Ultraviolet Oxidation (UV oxidation).

The *ex-situ* treatment technologies that were retained for *ex-situ* vapor treatment are as follows:

- Vapor-Phase GAC,
- Regenerative Vapor-Phase GAC,
- Catalytic Oxidation, and
- Flameless Thermal Oxidation (FTO).

Descriptions of the retained *ex-situ* treatment systems for groundwater and vapor have been included to provide information pertinent to the overall analysis and evaluation of the treatment alternatives.

Liquid-Phase Granular Activated Carbon (GAC) Adsorption - Groundwater

GAC adsorption is a treatment technology to remove primarily organic contaminants from groundwater. Groundwater is pumped through one or more vessels containing GAC. The thermal processing of carbon, often derived from ground coconut shells, creates small porous particles with a large internal surface area, an attribute that makes it activated. The activated carbon attracts and adsorbs organic molecules as well as certain metal and inorganic molecules. Dissolved contaminants sorb onto the surfaces of the activated carbon. Water is passed through the vessels relatively quickly. When the concentration of contaminants in the water exiting the vessels (effluent) exceeds a certain level, the carbon must be replaced. Exhausted carbon can be regenerated several times and reused prior to eventually being disposed offsite at an approved disposal facility.

Groundwater with suspended solids or oil and grease may cause fouling of the carbon. In many cases pretreatment to remove these contaminants may be required to ensure the treatment's effectiveness.

Costs are high if used as the primary treatment for groundwater with high concentrations of contaminants. Often, GAC is phased in after initially using a technology better suited for high concentrations.

Some degradation products, such as vinyl chloride and smaller molecules, are not sorbed well. Consequently, they must be monitored carefully.

All spent carbon eventually needs to be disposed in landfills or regenerated. Although activated carbon is a well-established technology for removing organic compounds, its use in the removal of inorganic contaminants has not been as widespread due to its low inorganic adsorption capacity as well as the difficulty of regeneration and cost of disposal.

Air Stripping - Groundwater

Air stripping is a technology in which VOCs are transferred from extracted water to air. Typically, air stripping takes place in a packed tower (known as an air stripper), a low-profile series of trays where water cascades from tray to tray, or an aeration tank. The “air stripper” includes a spray nozzle at the top of the tower. It sprays groundwater that has been pumped to the surface over the packing in the column. As the water descends, air is forced up through the column, stripping off the volatile compounds. Packing or baffles within the tower increase the surface area of the contaminated water that is exposed to air, thus maximizing the amount of volatilization. A sump at the bottom of the tower collects decontaminated water. Auxiliary equipment may include an air heater to improve removal efficiency and air emission “scrubbers.”

Traditional air strippers vary in height as the height is correlated to the chemical concentration of the contaminated water. A recent innovation in air strippers is the low-profile air stripper. These units have a number of trays that are set horizontally. Water is cascaded over the trays to maximize air-water contact while minimizing vertical space. Because they are not so visible, they are increasingly being used for groundwater treatment.

Air strippers transfer contaminants from one medium to another. There is no destruction of the contaminant. Consequently, the risks of emitting pollutants into the air must be carefully evaluated. Often, the air stream (or off-gas) is treated before it is emitted to the atmosphere. Based on the concentrations detected in groundwater, it is estimated that post-treatment of the off-gasses will be required prior to discharge. It is assumed, for the purpose of comparing alternatives, that vapor phase carbon (GAC) would be used to capture the COCs in the air stripping process emissions.

Air stripping is effective only for water contaminated with VOC or semi-volatile concentrations with a Henry’s constant greater than 0.01. (Henry’s Law is a measure of the extent to which a chemical separates between water and air. The higher the Henry’s Law constant, the more likely substances will volatize rather than remaining in water.) Compounds with low volatility (e.g., 1,4-dioxane) at ambient temperature may require preheating of the groundwater.

Algae, fungi, bacteria, and fine particles may foul the equipment, requiring pretreatment or periodic column cleaning. The visual impacts associated with air strippers and noise disturbance from blowers should be considered, as they are often viewed as a nuisance when located in residential areas.

Ultraviolet Oxidation - Groundwater

Ultraviolet (UV) oxidation is a destruction process that oxidizes organic contaminants in water. It works by the adding oxidizing agents such as ozone (O_3) or hydrogen peroxide

(H_2O_2) to the contaminated groundwater. The contaminated solution is passed through a chamber where it is exposed to intense UV radiation. UV radiation is provided by UV light bulbs. Oxidation of target contaminants is caused by direct reaction with the oxidizers and through the action of UV light in combination with ozone and/or hydrogen peroxide.

A major success factor is how well UV light is transmitted to dissolved contaminants. High turbidity (e.g., cloudiness) of the water would cause interference. The water should be relatively free of heavy metal ions and insoluble oil or grease to minimize the potential for fouling of the lights.

Energy requirements are very high; this is a large drawback to this technology. Handling and storage of hydrogen peroxide requires special safety precautions.

Vapor-Phase Granular Activated Carbon (GAC) Adsorption - Vapor

Vapor-phase GAC treatment is performed by passing an off-gas stream through one or more vessels containing activated carbon. Contaminants sorb onto the surfaces of the activated carbon grains. The thermal processing of carbon, often from coconut shells, creates small porous particles with a large internal surface area. This processing activates the carbon. The activated carbon attracts and adsorbs organic molecules as well as certain metal and inorganic molecules. When the concentration of contaminants in the vapor exiting the vessels exceeds a certain level, the carbon must be replaced. Spent carbon can be regenerated in place; removed and regenerated at an offsite facility; or most commonly, removed and disposed. Some degradation products such as vinyl chloride and smaller molecules are not sorbed well, and consequently must be monitored carefully.

All spent carbon eventually needs to be disposed in landfills or regenerated. The carbon used for some contaminants may not be regenerated. Spent carbon transport may require hazardous waste handling. Relative humidity greater than 50% can reduce carbon capacity. Elevated temperatures from soil vapor extraction (SVE) pumps (greater than 38° C or 100° F) inhibit adsorption capacity. Some compounds, such as ketones, may cause carbon bed fires because they release heat upon adsorption.

Regenerative Vapor-Phase Granular Activated Carbon (GAC) Adsorption - Vapor

The regenerative vapor-phase GAC alternative is identical to vapor-phase GAC with exception to the additional onsite carbon regeneration. The carbon regeneration process involves “backflushing” the GAC with high-pressure steam to drive off the adsorbed contaminants. The contaminated steam condenses to water and insoluble contaminants and must be disposed of according to state and federal regulations. All used carbon eventually needs to be disposed in landfills after its regenerative capacity has been exhausted.

Catalytic Oxidation - Vapor

Oxidation equipment is used for destroying contaminants in the exhaust gas from air strippers and SVE systems. There are two primary types of oxidation technologies used: thermal and catalytic. Thermal oxidation units are typically single chambered, equipped with a propane or natural gas burner and a stack. Air containing the organic vapors is heated to a temperature that oxidizes the compounds. Catalytic oxidation devices are similar to the pollution control device on automobiles. They use a metal catalyst, commonly platinum or palladium, to oxidize the contaminants at lower temperatures. Lower combustion temperatures decrease the amount of nitrous oxides (NOx) that are produced. NOx is a major cause of air pollution. The addition of a catalyst to the basic thermal oxidation configuration accelerates the rate of oxidation by sorbing the oxygen from the air stream and the contaminant vapor onto the catalyst surface where they react to form carbon dioxide, water, and hydrochloric gas.

For both catalytic and thermal oxidation, if chlorinated compounds are in the contaminant mix, there is a concern that either incomplete combustion or other chemical processes will lead to the formation of dioxins and furans. These substances may be toxic in the parts per trillion range. Therefore, a treatability study should be performed prior to implementation of the technology. Additionally, continuous emission monitoring is desirable.

With catalytic oxidation, the catalyst can be poisoned (i.e., deactivated) by emissions containing sulfur, halogenated compounds or some metals, such as lead. Destruction of halogenated compounds requires special catalysts and the possible addition of a flue-gas scrubber to reduce acid gas emissions.

Flameless Thermal Oxidation - Vapor

The Flameless Thermal Oxidizer is a destructive technology for off-gas treatment of VOCs and SVOCs. The process converts aromatic and chlorinated VOCs to carbon dioxide, water, and hydrogen chloride without exposing the vapors to a flame. The technology achieves uniform thermal oxidation of VOCs using a heated packed-bed reactor filled with ceramic material. The vapors are oxidized when they come into contact with the heated bed of ceramic pieces. Temperatures are typically maintained at 1600°-1850° Fahrenheit.

FTO is considered the most effective commercially available thermal technology available for the destruction of vapor phase organic contaminants. FTO yields extremely low NOx formation (typically < 2 ppmv), extremely low CO formation (typically below the limits of detection), and products of incomplete combustion (PICs; e.g. dioxin) that have been shown to be below Southern California background concentrations, as measured from the effluent stream. The FTO can compensate for operations of low flow rates with low concentrations to high flow rates with high concentrations without affecting organic destruction efficiency.

DETAILED EVALUATION OF ALTERNATIVES

The detailed evaluation of *ex-situ* technologies presents a comparison of relevant information needed to allow decision makers to select an appropriate and representative alternative for 1) *ex-situ* treatment of groundwater and 2) ex-situ treatment of vapor/secondary emissions for inclusion, if necessary, in the assembled remedial alternatives.

The U.S. EPA developed nine criteria to address Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) statutory considerations for remedial actions that must be addressed in the Record of Decision (ROD) as well as technical and policy considerations that have proven to be important for selecting remedial alternatives. The first two criteria are threshold criteria that must be met by each alternative. The next five criteria are the primary balancing criteria upon which the evaluation is mostly based. The final two criteria are referred to as modifying criteria and are applied, following the public comment period, to evaluate state and community acceptance. The evaluation of alternatives reflects the scope and complexity of site problems and alternatives being evaluated and considers the relative significance of the factors within each criterion. The nine evaluation criteria are as follows:

Threshold Criteria
1. Overall protection of human health and the environment
2. Compliance with ARARs (applicable or relevant and appropriate standards)

Primary Balancing Criteria
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility or volume
5. Short-term effectiveness
6. Implementability
7. Cost

Modifying Criteria
8. State acceptance
9. Community acceptance

The technologies selected for detailed evaluation were carefully developed through the screening process (see above) to eliminate technologies that do not meet the requirements under CERCLA. The retained *ex-situ* groundwater and vapor treatment technologies were fully evaluated against the nine criteria developed by EPA to select the preferred alternative for *ex-situ* treatment of groundwater and vapor for use, if necessary, in the assembled remedial alternatives.

Detailed Evaluation of Alternatives for Ex-situ Treatment of Extracted Groundwater

The three retained *ex-situ* groundwater treatment alternatives best suited for site-specific COCs include:

- Liquid-phase GAC
- Air Stripping, and
- Ultraviolet Oxidation.

These alternatives were evaluated in detail using the nine evaluation criteria described above. The detailed evaluations are presented in Table 3.0. Detailed cost evaluations for each alternative are provided in Tables 3.1 through 3.3. Note that additional evaluation of two of the criteria, state acceptance and community acceptance, will be performed following the public comment period of the FS report.

Detailed Evaluation of Alternatives for Ex-situ Treatment of Vapor

The three retained *ex-situ* vapor treatment alternatives best suited for site-specific COCs include:

- Vapor-phase GAC
- Catalytic Oxidation, and
- Flameless Thermal Oxidation.

These alternatives were evaluated in detail using the nine evaluation criteria described above. The detailed evaluations are presented in Table 4.0. Detailed cost evaluations for each alternative are provided in Tables 4.1A through 4.4B. Note that additional evaluation of two of the criteria, state acceptance and community acceptance, will be performed following the public comment period.

COMPARATIVE ANALYSIS OF ALTERNATIVES

The purpose of the comparative analysis is to identify the relative advantages and disadvantages of each alternative. The comparative analysis of *ex-situ* treatment alternatives for extracted groundwater and vapor are presented in separate sections below.

Comparative Analysis of Alternatives for Ex-situ Groundwater Treatment

The comparative analysis for *ex-situ* treatment systems for extracted groundwater is included below by criterion.

Overall Protection of Human Health and the Environment

All of the *ex-situ* treatment alternatives for extracted groundwater would be protective of human health and the environment when properly designed. Alternative TG3 (Ultraviolet Oxidation) would effectively destroy all VOCs, thereby providing the highest level of protection to human health and the environment. This alternative destroys all organic contaminants without the additional contaminant disposal requirement of air stripping or GAC treatment.

Alternative TG1 (Liquid-Phase Granular Activated Carbon) would be protective of human health and the environment through the adsorption of most organic contaminants. VOCs with low molecular weights, such as vinyl chloride, or COCs with low adsorptive capacities such as 1,4-dioxane would not be efficiently captured by GAC. Management of contaminated carbon (treatment residuals) would be required for the duration of the system operation. All used carbon eventually needs to be disposed in landfills after its regenerative capacity has been exhausted.

Alternative TG2 (Air Stripping) would be protective of human health and the environment for the removal of most VOCs through changing the phase of contaminants from dissolved-phase groundwater to vapor. Based on COC concentrations in groundwater, off-gases may require treatment. This alternative would likely only be protective with the addition of a secondary emissions (vapor) treatment alternative, such as GAC.

Compliance with the ARARs/TBCs

All of the *ex-situ* treatment alternatives for extracted groundwater would generally comply with ARARs and TBCs for groundwater. Alternative TG3 (Ultraviolet Oxidation) is capable of exceeding all ARARs/TBCs for COCs present in both the perched groundwater and the Exposition groundwater remediation zones.

For treatment of the perched groundwater zone, Alternative TG1 (Liquid-Phase Granular Activated Carbon) would likely be non-compliant with ARARs/TBCs due to the recurring presence of 1,4-dioxane at elevated concentrations (up to 990 µg/L) throughout this zone (aereal distribution of elevated concentrations extend throughout the majority of the Pemaco site and southwest of the site to the adjacent railroad right-of-way); this compound has a low adsorptive capacity. For treatment of the Exposition groundwater zones, where 1,4-dioxane is detected at a very low frequency, liquid-phase GAC would likely comply with ARARs/TBCs. Some degradation products, such as vinyl chloride, which are not sorbed as well as other organic compounds, would require careful monitoring to be compliant. If concentrations are exceedingly high for these smaller molecules, a treatment alternative other than GAC should be considered in order to be protective of the environment.

Similar to Alternative TG1, Alternative TG2 (Air Stripping) would likely be non-compliant with ARARs/TBCs for treatment of the perched groundwater zone due to the recurring presence of 1,4-dioxane at elevated concentrations, which has a low volatility. For treatment of the Exposition groundwater zones, where 1,4-dioxane is detected at a very low frequency, air stripping would likely comply with ARARs/TBCs. As previously stated, dependent on the influent COCs and concentrations, off-gases may require treatment via one of the vapor treatment alternatives discussed in Section 4.6.5. This alternative would likely only comply with ARARs/TBCs with the addition of a secondary emissions (vapor) treatment alternative.

Long-Term Effectiveness and Permanence

Alternative TG3 (Ultraviolet Oxidation) would afford the highest degree of long-term effectiveness and permanence because it uses a treatment process that has demonstrated reliable destruction of VOCs with high concentrations, while adhering to low criteria pollutant emissions. It is anticipated that the destruction of contaminants through this treatment process would be permanent and would result in no treatment residuals and no untreated residual risks. However, the effectiveness of UV oxidation is dependent on the aqueous stream being able to transmit UV light (i.e., sensitivity to turbidity and metals ions). Pretreatment (filtration) of the influent can minimize ongoing cleaning and maintenance of the UV reactor and ensure an effective method of treatment over time. Routine monitoring of the treatment process would be performed to assure effectiveness over the duration of system operation.

Alternative TG1 (Liquid-Phase Granular Activated Carbon) would be the most reliable of the three alternatives; however, it would not provide the same level of long-term effectiveness or permanence as Alternative TG3 (Ultraviolet Oxidation). Alternative TG1 does not destroy COCs; rather, it relies on the adsorption of COCs to the GAC media, which is later eventually transferred to an approved off-site disposal facility once it has exhausted its regenerative capacity. Additionally, carbon adsorption is not as effective for low molecular weight VOCs, such as vinyl chloride, or COCs with low adsorptive capacity such as 1,4-dioxane. Nonetheless, Alternative TG1 consists of a generally conventional and well-proven technology and would be an effective method for *ex-situ* treatment of groundwater when adequately operated and maintained. Modifications to the system and routine monitoring of the treatment process could be easily performed to assure effectiveness over time.

Alternative TG2 (Air Stripping) is a well-proven and effective method for removing VOCs from groundwater; however, vapor residuals would likely require treatment due to the elevated concentrations of VOCs in groundwater. Vapor treatment alternatives, typically either GAC or thermal oxidation, should be used to capture/destroy the COCs. The long-term effectiveness of air stripping is reduced if inorganic (e.g., iron greater than 5 ppm, hardness greater than 800 ppm) or biological fouling of the equipment requires periodic column cleaning. Pretreatment (filtration) of the influent for hardness and/or iron can ensure an effective method of treatment over time when adequately maintained and operated. Due to the relatively low volatility of 1,4-dioxane, air-stripping technologies are unable to remove it to levels suitable for discharge. Therefore, treatment of groundwater for the perched zone should consider other alternatives.

Reduction of Toxicity, Mobility, and Volume (TMV) through Treatment

Alternative TG3 (Ultraviolet Oxidation) utilizes a technology that would completely destroy all COCs with no residual wastes to manage. Thus, this alternative would eliminate the TMV of groundwater contaminants extracted from the subsurface.

Alternative TG1 (Liquid-Phase Granular Activated Carbon) would greatly reduce the mobility and volume of contaminants as COCs are adsorbed to the GAC. Toxicity would not be reduced onsite, but disposal facilities typically treat used carbon via thermal oxidation prior to landfilling, thereby reducing toxicity. Contaminants, such as vinyl chloride and 1,4-dioxane, which do not adsorb well to the carbon, must be monitored carefully to assure the TMV of these contaminants are being mitigated.

Alternative TG2 (Air Stripping) would greatly reduce the mobility and volume of contaminants as COCs are stripped from the groundwater and converted to the gaseous phase. Toxicity is slightly reduced by this alternative as COCs are diluted through the air stripping process. However, toxicity would typically be reduced via a post-stripping vapor treatment alternative, such as GAC or thermal oxidation. Some COCs, such as 1,4-dioxane, are not amenable to air stripping because of their low volatility. These COCs would be carefully monitored to be sure reduction in TMV is being addressed.

Short-Term Effectiveness

This evaluation criterion is two-fold. One aspect addresses the effects of the alternative during the construction and implementation; the other addresses the time until remedial action objectives are met. For all of the alternatives for *ex-situ* treatment of extracted groundwater, the time required to meet RAOs is a function of influent COCs and concentrations, and system design.

Alternative TG1 (Liquid-Phase Granular Activated Carbon) is anticipated to have the greatest short-term effectiveness with respect to risk to workers, the community, and the environment. Short-term risks are limited to transportation of used carbon to an offsite disposal facility that would involve such issues as: intermittent local traffic issues, hazardous waste transfer, and worker handling of the saturated GAC. These risks can be mitigated with proper planning and suitable health and safety measures, such as traffic control, worker PPE, and worker training. Air monitoring would likely be required to demonstrate no significant impacts to the community.

Alternative TG2 (Air Stripping) is anticipated to provide the second greatest short-term effectiveness for *ex-situ* treatment of groundwater, as this treatment process is mechanically reliable and simple to operate. This alternative would likely require the addition of an off-gas treatment system to capture/destroy COCs once they are transferred from the water phase to the vapor phase. Short-term risks to workers, the community, and the environment would have the same impacts as those associated with the selected vapor treatment alternative, likely GAC or thermal oxidation.

Alternative TG3 (Ultraviolet Oxidation) would pose greater risks to workers than Alternatives TG1 and TG2 because of the caustic oxidants that would be stored at the treatment facility. Risks to workers can be mitigated with suitable health and safety measures, such as chemical storage and contingency planning, worker PPE, and worker training.

Implementability

Alternative TG1 (Liquid-Phase Granular Activated Carbon) would be the simplest to construct and operate. Carbon treatment is a generally conventional and well-proven technology with many vendors. This alternative is expected to be highly reliable when adequately operated and maintained; no unusual technical problems are anticipated (clogging of the carbon media is the most typical problem). Personnel, equipment, and materials are readily available for implementation/operation. This alternative is administratively feasible since state and local agency permits are routinely issued. The system could be modified or improved based on treatment results (e.g., prefilitration to reduce clogging). The carbon treatment system requires occupation of a small area of the Maywood Riverfront Park until the cleanup objectives are reached.

Alternative TG2 (Air Stripping) is fairly simple to implement and consists of a generally conventional and well-proven technology with many vendors. This alternative is expected to be highly reliable when adequately operated and maintained. Personnel, equipment, and materials are readily available for implementation/operation. Henry's law constant, the ratio of the aqueous-phase concentration of a chemical to its equilibrium partial pressure in the gas phase, must be considered when specifying the type and amount of packing used in the tower. The system could be modified or improved based on treatment results (e.g., prefilitration to reduce fouling). Administratively, this alternative is feasible since state and local agency permits are routinely issued; however, public perception of the treatment system may not be positive due to the treatment tower associated with this alternative. The air stripping system requires occupation of a small area of the Maywood Riverfront Park until the cleanup objectives are reached.

Alternative TG3 (Ultraviolet Oxidation) is more difficult to implement than Alternatives TG1 and TG2. Although UV oxidation is not an innovative technology, relatively fewer vendors are available. Nonetheless, the technology is well proven in destroying 99.99% of VOCs and is expected to be highly reliable when adequately operated and maintained. The system could be modified or improved based on treatment results (e.g., the most typical problem is caused by fouling of the quartz sleeves which transmit UV light, a problem that can be solved through pretreatment). Administratively, this alternative is feasible since state and local agency permits are routinely issued. Although no risks to the community would result from UV oxidation as all contaminants are destroyed during the treatment process, public perception of the chemical storage area may not be positive. The UV oxidation system requires occupation of a small area of the Maywood Riverfront Park until the cleanup objectives are reached.

Cost

A summary the estimated costs for each of the *ex-situ* groundwater treatment alternatives are presented in Table 3.0. A more detailed cost estimate for each alternative is provided in Tables 3.1 through 3.3. The cost estimates presented in these tables have been developed strictly for comparing the *ex-situ* groundwater treatment alternatives. The final costs of the treatment alternatives will depend on competitive bids, actual market conditions, actual site conditions, final project scope, and implementation schedules. Because of these factors and those unforeseen, project feasibility and requirements must be reviewed carefully to adequately address the decisions related to project funding.

The cost estimates are “order-of-magnitude” estimates having an intended accuracy range of +50% to –30%. They are not intended to limit the flexibility in the selection of the remedial design but to provide a basis for evaluating cost in light of the other modifying criteria. The specific details of the remedial actions and cost estimates would be refined once all evaluation criteria are considered in preparation of the ROD.

For fairness in the comparative analysis, a 20-year duration was selected for the *ex-situ* treatment of groundwater. The contaminant mass to be treated was based on average VOC concentrations in groundwater and the results of a high-vacuum dual phase extraction pilot test performed in the Exposition ‘A’ and ‘B’ groundwater zones. The groundwater extraction rate and contaminant-loading rate was derived from pump tests and the pilot test mentioned above, respectively. The assumptions and calculations are summarized in Table 3.4 (Summary of Groundwater Extraction Design Parameters for the Exposition Zone) and Table 3.5 (Liquid-Phase Carbon Usage Worksheet for Groundwater).

The cost estimates, presented in Tables 3.1 through 3.3, considered capital costs for startup, annual O&M costs, O&M present worth (for 20 years of operation), and total present worth (sum of O&M present worth and capital costs).

Alternative TG1 (Liquid-Phase Granular Activated Carbon) is estimated to be the least expensive alternative with a total present worth for 20 years of operation of approximately $1.5 million. The second least expensive was Alternative TG2 (Air Stripping), priced at approximately $2.1 million with off-gas treatment. The most expensive was Alternative TG3 (Ultraviolet Oxidation) priced at approximately $3.2 million. The difference in total present worth between Alternative TG1 and Alternative TG2 is approximately $0.6 million and the difference between Alternative TG2 and Alternative TG3 is approximately $1.1 million.

Alternative TG2 was priced higher than TG1 primarily because of the assumption that off-gasses would require treatment. The cost of off-gas treatment was included in the estimate for TG2 using a typical vapor phase carbon treatment system that is discussed in Table 4.0. This assumption is considered reasonable and justified by the concentration of VOCs in groundwater and the net mass of contaminants that would otherwise be emitted over a 20-year period.

Alternative TG3 was priced higher than the other two alternatives primarily because of high annual O&M costs. The detailed cost estimate in Table 3.3 shows that the most significant O&M cost ($94,608/year) originates from the cost of electricity to power the UV lamps in the treatment system.

State Acceptance

To be addressed in the ROD.

Community Acceptance

To be addressed in the ROD.

Comparative Analysis of Alternatives for Ex-situ Vapor Treatment

The comparative analysis for *ex-situ* treatment systems for soil vapor and secondary emissions is included below by criterion.

Overall Protection of Human Health and the Environment

All of the *ex-situ* treatment alternatives for soil vapor/secondary emissions would be protective of human health and the environment when properly designed. Alternative TV4 (Flameless Thermal Oxidation) the most effective commercially available thermal technology available for the destruction of vapor phase organic contaminants, thereby providing the highest level of protection to human health and the environment. Alternatives TV1 (Vapor-Phase Granular Activated Carbon) and TV2 (Regenerative Vapor-Phase Granular Activated Carbon) would be equally protective of human health and the environment through the adsorption of organic compounds as well as certain metals and inorganic compounds. Some degradation products such as vinyl chloride are not sorbed as well, and would require careful monitoring. Alternative TV3 (Catalytic Oxidation) would be the least protective *ex-situ* alternative for soil vapor and secondary emissions. Although this alternative destroys up to 98% of organic contaminants, the high combustion temperatures increase the amount of nitrous oxides produced. In addition, there is a concern that the incomplete combustion of chlorinated compounds could lead to the formation of lower levels of products of incomplete combustion (PICs) (e.g., dioxins and furans).

Compliance with the ARARs/TBCs

All of the *ex-situ* treatment alternatives for soil vapor/secondary emissions would generally comply with ARARs and TBCs for ambient air. Alternative TV4 (Flameless Thermal Oxidation) is capable of exceeding all ARARs/TBCs for COCs present in both the upper vadose and perched groundwater remediation zone and the lower vadose and Exposition groundwater remediation zone.

For treatment of the upper vadose and perched groundwater remediation zone, Alternatives TV1 (Vapor-Phase Granular Activated Carbon) and TV2 (Regenerative Vapor-Phase Granular Activated Carbon) would likely be non-compliant with ARARs/TBCs due to the recurring presence of 1,4-dioxane at elevated concentrations (up to 990 µg/L) throughout this zone (aereal distribution of elevated concentrations extend throughout the majority of the Pemaco site and southwest of the site to the adjacent railroad right-of-way); this compound has a low adsorptive capacity. For treatment of the lower vadose and Exposition groundwater remediation zone, where 1,4-dioxane is detected at a very low frequency, these alternatives would likely comply with ARARs/TBCs. For both GAC alternatives, some degradation products such as vinyl chloride, which are not sorbed as well as other organic compounds, would require careful monitoring to be compliant.

Alternative TV3 (Catalytic Oxidation) would likely comply with ARARs/TBCs. Additionally, the catalyst can be fouled (i.e., deactivated) by emissions containing sulfur, halogenated compounds or some metals. Destruction of these compounds would require special catalysts and the possible addition of a gas scrubber to reduce acid gas emissions. The appropriate catalyst for the contaminated air stream would need to be selected to assure efficient destruction of contaminants and compliance with discharge requirements.

Long-Term Effectiveness and Permanence

Alternative TV4 (Flameless Thermal Oxidation) would afford the highest degree of long-term effectiveness and permanence because it uses a treatment process that has demonstrated reliable destruction of VOCs with high concentrations, while adhering to low criteria pollutant emissions. Contaminants are permanently destroyed onsite with highly effective removal efficiency. Routine monitoring of the treatment process would be performed to assure effectiveness over time.

Alternative TV3 (Catalytic Oxidation) would be an effective method for treatment of *ex-situ* soil vapor and secondary emissions over time. This alternative would not be as effective as Alternative TV4 (FTO) because the system can be fouled by sulfur, lead, and particulates. Destruction efficiencies would be dependent on engineering modifications to adjust for the influent gas COCs and concentrations. Routine monitoring of the treatment process would be performed to assure effectiveness over time.

Alternatives TV1 (Vapor-Phase Granular Activated Carbon) and TV2 (Regenerative Vapor-Phase Granular Activated Carbon) would not involve the destruction of COCs onsite, rather they rely on the ability of COCs to adsorb to the activated carbon. Once the carbon has reached its contaminant threshold (Alternative TV1) or has exhausted its regenerative capacity (Alternative TV2), the carbon needs to be transferred to an approved off-site disposal facility. Contaminants stripped from the carbon during onsite carbon regeneration (Alternative TV2) would also need to be disposed at an appropriate off-site facility. Nonetheless, both alternatives consist of generally well-proven technologies and are expected to be highly reliable when adequately operated and maintained. These alternatives are not as effective on low molecular weight VOCs such as vinyl chloride or COCs with low adsorptive capacities such as 1,4-dioxane. Routine monitoring of the treatment process would be performed to assure effectiveness over time.

Reduction of Toxicity, Mobility, and Volume (TMV) through Treatment

Alternative TV4 (Flameless Thermal Oxidation) utilizes a technology that would physically destroy COCs onsite. Thus, this alternative would eliminate the TMV of vapor contaminants extracted from the subsurface or of secondary emissions from extracted groundwater treatment systems. Alternative TV4 could result in the generation of acidic gases; these treatment residuals could be controlled through the addition of a scrubber.

Alternative TV2 (Regenerative Vapor-Phase Granular Activated Carbon) would reduce the mobility and volume of contaminants as COCs are adsorbed to the GAC. Contaminant saturated vapor-phase carbon would be regenerated onsite using steam-stripping technology. The contaminants would be recovered from the steam in a specially designed tank that so that concentrated volumes of liquid contaminants and condensate could be separately contained. Once the carbon has exhausted its regenerative capacity (Alternative TV2), the used carbon, liquid contaminants, and condensate would be transferred to an approved offsite disposal facility.

Alternative TV1 (Vapor-Phase Granular Activated Carbon) would reduce the mobility and volume of contaminants as COCs are adsorbed to the GAC in the same manner as Alternative TV2. However, once the carbon has reached its initial contaminant threshold, the carbon needs to be transferred to an approved offsite facility for regeneration or landfilling. As the carbon is not regenerated onsite, contaminant volume would remain that of the carbon vessels.

Alternative TV3 (Catalytic Oxidation) would reduce the TMV of vapor contaminants extracted from the subsurface or of secondary emissions from extracted groundwater treatment systems similar to Alternative TV4. However, emissions include acidic gases and, potentially, PICs (dioxins and furans). Adding on a scrubber system would control the acidic gasses. The presence of products of incomplete would be detected by careful monitoring of effluent emissions.

Short-Term Effectiveness

This evaluation criterion is two-fold. One aspect addresses the effects of the alternative during the construction and implementation phase of the alternative; the other addresses the time until remedial action objectives are met. For all of the alternatives for *ex-situ* treatment of soil vapor and secondary emissions, the time required to meet RAOs is a function of influent COCs and concentrations and system design.

Alternative TV1 (Vapor-Phase Granular Activated Carbon) is anticipated to have the greatest short-term effectiveness with respect to risk to workers, the community, and the environment. Transportation of used carbon to an offsite disposal facility presents intermittent local traffic issues and worker handling of the saturated GAC. These risks can be mitigated with proper planning and suitable health and safety measures, such as traffic control, worker PPE, and worker training. Air monitoring would likely be required to demonstrate no significant impact to the community from low molecular weight VOCs such as vinyl chloride or COCs with low adsorptive capacities such as 1,4-dioxane.

Although Alternative TV2 (Regenerative Vapor-Phase Granular Activated Carbon) would require fewer transfers of used GAC to offsite disposal facilities than Alternative TV1, Alternative TV2 presents additional risks to workers. The regenerative stripping process would require additional worker handling of saturated GAC and the more-concentrated by-products of the regenerative process (liquid contaminants and condensate). In addition, the high-pressure onsite steam source could be a hazard to workers in the event of a system malfunction. These risks can be mitigated with proper system design and suitable health and safety measures, such as worker PPE and worker training. Like Alternative TV1, air monitoring would likely be required to demonstrate no significant impact to the community from low molecular weight VOCs such as vinyl chloride or COCs with low adsorptive capacities such as 1,4-dioxane.

Alternatives TV3 (Catalytic Oxidation) and TV4 (Flameless Thermal Oxidation) are very similar with respect to short-term effectiveness. Both alternatives would have scrubbers to control acid gas emissions but PICs could potentially result for Alternative TV3 only. Evaluation of air emissions would be required to demonstrate no significant impacts. Workers performing installation and monitoring activities associated with these alternatives may risk contact to high temperatures (thermal burns) and waste materials or incomplete combustion byproducts. Operating oxidizer systems above the design concentration or temperature may cause auto-ignition and a resulting fire hazard. These risks could be mitigated with proper design specifications and suitable health and safety measures, such as worker PPE and worker training.

Implementability

Alternative TV1 (Vapor-Phase Granular Activated Carbon) would be the simplest to construct and operate. Carbon treatment is a generally conventional, well proven, and very reliable technology with many vendors. This alternative is expected to be highly reliable when adequately operated and maintained and no unusual technical problems are anticipated. Personnel, equipment, and materials are readily available for implementation/operation. This alternative is administratively feasible since state and local agency permits are routinely issued. The system could be modified or improved based on treatment results. The carbon treatment system requires occupation of a small area of the Maywood Riverfront Park until the cleanup objectives are reached. Alternative TV2 (Regenerative Vapor-Phase Granular Activated Carbon) would provide a similar degree of implementability as Alternative TV1, with the exception that there would be a higher operation and maintenance requirement to have the regeneration process onsite.

Alternative TV3 (Catalytic Oxidation) is fairly simple to implement and consists of a generally conventional, well proven, and accessible technology (many vendors). This alternative is expected to be highly reliable when adequately operated and maintained. Personnel, equipment, and materials are readily available for implementation/operation. The administrative feasibility of obtaining permits is uncertain since the previous oxidation system at the site (Section 1.4.4) was shut down due to community concern of potential dioxin releases. Modifications to the system may cause significant downtime if contaminant loading contains compounds that foul the catalyst.

Alternative TV4 (Flameless Thermal Oxidation) is more difficult to implement than Alternatives TV1 through TV3. Although FTO is not an innovative technology, but a fewer number of vendors are available. Nonetheless, it is well proven as the most effective thermal technology for destroying VOCs and is expected to be highly reliable when adequately operated and maintained. The alternative is anticipated to be administratively feasible since similar systems have been operating in the SCAQMD since 1998 and the system does not have measurable emissions of dioxin. No system modifications are anticipated.

Cost

A summary of the estimated costs for each of the *ex-situ* vapor/secondary emissions treatment alternatives are presented in Table 4.0. A more detailed cost estimate for each alternative is provided in Tables 4.1A through 4.4B. The cost estimates presented in these tables have been developed strictly for comparing the *ex-situ* vapor/secondary emissions treatment alternatives. The final costs of the treatment alternatives will depend on competitive bids, actual market conditions, actual site conditions, final project scope, and implementation schedules. Because of these factors and those unforeseen, project feasibility and requirements must be reviewed carefully to adequately address the decisions related to project funding.

The cost estimates are "order-of-magnitude" estimates having an intended accuracy range of +50% to –30%. They are not intended to limit the flexibility in the selection of the remedial design but to provide a basis for evaluating cost in light of the other modifying criteria. The specific details of the remedial actions and cost estimates would be refined once all evaluation criteria are considered in preparation of the ROD.

For fairness in the comparative analysis, two standard *ex-situ* vapor treatment scenarios were created. The one-year treatment scenario represents *ex-situ* vapor treatment for a system such as ERH with VE where the majority of contaminant mass is removed in a one-year period. The 20-year treatment scenario represents treatment for a less aggressive system; e.g. HVDPE, or enhanced pump and treat, where the contaminant mass is removed over 20 years. The contaminant mass and removal rates used in both scenarios are calculated in Tables 4.5 and 4.6 and are based on results of the high-vacuum dual phase extraction pilot test performed on the perched groundwater zone and Exposition 'A' and 'B' groundwater zones in December 2002.

<u>One-Year Treatment Scenario</u>

Alternative TV2 (Regenerative Granular Activated Carbon) is estimated to be the least expensive (1 year) alternative with a total present worth of approximately $0.96 million. The second least expensive (1 year) alternative was TV3 (Catalytic Oxidation) with a total present worth of approximately $1.07 million. Alternative TV4 (Flameless Thermal Oxidation), the third least expensive alternative at $1.11 million, is more expensive than Alternative TV3 mostly as a result of the additional fuel required for operation.

The most expensive alternative was Alternative TV1 (Granular Activated Carbon) with a total present worth of approximately $2.12 million. The higher cost of Alternative TV1 is primarily due to the purchase and disposal of carbon.

<u>Twenty-Year Treatment Scenario</u>

Alternative TV1 (Granular Activated Carbon) is estimated to be the least expensive alternative with a total present worth of approximately $2.94 million for 20 years of operation. The second least expensive alternative was Alternative TV2 (Regenerative Granular Activated Carbon) with a total present worth of approximately $3.04 million. Alternative TV2 is more expensive than TV1 mostly because of the required investment in the regeneration equipment and O&M costs resulting from energy consumption.

The third least expensive was Alternative TV3 (Catalytic Oxidation) with a total present worth of approximately $5.23 million for 20 years of operation. The most expensive alternative is TV4 (Flameless Thermal Oxidation) with a total present worth of approximately $6.82 million.

As shown to a lesser degree in the one-year scenario, Alternative TV4 is more expensive than Alternative TV3 mostly as a result of additional fuel required for operation.

State Acceptance

To be addressed in the ROD.

Community Acceptance

To be addressed in the ROD.

PREFERRED *EX-SITU* TREATMENT ALTERNATIVES

Based on the comparative analysis summarized in the previous section, the preferred *ex-situ* groundwater treatment technology is UV oxidation and the preferred *ex-situ* vapor treatment technologies are FTO and GAC. These systems were selected because they are considered the most capable of destroying and/or reducing site contaminants to concentrations acceptable for discharge. The preferred alternatives are deemed representative technologies for *ex-situ* groundwater treatment and *ex-situ* vapor treatment to be included, if necessary, in the assembled remedial alternatives.

Two ex-situ vapor treatment alternatives are suggested for use because the contaminant loading and duration of treatment could be very different depending on which cleanup technology is used. Economically, FTO is better suited for short term use with high contaminant loading and GAC is better suited to long-term use with low contaminant loading.

It should be noted that any *ex-situ* groundwater and/or vapor treatment system would require implementation with consideration for the future Maywood Riverfront Park design. The remediated groundwater may be disposed by one of the following retained disposal options: sewer system discharge (i.e., storm drain), surface water discharge (i.e., Los Angeles River), or reinjection to subsurface.

TABLES

TABLES (CONTINUED)

TABLE 1.0
Technology/Process Option Screening —*Ex-situ* Groundwater Treatment and Disposal

General Response Action	Remedial Technologies	Process Options	Technical Implementability	Effectiveness	Cost	Comments
Ex-Situ (Post-Collection Treatment of Groundwater)	Physical	Adsorption with GAC	Good	Demonstrated	Moderate to High	Retained. Some COPCs with low adsorption coefficients (e.g. acetone) may be present at concentrations exceeding discharge limits in process stream; secondary treatment may be required.
		Air Stripping	Good	Good	Moderate	Retained. Only treats water process stream; off-gas would require treatment; some COPCs with low adsorption coefficients (e.g. acetone) may be present at concentrations exceeding discharge limits in process stream; secondary treatment may be required.
		Clarification (Sedimentation)	Good	Poor	Low	Does not address COPCs.
		Coagulation	Good	Poor	Low	Does not address COPCs.
		Component Separation	Good	Poor	Low	Does not address COPCs.
		Evaporation	Good	Good	Low	Vapor emissions not controllable or permitable.
		Flocculation	Will not remove COPCs from process stream.			
		Freeze Crystallization	Will not remove COPCs from process stream.			
		Ion Exchange	Will not remove COPCs from process stream			
		Metals Precipitation	Will not remove COPCs from process stream.			
		Microfiltration/ Ultrafiltration	Will not remove COPCs from process stream.			

General Response Action	Remedial Technologies	Process Options	Technical Implementability	Effectiveness	Cost	Comments
		Phase Separation	Good	Poor	Low	Not effective for destruction and/or reduction of COPCs.
		Precipitation with Sand Filtration	Will not remove COPCs from process stream.			
		Reverse Osmosis	Will not remove COPCs from process stream.			
		Steam Stripping	Not feasible due to cost			
	Chemical	Neutralization	Will not remove COPCs from process stream.			
		Oxidation	Good	Good	High	Safety issues associated with the handling and use of oxidants may complicate the application of this process.
		Reduction	Will not remove COPCs from process stream.			
		UV Oxidation	Good	Demonstrated	Moderate	Retained. Potentially applicable for treatment of water process stream.
	Biological	Aeration/Aerobic	Good	Poor to Fair	Low	Does not address COPCs and long residence time not feasible.
		Bioreactors	Good	Fair	Moderate	Difficult to implement due to wide variety of COPCs; would require both aerobic and anaerobic processes.
		Fixed Film	Good	Fair	Moderate	Difficult to implement due to wide variety of COPCs; would require both aerobic and anaerobic processes.
		Oxidation Enhancement w/ Hydrogen Peroxide	Good	Poor to Fair	Low	Only addresses aerobically degradable COPCs.

General Response Action	Remedial Technologies	Process Options	Technical Implementability	Effectiveness	Cost	Comments
Ex –Situ Groundwater Disposal	Pre–Treatment Discharge	RCRA TSDF	Good	Good	High	High cost.
	Post –Treatment Discharge	Reuse as drinking water	Good	Good	Moderate	Low quantities of water would not justify required additional treatment due to unpotable nature of groundwater; not acceptable by community and other stakeholders.
		Reuse as irrigation water	Good	Good	Moderate	Potentially feasible for park watering, but community acceptance not likely.
		Reuse as process water	Remedial options will not require process water			
		Sewer system discharge	Good	Good	Low	Retained. Local POTW may not accept water discharge.
		Surface water discharge	Good	Good	Low	Retained. Potentially feasible to Los Angeles River.
	Subsurface	Deep Well Injection	Good	Good	Moderate	Retained. Potentially feasible.

Effectiveness is the ability to perform as part of a comprehensive alternative that can meet RAOs under conditions and limitations that exist at the site. Implementability is the likelihood that the process could be implemented as part of the remedial action plan under the regulatory, technical, and schedule constraints. Technical Implementability encompasses the applicability/feasibility of performing the process option. Administrative Implementability encompasses permitability, regulatory acceptance, and community acceptance. Cost is for comparative purposes only, relative to other processes/technologies that perform similar functions.

COPCs	Chemicals of Potential Concern	RAOs	Remedial Action Objectives
GAC	Granular activated carbon	RCRA	Resource Conservation and Recovery Act
GW	Groundwater	SVE	Soil Vapor Extraction
NA	Not applicable	VOCs	Volatile Organic Contaminants
NCP	National Contingency Plan	TSDF	Treatment, storage, or disposal facility
POTW	Publicly Owned Treatment Works	UV	Ultraviolet

TABLE 2.0
Technology/Process Option Screening — *Ex-situ* Vapor Treatment
Page 1 of 1

General Response Action	Remedial Technologies	Process Options	Technical Implementability	Effectiveness	Cost	Comments
Ex –Situ (Post Collection Treatment of Vapor)	Physical	Adsorption with GAC	Good	Demonstrated	High	Retained. Some COPCs with low adsorption coefficients (e.g. acetone) may be present at concentrations exceeding discharge limits in process stream; exothermic reactions may result between carbon and acetone.
		Adsorption	Good	Demonstrated	High	Potentially applicable to reduce acetone concentrations in process stream without exothermic reactions.
		Membrane Separation	Innovative	Uncertain	High	Inability to handle fluctuations in concentrations; moisture sensitive; high cost.
	Chemical	Gas Scrubbing	Good	Poor	Moderate	Potentially applicable to remove acid exhaust from thermal treatment to comply with air emission requirements.
	Biological	Biofiltration	Good	Potential	Moderate to High	Flow rates limited; treatment of halogenated VOCs less effective.
	Thermal	Catalytic Oxidation	Good	Good	Moderate	Retained. Probable community issues; possible generation of acid.
		High Energy Corona	Good – Innovative	Good	High	New technology may not be feasible due to lack of case study data.
		Internal Combustion Engine Oxidation	Good	Fair	Moderate	Possible incomplete combustion of chlorinated VOCs; engine performance problematic with halogenated compounds.
		Thermal Oxidation	Good	Good	Moderate	Retained. Probable community issues; possible generation of acid gas; may require gas scrubbing.

Effectiveness is the ability to perform as part of a comprehensive alternative that can meet RAOs under conditions and limitations that exist at the site. Implementability is the likelihood that the process could be implemented as part of the remedial action plan under the regulatory, technical, and schedule constraints. Technical Implementability encompasses the applicability/feasibility of performing the process option. Administrative Implementability encompasses permitability, regulatory acceptance, and community acceptance. Cost is for comparative purposes only, relative to other processes/technologies that perform similar functions.

COPCs Chemicals of Potential Concern GAC Granular activated carbon VOCs Volatile Organic Contaminants

Table 3.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Groundwater
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES		
	TG1 – Granular Activated Carbon	**TG2 – Air Stripping**	**TG3 – UV Oxidation**
1. Overall Protection of Human Health and the Environment.	• A properly designed GAC treatment system is protective of human health and the environment for the removal of most organic contaminants. • Treatment compound must be adequately secured, maintained, and monitored to prevent leaks and creation of exposure pathways. • The GAC treatment system requires routine monitoring and maintenance to assure effective capture of contaminants in accordance with discharge permits. • All used carbon eventually needs to be disposed in landfills after its regenerative capacity has been exhausted.	• A properly designed air stripping treatment system is protective of human health and the environment for the removal of most VOCs. • Treatment compound must be adequately secured, maintained, and monitored to prevent leaks and creation of exposure pathways. • The air stripping treatment system requires routine monitoring and maintenance to assure effective capture of contaminants in accordance with discharge permits. • Off-gases would require treatment via one of the vapor treatment alternatives listed in Table 4.0. • Typically the collected contaminants from the stripping process require disposal.	• A properly designed UV oxidation treatment system is protective of human health and the environment for the removal of most VOCs. • Treatment compound must be adequately secured, maintained, and monitored to prevent leaks and creation of exposure pathways. • This alternative destroys all VOC COCs without the additional contaminant disposal requirements of air stripping or GAC treatment. • System requires routine monitoring and maintenance to assure effective destruction of contaminants in accordance with discharge permits.

Table 3.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Groundwater
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES		
	TG1 – Granular Activated Carbon	**TG2 – Air Stripping**	**TG3 – UV Oxidation**
2. Compliance With ARARs and TBCs	• For treatment of the perched zone: 1,4-dioxane's low adsorptive capacity would likely result in non-compliance with ARARs and/or TBCs (discharge requirements). • Treatment of the deep zone using GAC would comply with ARARs and/or TBCs since 1,4 dioxane is not known to be present. • Engineering controls would be established to meet associated treatment, storage, recycle, and/or disposal of solid/hazardous wastes requirements. • Some degradation products, such as vinyl chloride and smaller molecules (e.g., 1,4 dioxane) are not sorbed well. Consequently they must be monitored carefully; or if in high enough concentrations, a treatment alternative other than GAC should be used in order to be protective of the environment.	• For treatment of the perched zone, 1,4-dioxane's low volatility would likely result in non-compliance with ARARs and/or TBCs (discharge requirements). • Treatment of the deep zone using air stripping would comply with ARARs and/or TBCs since 1,4 dioxane is not known to be present. • Engineering controls would be established to meet associated treatment, storage, recycle, and/or disposal of solid/hazardous wastes requirements. • The treatment process for air stripping off-gases (typically GAC or thermal oxidation) would be required to meet the air emissions discharge requirements.	• Treatment process would comply with all ARARs and TBCs discharge requirements.

Table 3.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Groundwater
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES		
	TG1 – Granular Activated Carbon	**TG2 – Air Stripping**	**TG3 – UV Oxidation**
3. Long-Term Effectiveness And Permanence	• Carbon adsorption is a well proven and effective method of treatment over time when adequately operated and maintained. • COCs are adsorbed by the carbon; however, permanent destruction of the COCs would take place at an off-site approved facility. • Carbon adsorption is not as effective on low molecular weight VOCs such as vinyl chloride or COCs with low adsorptive capacity such as 1,4 dioxane. • Routine monitoring of the treatment process would be performed to assure effectiveness over time.	• Air stripping is a well-proven and effective method for removing VOCs from groundwater; however, another treatment for off-gasses, typically either GAC or thermal oxidation should be used to capture/destroy the COCs. • The long-term effectiveness of air stripping is reduced if inorganic (e.g. iron greater than 5 ppm, hardness greater than 800 ppm) or biological fouling of the equipment requires periodic column cleaning. • Pretreatment of the influent for hardness and/or iron can ensure an effective method of treatment over time when adequately operated and maintained. • The COC 1,4, dioxane exists in the perched zone. Due to 1,4-dioxane's relatively low volatility, air-stripping technologies are unable to remove it to levels suitable for discharge. Therefore treatment of groundwater from the perched zone should consider other treatment alternatives. If used for the deep grounder zone, routine monitoring of the treatment process would be performed to assure effectiveness over time.	• UV oxidation is a well proven and effective method of treatment over time when adequately operated and maintained. • The effectiveness of UV oxidation is dependent on the aqueous stream being able to transmit UV light; i.e., low turbidity and metal ions < 10 mg/L. • Pretreatment of the influent can minimize ongoing cleaning and maintenance of the UV reactor and ensure an effective method of treatment over time. • Routine monitoring of the treatment process would be performed to assure effectiveness over time.

Table 3.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Groundwater
Pemaco Superfund Site, Maywood, California

Criterion	**TREATMENT ALTERNATIVES**		
	TG1 – Granular Activated Carbon	**TG2 – Air Stripping**	**TG3 – UV Oxidation**
4. Reduction of Toxicity, Mobility or Volume (TMV) through Treatment	• The mobility and volume of COCs are greatly reduced as they become adsorbed to the GAC. • Toxicity is not reduced on-site but is typically performed at the disposal facility via thermal oxidation. • Carbon that has exceeded its useful lifespan would be transported for off-site regeneration or landfilling. • Some COCs, such as vinyl chloride and smaller molecules (e.g., 1,4 dioxane) are not adsorbed well and must be monitored carefully to be sure the TMV of these contaminants are being treated.	• The mobility and volume of COCs are greatly reduced as they are stripped from the groundwater and converted to the gaseous phase. • Toxicity is slightly reduced by air stripping. Toxicity would typically be reduced via a post-stripping process such as thermal oxidation. • Some COCs, such as 1,4 dioxane, are not amenable to air stripping because of their low volatility and must be monitored carefully to be sure reduction in TMV is being addressed.	• UV oxidation is a very effective treatment method for reducing the TMV of almost all organic contaminants. • All COCs would be completely destroyed on-site with no residual wastes to manage.

Table 3.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Groundwater
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES		
	TG1 – Granular Activated Carbon	**TG2 – Air Stripping**	**TG3 – UV Oxidation**
5. Short-term Effectiveness	• Transportation of used carbon to an off-site facility for regeneration or disposal would encounter hazardous waste manifesting issues and increase local traffic. • Risks to workers performing monitoring activities can be controlled and mitigated with proper health and safety measures; e.g., air monitoring and PPE. • Evaluation of the air emissions would be performed to demonstrate no significant impact to the community.	• The air stripping off-gas treatment (typically GAC or thermal oxidation) would have the same impacts described for those treatment systems (see Table 4.0). • Risks to workers performing monitoring activities can be controlled and mitigated with proper health and safety measures; e.g., air monitoring and PPE. • Evaluation of the air emissions may be required to demonstrate no significant impact to the community from untreatable COCs such as 1,4 dioxane.	• The UV oxidation requires that caustic oxidants be stored at the treatment facility. • Risks to workers from oxidant storage and handling and from monitoring activities can be controlled and mitigated with proper health and safety measures; e.g., air monitoring and PPE.

Table 3.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Groundwater
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES		
	TG1 – Granular Activated Carbon	**TG2 – Air Stripping**	**TG3 – UV Oxidation**
6. Implementability	• Carbon treatment is a mature and very reliable technology with many vendors and no unusual technical problems anticipated. • Consideration should be given to the presence of suspended solids that can significantly reduce the life of the carbon. • Operation and maintenance personnel, materials, and utilities are readily available or in place since remediation has previously been performed at the site. • This alternative is administratively feasible since state and local agency permits are routinely issued. • The system can be modified or improved based on treatment results; e.g., prefiltration. Clogging of the carbon media is the most typical problem. • The carbon treatment system requires occupation of a small area of the MRP until the cleanup objectives are reached.	• Air Stripping is a mature and very reliable technology with many vendors and no unusual technical problems anticipated. • Consideration should be given to the Henry's Law Constant to the COCs and the type and amount of packing used in the tower. • Operation and maintenance personnel, materials, and utilities are readily available. • This alternative is administratively feasible since state and local agency permits are routinely issued. • The system can be modified or improved based on treatment results; e.g., pretreatment. Fouling of the tower media is the most typical problem. • The catalytic oxidation system requires occupation of a small area of the MRP until the cleanup objectives are reached.	• UV oxidation is a relatively newer technology with sufficient vendors and no unusual technical problems anticipated. • Consideration should be given to the turbidity and hardness of the aqueous stream, which can interfere with the oxidation process. • Operation and maintenance personnel, materials, and utilities are readily available. • This alternative is administratively feasible since state and local agency permits are routinely issued. • The system can be modified or improved based on treatment results; e.g., prefiltration. Fouling of the quartz sleeves, which transmit UV light, is the most typical problem. • The UV oxidation system requires occupation of a small area of the MRP until the cleanup objectives are reached.

Table 3.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Groundwater
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES		
	TG1 – Granular Activated Carbon	**TG2 – Air Stripping**	**TG3 – UV Oxidation**
7. Estimated Cost[1]			
Direct Capital Cost	$94,000	$135,000	$194,000
Annual O&M Cost	$104,000	$148,000	$225,000
O&M Present Worth	$1,384,000 (20 yr term at 4.25% interest)	$1,974,000 (20 yr term at 4.25% interest)	$2,994,000 (20 yr term at 4.25% interest)
Total Present Worth	$1,479,000	$2,109,000	$3,188,000
8. State Acceptance	• Statewide acceptance under CalEPA on numerous projects. • SCAQMD approval of discharge permits would be required. • Further comments will be addressed in the ROD after public comment period.	• Statewide acceptance under CalEPA on numerous projects. • SCAQMD approval of discharge permits would be required. • Further comments will be addressed in the ROD after public comment period.	• Statewide acceptance under CalEPA on numerous projects. • SCAQMD approval of discharge permits would be required. • Further comments will be addressed in the ROD after public comment period.
9. Community Acceptance	• System would be operated aboveground leading to potential conflicts with future park activities. • Further comments will be addressed in the during the public comment period.	• System would be operated aboveground leading to potential conflicts with future park activities. • Further comments will be addressed in the during the public comment period.	• System would be operated aboveground leading to potential conflicts with future park activities. • Further comments will be addressed in the during the public comment period.

1. Refer to Tables 3.1 through 3.6 for a detailed analysis of capital, operations and maintenance costs, and present worth assumptions.

TABLE 3.1 - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TG1
LIQUID-PHASE CARBON ADSORPTION FOR GROUNDWATER - 20 YEAR PURCHASE SCENARIO

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Mobilization/Demobilization	4	each	$1,200.00	$4,800	EnviroSupply Services, Inc.
2	Utility Connections (electric, gas, sewer)	1	lump sum	$6,805.00	$6,805	RS Means
3	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
4	Water Filtration Skid, (4)-bag filter, 500-gal tank, 1/2 HP pump, skid mount	1	lump sum	$16,452.00	$16,452	McMaster-Carr
5	1200 lb Liquid Phase Carbon Adsorption Vessels	2	lump sum	$5,700.00	$11,400	EnviroSupply Services, Inc.
6	Discharge Conveyance System	1	lump sum	$12,675.00	$12,675	McMaster-Carr and RS Means
7	Installation and Start-Up	1	lump sum	$12,000.00	$12,000	EnviroSupply Services, Inc.
8	Handling Fees (3%)	1	lump sum	$2,249.88	$2,250	T N & Associates
9	Contingency (10%)	1	lump sum	$7,499.60	$7,500	RS Means
10	**Subtotal (Equipment, Materials, and Subs)**				**$84,745**	
TN&A Labor						
11	Construction Manager	75	hours	$85.00	$6,375	T N & Associates
12	Project Admin. and Management	50	hours	$65.00	$3,250	T N & Associates
	Subtotal (TN&A Labor)				**$9,625**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$94,370**	

Assumptions:

1. The 20 year cost scenario represents a likely outcome for ex-situ groundwater treatment and was created as a basis for comparison with other alternatives. The contaminant mass and removal rates are based on results of the high-vacuum dual phase extraction pilot test performed on the perched groundwater zone and the Exposition 'A' and 'B' Zones in December 2002 and Tables 3.4 through 3.6.
2. Surface piping and conveyance systems other than discharge from the GAC system are covered under the remedial alternative.
3. Based on average measured turbidity, prefiltration of the groundwater is assumed to be necessary to prevent clogging of the carbon media.

TABLE 3.1 - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TG1
LIQUID-PHASE CARBON ADSORPTION FOR GROUNDWATER - 20 YEAR PURCHASE SCENARIO

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Electrical Consumption	33,750	kWH	$0.18	$6,075	EnviroSupply and S.C. Edison
2	Replacement Carbon (average over 20 years)	4,800	lbs	$1.05	$5,040	EnviroSupply and S.C. Gas Company
3	Carbon Analytical Profiling	4	per vessel	$350.00	$1,400	EnviroSupply Service Inc.
4	Carbon Disposal (average over 20 years)	4,800	lbs	$0.55	$2,640	EnviroSupply Service Inc.
5	Laboratory Analysis of Water Discharge	12	lump sum	$595.00	$7,140	Calscience Environmental Labs.
6	Maintenance/Replacement Parts	1	month	$950.00	$950	T N & Associates
7	Handling Fees (3%)	1	lump sum	$668.85	$669	T N & Associates
8	Contingency (10%)	1	lump sum	$2,229.50	$2,230	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$26,143**	
TN&A Labor						
9	Weekly Inspection and Monthly Sampling	520	hours	$85.00	$44,200	T N & Associates
10	Project Reporting and Management	520	hours	$65.00	$33,800	T N & Associates
	Subtotal (TN&A Labor)				**$78,000**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$104,143**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$104,143	4.25%	20	**$1,384,482**	Calculated using uniform series present worth factor.

Assumptions:

1. Replacement carbon costs are based on groundwater extraction and VOC removal rates explained in Tables 3.4 through 3.6.
2. Electrical rate for small business were provided by Southern California Edison (Los Angeles) and range from $.14 - $.21/kWH.
3. Lab analysis of vapor is based on weekly VOC analysis via EPA Method TO-15.
4. Lab analysis of water is based on monthly analysis for VOCs, Metals, and pH via EPA Methods 8260B, 6010B, and 9045, respectively.
5. Weekly inspections will be performed and reported in conjunction with the remediation system monitoring and compliance sampling.
6. The interest rate used in the present worth calculation (4.25%) is the reported Prime Rate (Nov. 2002).

TABLE 3.2 - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TG2
AIR STRIPPING FOR GROUNDWATER - 20 YEAR PURCHASE SCENARIO

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections (electric, gas, sewer)	1	lump sum	$6,805.00	$6,805	RS Means
3	Mobilization/Installation/Start-Up	1	lump sum	$12,920.00	$12,920	Schrader Environmental
4	Water Filtration Skid, (4)-bag filter, 500-gal tank, 1/2 HP pump, skid mount	1	lump sum	$16,452.00	$16,452	McMaster-Carr
5	Carbonaire Model STAT180 air stripper, 10 HP regen. Blower, NEMA 4 panel, skid mount. Flow rated at 10 to 200 gpm.	1	lump sum	$35,000.00	$35,000	Schrader Environmental
6	1200 lb Vapor Phase Carbon Adsorption Vessels	2	lump sum	$5,700.00	$11,400	Slaby Sales Inc.
7	Discharge Conveyance System	1	lump sum	$12,675.00	$12,675	McMaster-Carr and RS Means
8	Handling Fees (3%)	1	lump sum	$3,183.48	$3,183	T N & Associates
9	Contingency (10%)	1	lump sum	$10,611.60	$10,612	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$119,911**	
TN&A Labor						
10	Mechanical Assembly and Installation	120	hours	$85.00	$10,200	T N & Associates
11	Project Admin. and Management	80	hours	$65.00	$5,200	T N & Associates
	Subtotal (TN&A Labor)				**$15,400**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$135,311**	

Assumptions:

1. The 20 year cost scenario represents a likely outcome for ex-situ groundwater treatment and was created as a basis for comparison with other alternatives. The contaminant mass and removal rates are based on results of the high-vacuum dual phase extraction pilot test performed on the perched groundwater zone and the Exposition 'A' and 'B' Zones in December 2002 and Tables 3.4 through 3.6.
2. Surface piping and conveyance systems other than discharge from the Air Stripper are covered under the remedial alternative.
3. Based on average measured turbidity, prefiltration of the groundwater is assumed to be necessary to prevent fouling of the air stripping media.
4. Carbon treatment of the off-gasses is assumed based on proximity to residential neighborhoods and SCAQMD permit requirements.

TABLE 3.2 - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TG2
AIR STRIPPING FOR GROUNDWATER - 20 YEAR PURCHASE SCENARIO

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Electrical Consumption	113,400	kWH	$0.18	$20,412	Schrader and S.C. Edison
2	Replacement Carbon (average over 20 years)	4,800	lbs	$1.05	$5,040	EnviroSupply and S.C. Gas Company
3	Carbon Analytical Profiling	4	per vessel	$350.00	$1,400	EnviroSupply Service Inc.
4	Carbon Disposal (average over 20 years)	4,800	lbs	$0.55	$2,640	EnviroSupply Service Inc.
5	Prefiltration replacement filters and O&M	1	lump sum	$1,975.00	$1,975	Drewlow Engineering
6	Stripper Cleaning, Parts, and Maintenance	1	lump sum	$2,500.00	$2,500	T N & Associates
7	Laboratory Analysis of Vapor Discharge	12	month	$1,867.00	$22,404	Air Toxics
8	Laboratory Analysis of Water Discharge	12	month	$500.00	$6,000	Calscience Environmental Labs.
9	Handling Fees (3%)	1	lump sum	$1,871.13	$1,871	T N & Associates
10	Contingency (10%)	1	lump sum	$6,237.10	$6,237	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$70,479**	
TN&A Labor						
11	Weekly Inspection and Sampling	520	hours	$85.00	$44,200	T N & Associates
12	Project Reporting and Management	520	hours	$65.00	$33,800	T N & Associates
	Subtotal (TN&A Labor)				**$78,000**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$148,479**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$148,479	4.25%	20	**$1,973,883**	Calculated using uniform series present worth factor.

Assumptions:
1. Replacement carbon costs are based on VOC removal rates explained in Tables 3.4 through 3.6.
2. Electrical rate for small business were provided by Southern California Edison (Los Angeles) and range from \$.14 - \$.21/kWH.
3. Lab analysis of vapor is based on weekly VOC analysis via EPA Method TO-15.
4. Lab analysis of water is based on monthly analysis for VOCs, Metals, and pH via EPA Methods 8260B, 6010B, and 9045, respectively.
5. Weekly inspections will be performed and reported in conjunction with the remediation system monitoring and compliance sampling.
6. The interest rate used in the present worth calculation (4.25%) is the reported Prime Rate (Nov. 2002).

TABLE 3.3 - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TG3
UV OXIDATION FOR GROUNDWATER - 20 YEAR PURCHASE SCENARIO

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections (electric)	1	lump sum	$6,805.00	$6,805	RS Means
3	Mobilization/Installation/Start-Up	1	lump sum	$16,650.00	$16,650	T N & Associates
4	Rayox Reactor System. Flow rated at 170 gpm.	1	lump sum	$111,000.00	$111,000	Calgon Carbon
5	Discharge Conveyance System	1	lump sum	$12,675.00	$12,675	McMaster-Carr and RS Means
6	Handling Fees (3%)	1	lump sum	$4,739.82	$4,740	T N & Associates
7	Contingency (10%)	1	lump sum	$15,799.40	$15,799	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$178,533**	
TN&A Labor						
8	Mechanical Assembly and Installation	120	hours	$85.00	$10,200	T N & Associates
9	Project Admin. and Management	80	hours	$65.00	$5,200	T N & Associates
	Subtotal (TN&A Labor)				**$15,400**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$193,933**	

Assumptions:

1. The 20 year cost scenario represents a likely outcome for ex-situ groundwater treatment and was created as a basis for comparison with other alternatives. The contaminant mass and removal rates are based on results of the high-vacuum dual phase extraction pilot test performed on the perched groundwater zone and the Exposition 'A' and 'B' Zones in December 2002 and Tables 3.4 through 3.6.
2. Surface piping and conveyance systems other than discharge from the UV oxidation are covered under the remedial alternative.
3. Based on average measured turbidity, prefiltration of the groundwater is assumed to be necessary to prevent clogging of the carbon media.

TABLE 3.3 - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TG3
UV OXIDATION FOR GROUNDWATER - 20 YEAR PURCHASE SCENARIO

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Electrical Consumption	525,600	kWH	$0.18	$94,608	Calgon and S.C. Edison
2	Peroxide, Delivered as 50% Solution (in lbs)	31,755	lbs	$0.65	$20,641	Calgon Carbon
3	Maintenance, Parts, Lamp Replacement (Avg. 20 year)	1	lump sum	$9,007.00	$9,007	Calgon Carbon
4	Laboratory Analysis of Water Discharge	12	month	$500.00	$6,000	Calscience Environmental Labs.
5	Handling Fees (3%)	1	lump sum	$3,907.67	$3,908	T N & Associates
6	Contingency (10%)	1	lump sum	$13,025.58	$13,026	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$147,189**	
TN&A Labor						
7	Weekly Inspection and Sampling	520	hours	$85.00	$44,200	T N & Associates
8	Project Reporting and Management	520	hours	$65.00	$33,800	T N & Associates
	Subtotal (TN&A Labor)				**$78,000**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$225,189**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$225,189	4.25%	20	**$2,993,663**	Calculated using uniform series present worth factor.

Assumptions:

1. Electrical rate for small business were provided by Southern California Edison (Los Angeles) and range from $.14 - $.21/kWH.
2. Lab analysis of water is based on monthly analysis for VOCs, Metals, and pH via EPA Methods 8260B, 6010B, and 9045, respectively.
3. Weekly inspections will be performed and reported in conjunction with the remediation system monitoring and compliance sampling.
4. The interest rate used in the present worth calculation (4.25%) is the reported Prime Rate (Nov. 2002).

TABLE 3.4
GROUNDWATER EXTRACTION DESIGN SUMMARY FOR UPPER VADOSE AND PERCHED GROUNDWATER REMEDIATION ZONE (3 TO 35 FEET BGS)
ALTERNATIVE SP2a and SP2b

Item	Perched Zone Wells
Design No. of Wells	32
Average VOC Concentration (µg/L)	294
Average Pumping Rate Per Well (gpm)	0.4
Average Flow (gpm)	12.8
Daily Flow (gpd)	18,432
Initial Daily VOC Removal (lbs/day)	1.00

Notes:

1. Information is based on HVDPE Pilot Test. (See Appendix D)
2. No. of wells based on 54-foot radius of influence.
3. Average VOC concentration calculated from wells B-01, B-03, B-04, B-05, B-10, B-12, B-13, B-17 through B-27, B-30, B-31, B-32, B-33, B-36, B-37, and SV-01 through SV-05.
4. Pumping rate for perched zone wells is based on well purging/sampling logs.
5. Since pilot test was not performed in the area of highest concentration, the Initial Daily VOC Removal rate was increased by 2 orders of magnitude. Remediation of VOCs is in progress at the adjacent W.W. Henry Site. Wells in the vicinity of the W.W. Henry property may contribute significant amounts of additional VOCs depending on when the Pemaco remedial action is implemented.

µg/L - microgram per liter
gpm - gallons per minute
lbs/day - pounds per day

TABLE 3.5

GROUNDWATER EXTRACTION DESIGN SUMMARY FOR LOWER VADOSE AND EXPOSITION GROUNDWATER REMEDIATION ZONE (35 TO 100 FEET BGS) ALTERNATIVES SG2 AND SG3

Item	'A' Zone Wells[1]	'B' Zone Wells[2]	'A' & 'B' Zone Wells[3]	Totals of All Wells
Design Number of Wells[4]	3	3	9	15
Total Average VOC Concentration (µg/L)	12,503	6,227	36	2,368
Avg. Pumping Rate Per Well[5] (gpm)	2	2	4	NA
Total Average Flow (gpm)	6	6	36	48
Daily Flow (gpd)	8,640	8,640	51,840	69,120
Initial Daily VOC Removal (lbs/day)	0.19	0.09	0.003	0.281

Notes:

1. Average VOC concentration calculated from wells MW-18-70, MW-17-70, and MW 19-70.
2. Average VOC concentration calculated from wells MW-02-95, MW-13-85, MW-14-90, MW-17-85, and MW-19-90.
3. Average VOC concentration calculated from wells MW-07-75, MW-09-70, MW-09-85, and MW-13-85.
4. No. of wells based on 45-foot width of capture along downgradient axis and 69-foot width of capture along the crossgradient axis; to provide hydraulic control of the plume area.
5. Avg. pumping rate per well is a probable maximum flow rate based on pump tests and field observations.

µg/L - microgram per liter
gpm - gallons per minute
lbs/day - pounds per day

TABLE 3.6
GROUNDWATER EXTRACTION DESIGN SUMMARY FOR LOWER VADOSE AND EXPOSITION GROUNDWATER REMEDIATION ZONE (35 TO 100 FEET BGS)
ALTERNATIVES SG4a, SG4b, SG5a, and SG5b

Item	'A' Zone Wells[1]	'B' Zone Wells[2]	'A' & 'B' Zone Wells[3]	Totals of All Wells
Design Number of Wells[4]	13	13	9	35
Total Average VOC Concentration (µg/L)	21,000	0	36	6,219
Avg. Pumping Rate Per Well[5] (gpm)	2	2	4	NA
Total Average Flow (gpm)	26	26	36	88
Daily Flow (gpd)	37,440	37,440	51,840	126,720
Initial Daily VOC Removal (lbs/day)	1.35	0.00	0.003	1.353

Notes:

1. Average VOC concentration calculated from wells MW-18-70, MW-17-70, and MW 19-70.
2. Average VOC concentration calculated from wells MW-02-95, MW-13-85, MW-14-90, MW-17-85, and MW-19-90.
3. Average VOC concentration calculated from wells MW-07-75, MW-09-70, MW-09-85, and MW-13-85.
4. No. of wells based on 45-foot width of capture along downgradient axis and 69-foot width of capture along the crossgradient axis; to provide hydraulic control of the plume area.
5. Avg. pumping rate per well is a probable maximum flow rate based on pump tests and field observations.

µg/L - microgram per liter
gpm - gallons per minute
lbs/day - pounds per day

Table 4.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Soil Vapor
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES			
	TV1 – Granular Activated Carbon	**TV2 – Regenerative Granular Activated Carbon**	**TV3 – Catalytic Oxidation**	**TV4 – Flameless Thermal Oxidation**
1. Overall Protection of Human Health and the Environment.	• A properly designed GAC treatment system is protective of human health and the environment for the removal of most organic contaminants. • Treatment compound must be adequately secured, maintained, and monitored to prevent leaks and creation of exposure pathways. • The GAC treatment system requires routine monitoring and maintenance to assure effective capture of contaminants in accordance with discharge permits. • All used carbon eventually needs to be disposed in landfills.	• This alternative provides the same overall protection as TV1. The only difference would be additional maintenance and handling to assure effective capture of contaminants in accordance with discharge permits. • Regenerative carbon is being evaluated separate from GAC (TV1) because of the significant cost difference when treating high concentrations of VOCs that would be encountered with the ERH alternative for the lower vadose and Exposition groundwater remediation zone. • All used carbon eventually needs to be disposed in landfills after its regenerative capacity has been exhausted.	• A properly designed catalytic oxidizer treatment system is protective of human health and the environment for the removal of most organic contaminants. • Treatment compound must be adequately secured, maintained, and monitored to prevent leaks and creation of exposure pathways. • The catalytic oxidizer treatment system requires routine monitoring and maintenance to assure effective capture of contaminants in accordance with discharge permits. • COCs are effectively destroyed on-site.	• A properly designed FTO treatment system is protective of human health and the environment for the removal of most organic contaminants. • Treatment compound must be adequately secured, maintained, and monitored to prevent leaks and creation of exposure pathways. • The FTO treatment system requires routine monitoring and maintenance to assure effective capture of contaminants in accordance with discharge permits. • COCs are effectively destroyed on-site.

Table 4.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Soil Vapor
Pemaco Superfund Site, Maywood, California

Criterion	**TREATMENT ALTERNATIVES**			
	TV1 – Granular Activated Carbon	**TV2 – Regenerative Granular Activated Carbon**	**TV3 – Catalytic Oxidation**	**TV4 – Flameless Thermal Oxidation**
2. Compliance With ARARs and TBCs	• For treatment of the perched zone: 1,4-dioxane's low adsorptive capacity would likely result in non-compliance with ARARs and/or TBCs (discharge requirements). • Treatment of the deep zone using GAC would comply with ARARs and/or TBCs since 1,4 dioxane is only present in one well above the 1,4-dioxane TBC. • Engineering controls would be established to meet associated requirements for treatment, storage, and disposal of used carbon. • Some degradation products, such as vinyl chloride and smaller molecules (e.g., 1,4 dioxane) are not sorbed well. Consequently they must be monitored carefully; or if in high enough concentrations, a treatment alternative other than GAC should be used in order to be protective of the environment.	• This alternative provides the same level of compliance as TV1. • Additional engineering controls would be required for on-site regenerative processes to assure proper treatment, storage, and disposal of the COCs and used carbon.	• Treatment process would comply with all ARARs and TBCs discharge requirements. • The appropriate catalyst for the contaminated air stream would need to be selected to assure efficient COC destruction and compliance with discharge permits. • Engineering controls would be established to manage any residuals in accordance with requirements for treatment, storage, and disposal of solid wastes. • The formation of dioxin as a combustion byproduct may limit applicability. • A discharge gas scrubber would be required to reduce acid gas emissions. • Emissions of products of incomplete combustion (e.g.; dioxin) may exceed background concentrations.	• Treatment process is capable of exceeding all ARARs and TBCs discharge requirements. • Engineering controls would be established to manage any residuals in accordance with requirements for treatment, storage, and disposal of solid wastes. • A discharge gas scrubber would be required to reduce acid gas emissions. • Products of incomplete combustion (e.g.; dioxin) would likely be less than background concentrations.

Table 4.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Soil Vapor
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES			
	TV1 – Granular Activated Carbon	**TV2 – Regenerative Granular Activated Carbon**	**TV3 – Catalytic Oxidation**	**TV4 – Flameless Thermal Oxidation**
3. Long-Term Effectiveness And Permanence	• Carbon adsorption is a well proven and effective method of treatment over time when adequately operated and maintained. • COCs are adsorbed by the carbon; however, permanent destruction of the COCs would take place at an off-site approved facility. • Carbon adsorption is not as effective on low molecular weight VOCs such as vinyl chloride or COCs with low adsorptive capacity such as 1,4 dioxane. • Routine monitoring of the treatment process would be performed to assure effectiveness over time.	• This alternative provides the same level of long-term effectiveness as TV1.	• Catalytic oxidation is an effective method for treatment over time. • Contaminants are permanently destroyed on-site. • Not as effective if influent gas contains sulfur or some heavy metals, e.g., lead. • Destruction efficiencies are dependant on engineered modifications to adjust for influent gas COCs and concentrations. • Routine monitoring of the treatment process would be performed to assure effectiveness over time.	• Flameless thermal oxidation is a highly effective treatment process for the destruction of all VOCs. • Contaminants are permanently destroyed on-site. • Routine monitoring of the treatment process would be performed to assure effectiveness over time.

Table 4.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Soil Vapor
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES			
	TV1 – Granular Activated Carbon	**TV2 – Regenerative Granular Activated Carbon**	**TV3 – Catalytic Oxidation**	**TV4 – Flameless Thermal Oxidation**
4. Reduction of Toxicity, Mobility or Volume (TMV) in Through Treatment	• The mobility and volume of COCs are greatly reduced as they become adsorbed to the GAC. • Toxicity is not reduced on-site but is typically performed at the disposal facility via thermal oxidation. • Carbon that has exceeded its useful lifespan would be transported for off-site regeneration or landfilling. • Some degradation products, such as vinyl chloride and smaller molecules (e.g., 1,4 dioxane) are not adsorbed well. Consequently they must be monitored carefully to be sure the TMV of these contaminants are being addressed.	• This alternative provides similar reductions in TMV as Alternative TV1. • The volume of contaminants is further reduced on-site through the regenerative stripping process. The concentrated volume of stripped free-product can eventually be recycled.	• The contaminants are locally destroyed resulting in a permanent reduction in TMV. • The generation of acid gasses can be controlled through the operation of a scrubber. • There is the potential for the formation of combustion by-products; e.g. dioxin, that would have to be monitored.	• The contaminants are locally destroyed resulting in a permanent reduction in TMV. • The generation of acid gasses can be controlled through the operation of a scrubber.

Table 4.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Soil Vapor
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES			
	TV1 – Granular Activated Carbon	**TV2 – Regenerative Granular Activated Carbon**	**TV3 – Catalytic Oxidation**	**TV4 – Flameless Thermal Oxidation**
5. Short-term Effectiveness	• Transportation of used carbon to an off-site facility for regeneration or disposal would encounter hazardous waste manifesting issues and increase local traffic. • Risks to workers performing monitoring activities can be controlled and mitigated with proper health and safety measures; e.g., air monitoring and PPE.	• This alternative provides a similar degree of short-term effectiveness as Alternative TV1. • There would be fewer trucks required for transportation since the carbon would be regenerated on-site. • Regenerative process would present additional worker hazards during GAC handling.	• The catalytic oxidation system has a tendency to produce combustion by-products; e.g., dioxin. • Risks to workers performing monitoring activities can be controlled and mitigated with proper health and safety measures; e.g., air monitoring and PPE. • Evaluation of the air emissions may be required to demonstrate no significant impact to the community from combustion by-products.	• Flameless thermal oxidation has a reduced tendency over thermal or catalytic oxidation to produce combustion by-products; e.g. dioxin. • Risks to workers performing monitoring activities can be controlled and mitigated with proper health and safety measures; e.g., air monitoring and PPE. • Evaluation of the air emissions may be required to demonstrate no significant impact to the community from combustion by-products.

Table 4.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Soil Vapor
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES			
	TV1 – Granular Activated Carbon	**TV2 – Regenerative Granular Activated Carbon**	**TV3 – Catalytic Oxidation**	**TV4 – Flameless Thermal Oxidation**
6. Implementability	• Carbon treatment is a mature and very reliable technology with many vendors. No unusual technical problems are anticipated. • Operation and maintenance personnel, materials, and utilities are readily available. • This alternative is administratively feasible since state and local agency permits are routinely issued. • The system can be modified or improved based on treatment results. • The carbon treatment system requires occupation of a small area of the MRP until the cleanup objectives are reached.	• This alternative provides a similar degree of implementability as Alternative TV1 with the exception that there is a higher operation and maintenance requirement to have the regeneration process on-site. • There are many vendors of regeneration equipment. • The regeneration system is administratively feasible since state and local agency permits are routinely issued. • The regeneration system can be removed if it becomes inefficient over time; due to reduced contaminant loading.	• Catalytic oxidation is a mature technology with many vendors and no unusual technical problems. • Operation and maintenance, personnel, materials, and utilities are available or in place since oxidation system had been previously operated at the site. • The administrative feasibility of obtaining permits is uncertain since the previous oxidation system at the site was shut down under community protest of dioxin emissions – a by-product of combustion. • Modifications may cause significant downtime if contaminant loading contains compounds that foul the catalyst; e.g., sulfur, or some chlorinated compounds. • The catalytic oxidation system requires occupation of a small area of the MRP until the cleanup objectives are reached.	• Flameless thermal oxidation is a mature technology with many vendors and no unusual technical problems. • Operation and maintenance personnel, materials, and utilities are available or in place since a similar technology (oxidation) had been previously operated at the site. • The alternative is anticipated to be administratively feasible since similar systems have been operating in the SCAQMD since 1998 and the system does not have measurable emissions of dioxin – a by-product of combustion. • No modifications would be anticipated. • The flameless thermal oxidation system requires occupation of a small area of the MRP until the cleanup objectives are reached.

Table 4.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Soil Vapor
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES							
	TV1 – Granular Activated Carbon		TV2 – Regenerative Granular Activated Carbon		TV3 – Catalytic Oxidation		TV4 – Flameless Thermal Oxidation	
7. Estimated Cost[1]	**1 YR Scenario**	**20 YR Scenario**	**1 YR Scenario**	**20 YR Scenario**	**1 YR Scenario**	**20 YR Scenario**	**1 YR Scenario**	**20 YR Scenario**
Direct Capital Cost	$39,000	$80,000	$64,000	$433,000	$81,000	$416,000	$88,000	$613,000
Annual O&M Cost	$2,084,000	$215,000	$902,000	$196,000	$990,000	$362,000	$1,018,000	$467,000
O&M Present Worth	N/A	$2,860,000	N/A	$2,610,000	N/A	$4,812,000	N/A	$6,205,000
Total Present Worth	$2,123,000	$2,940,000	$965,000	$3,042,000	$1,071,000	$5,228,000	$1,106,000	$6,819,000
8. State Acceptance	• Statewide acceptance under CalEPA on numerous projects. • SCAQMD approval of discharge permits would be required. • Further comments will be addressed in the ROD after public comment period.		• This alternative provides the same degree of state acceptance as Alternative TV1.		• Statewide acceptance under CalEPA on numerous projects. • SCAQMD approval of discharge permits would be required. • Further comments will be addressed in the ROD after public comment period.		• Statewide acceptance under CalEPA on numerous projects. • SCAQMD approval of discharge permits would be required. • Further comments will be addressed in the ROD after public comment period	

Table 4.0
Detailed Evaluation of Remedial Alternatives – *Ex-Situ* Treatment Alternatives for Soil Vapor
Pemaco Superfund Site, Maywood, California

Criterion	TREATMENT ALTERNATIVES			
	TV1 – Granular Activated Carbon	**TV2 – Regenerative Granular Activated Carbon**	**TV3 – Catalytic Oxidation**	**TV4 – Flameless Thermal Oxidation**
9. Community Acceptance	• System would be operated above-ground leading to potential conflicts with future park activities. • Further comments will be addressed in the during the public comment period.	• This alternative provides the same degree of state acceptance as Alternative TV1.	• Certain members of public opposed thermal oxidation treatment that was associated with operation of SVE system in 1999. • System would be operated aboveground leading to potential conflicts with future park activities. • Further comments will be addressed in the during the public comment period.	• System would be operated above-ground leading to potential conflicts with future park activities. • Further comments will be addressed in the during the public comment period.

1. Refer to Tables 4.5 and 4.6 for a detailed analysis of capital, operations and maintenance costs, and present worth assumptions. The present worth calculation was performed for a 20 yr term at 4.25% interest.

TABLE 4.1A - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV1
VAPOR-PHASE CARBON ADSORPTION - 1 YEAR LEASE SCENARIO

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Temp. Treatment Compound - Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections (electric)	1	lump sum	$6,805.00	$6,805	RS Means
3	Mobilization/Demobilization	2	each	$2,400.00	$4,800	EnviroSupply Service Inc.
4	Installation and Start-Up	1	lump sum	$3,200.00	$3,200	EnviroSupply Service Inc.
5	Handling Fees (3%)	1	lump sum	$770.07	$770	T N & Associates
6	Contingency (10%)	1	lump sum	$2,566.90	$2,567	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$29,006**	
TN&A Labor						
7	Construction Manager	75	hour	$85.00	$6,375	T N & Associates
8	Project Admin. and Management	50	lump sum	$65.00	$3,250	T N & Associates
	Subtotal (TN&A Labor)				**$9,625**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$38,631**	

Note:
All equipment lease costs are included below.

TABLE 4.1A - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV1
VAPOR-PHASE CARBON ADSORPTION - 1 YEAR LEASE SCENARIO

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Lease (2)-2000 lb Vapor Phase Carbon Adsorp. Vessel	12	month	$800.00	$9,600	EnviroSupply Service Inc.
2	Electrical Consumption	75,000	kWH	$0.18	$13,500	EnviroSupply and S.C. Edison
3	Replacement Carbon	928,000	lbs	$1.05	$974,400	EnviroSupply and S.C. Gas Company
4	Carbon Analytical Profiling	464	per vessel	$350.00	$162,400	EnviroSupply Service Inc.
5	Carbon Disposal	928,000	lbs	$0.55	$510,400	EnviroSupply Service Inc.
6	Blower and System Maintenance	1	lump sum	$2,200.00	$2,200	T N & Associates
7	Laboratory Analysis of Vapor Discharge	12	month	$1,867.14	$22,406	Air Toxics
8	Handling Fees (3%)	1	lump sum	$50,559.17	$50,559	T N & Associates
9	Contingency (10%)	1	lump sum	$168,530.57	$168,531	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$1,913,995**	
TN&A Labor						
10	Weekly Inspection and Sampling	1,560	hours	$85.00	$132,600	T N & Associates
11	Project Reporting and Management	580	hours	$65.00	$37,700	T N & Associates
	Subtotal (TN&A Labor)				**$170,300**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$2,084,295**	

Assumptions:

1. Replacement carbon costs are based on VOC removal rates explained in Tables 4.5 and 4.6.
2. Lab analysis of vapor is based on weekly VOC analysis via EPA Method TO-15.
3. Weekly inspections will be performed and reported in conjunction with the remediation system monitoring and compliance sampling.

TABLE 4.1B - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV1
VAPOR-PHASE CARBON ADSORPTION - 20 YEAR PURCHASE SCENARIO

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections (electric)	1	lump sum	$6,805.00	$6,805	RS Means
3	Mobilization/Demobilization	2	each	$3,000.00	$6,000	EnviroSupply Service, Inc.
4	2000 lb Vapor Phase Carbon Adsorption Vessels	2	lump sum	$10,400.00	$20,800	EnviroSupply Service, Inc.
5	Installation and Start-Up	1	lump sum	$7,320.00	$7,320	EnviroSupply Service, Inc.
6	Handling Fees (3%)	1	lump sum	$1,553.67	$1,554	T N & Associates
7	Contingency (10%)	1	lump sum	$5,178.90	$5,179	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$58,522**	
TN&A Labor						
8	Construction Manager	200	hour	$85.00	$17,000	T N & Associates
9	Project Admin. and Management	75	lump sum	$65.00	$4,875	T N & Associates
	Subtotal (TN&A Labor)				**$21,875**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$80,397**	

Assumptions:

1. The 20 year cost scenario for ex-situ vapor treatment was created as a basis for comparison with other alternatives. The contaminant mass and removal rates are based on results of the high-vacuum dual phase extraction pilot test performed on the perched groundwater zone and the Exposition 'A' and 'B' Zones in December 2002 and Tables 4.5 and 4.6.
2. The cost to replace the blower after 10 years has been annualized and included as an annual cost.
3. The salvage value of the equipment after 20 years is not considered for any of the treatment alternatives.
4. Surface piping and conveyance systems are include with costs for the primary remedial treatment alternative.

TABLE 4.1B - DETAILED COST SUMMARY FOR REMEDIAL ALTERNATIVE TV1
VAPOR-PHASE CARBON ADSORPTION - 20 YEAR PURCHASE SCENARIO

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Electrical Consumption	75,000	kWH	$0.18	$13,500	EnviroSupply and S.C. Edison
2	Replacement Carbon (average over 20 years)	46,000	lbs	$1.05	$48,300	EnviroSupply and S.C. Gas Company
3	Carbon Analytical Profiling	23	per vessel	$350.00	$8,050	EnviroSupply Service Inc.
4	Carbon Disposal	46,000	lbs	$0.55	$25,300	EnviroSupply Service Inc.
5	System Maintenance	1	lump sum	$3,800.00	$3,800	T N & Associates
7	Laboratory Analysis of Vapor Discharge	12	month	1,867.14	$22,406	Air Toxics
8	Handling Fees (3%)	1	lump sum	$3,640.67	$3,641	T N & Associates
9	Contingency (10%)	1	lump sum	$12,135.57	$12,136	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$137,132**	
TN&A Labor						
10	Weekly Inspection and Sampling	520	hours	$85.00	$44,200	T N & Associates
11	Project Reporting and Management	520	hours	$65.00	$33,800	T N & Associates
	Subtotal (TN&A Labor)				**$78,000**	
TOTAL ANNUAL OPERATION AND MAINTENANCI					**$215,132**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$215,132	4.25%	20	**$2,859,964**	Calculated using uniform series present worth factor.

Assumptions:

1. Replacement carbon costs are based on VOC removal rates explained in Tables 4.5 and 4.6.
2. Lab analysis of vapor is based on bi-weekly VOC analysis via EPA Method TO-15.
3. A major blower overhaul or replacement cost is assumed to occur at year 10. This cost has been annualized and included above.
4. Weekly inspections will be performed and reported in conjunction with the remediation system monitoring and compliance sampling.

TABLE 4.2A - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV2
VAPOR-PHASE CARBON ADSORPTION WITH ONSITE REGENERATION - 1 YEAR LEASE SCENARIO

Treatment Equipment Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Temp. Treatment Compound - Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections (electric)	1	lump sum	$6,805.00	$6,805	RS Means
3	Mobilization/Demobilization	4	each	$3,200.00	$12,800	EnviroSupply Service Inc.
4	Installation and Start-Up	1	lump sum	$4,800.00	$4,800	EnviroSupply Service Inc.
5	Handling Fees (3%)	1	lump sum	$1,058.07	$1,058	T N & Associates
6	Contingency (10%)	1	lump sum	$3,526.90	$3,527	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$39,854**	
TN&A Labor						
7	Construction Manager	220	hour	$85.00	$18,700	T N & Associates
8	Project Admin. and Management	80	lump sum	$65.00	$5,200	T N & Associates
	Subtotal (TN&A Labor)				**$23,900**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$63,754**	

Note:

All equipment lease costs are included below.

TABLE 4.2A - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV2
VAPOR-PHASE CARBON ADSORPTION WITH ONSITE REGENERATION - 1 YEAR LEASE SCENARIO

Annual Costs

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Lease (2)-2000 lb Vapor Phase Carbon Adsorp. Vessel	12	month	$400.00	$4,800	EnviroSupply Service Inc.
2	Lease Carbon Regeration Bed (steam), 2000 lb.	12	month	$7,800.00	$93,600	Process Engineering Services
3	Lease Product Recovery/Separator System	12	month	$3,300.00	$39,600	Process Engineering Services
4	Electrical Consumption	75,000	kWH	$0.18	$13,500	EnviroSupply and S.C. Edison
5	Gas Consumption	118,000	therm	$0.86	$101,480	The Gas Company & PES
6	Replacement Carbon	186,000	lbs	$1.05	$195,300	EnviroSupply Service Inc.
7	Carbon Analytical Profiling	93	per vessel	$350.00	$32,550	EnviroSupply Service Inc.
8	Carbon Disposal	186,000	lbs	$0.55	$102,300	EnviroSupply Service Inc.
9	Haxardous Waste Liquid Transportation and Disposal	13,143	Gal	$3.00	$39,429	T N & Associates
10	System Maintenance	1	lump sum	$2,200.00	$2,200	T N & Associates
11	Laboratory Analysis of Vapor Discharge	12	month	$1,867.14	$22,406	Air Toxics
12	Handling Fees (3%)	1	lump sum	$19,414.93	$19,415	T N & Associates
13	Contingency (10%)	1	lump sum	$64,716.43	$64,716	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$731,296**	
TN&A Labor						
14	Weekly Inspection and Sampling	1,560	hours	$85.00	$132,600	T N & Associates
15	Project Reporting and Management	580	hours	$65.00	$37,700	T N & Associates
	Subtotal (TN&A Labor)				**$170,300**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$901,596**	

Assumptions:

1. Lab analysis of vapor is based on weekly VOC analysis via EPA Method TO-15.
2. Weekly inspections will be performed and reported in conjunction with the remediation system monitoring and compliance sampling.

TABLE 4.2B - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV2
VAPOR-PHASE CARBON ADSORPTION WITH ONSITE REGENERATION - 20 YEAR PURCHASE SCENARIO

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections (electric)	1	lump sum	$6,805.00	$6,805	RS Means
3	Mobilization/Demobilization	4	each	$3,200.00	$12,800	EnviroSupply Service, Inc.
4	2000 lb Vapor Phase Carbon Adsorption Vessels	2	lump sum	$4,800.00	$9,600	EnviroSupply Service, Inc.
5	Carbon Regeration Bed (steam), 2000 lb.	1	lump sum	$195,000.00	$195,000	Process Engineering Services
6	Product Recovery/Separator System	1	lump sum	$118,800.00	$118,800	Process Engineering Services
7	Installation and Start-Up	1	lump sum	$4,800.00	$4,800	EnviroSupply Service, Inc.
8	Handling Fees (3%)	1	lump sum	$10,760.07	$10,760	T N & Associates
9	Contingency (10%)	1	lump sum	$35,866.90	$35,867	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$405,296**	
TN&A Labor						
10	Construction Manager	260	hour	$85.00	$22,100	T N & Associates
11	Project Admin. and Management	80	lump sum	$65.00	$5,200	T N & Associates
	Subtotal (TN&A Labor)				**$27,300**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$432,596**	

Assumptions:

1. The 20 year cost scenario for ex-situ vapor treatment was created as a basis for comparison with other alternatives.
   The contaminant mass and removal rates are based on results of the high-vacuum dual-phase extraction pilot test performed on the perched groundwater zone and the Exposition 'A' and 'B' Zones in December 2002 and Tables 4.5 and 4.6.
2. The cost to replace the blower after 10 years has been annualized and included as an annual cost.
3. The salvage value of the equipment after 20 years is not considered for any of the treatment alternatives.
4. Surface piping and conveyance systems are include with costs for the primary remedial treatment alternative.

TABLE 4.2B - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV2
VAPOR-PHASE CARBON ADSORPTION WITH ONSITE REGENERATION - 20 YEAR PURCHASE SCENARIO

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Electrical Consumption	75,000	kWH	$0.18	$13,500	EnviroSupply and S.C. Edison
2	Gas Consumption (average over 20 years)	30,000	therm	$0.86	$25,800	The Gas Company & PES
3	Replacement Carbon (average over 20 years)	10,000	lbs	$1.05	$10,500	EnviroSupply and S.C. Gas Co.
4	Carbon Analytical Profiling	5	per vessel	$350.00	$1,750	EnviroSupply Service Inc.
5	Carbon Disposal	10,000	lbs	$0.55	$5,500	EnviroSupply Service Inc.
6	Haz. Liquid Transport. & Disposal (avg. over 20 years)	657	Gal	$3.00	$1,971	T N & Associates
7	System Maintenance	1	lump sum	$2,200.00	$2,200	T N & Associates
8	Laboratory Analysis of Vapor Discharge	12	month	$1,867.14	$22,406	Air Toxics
9	Handling Fees (3%)	1	lump sum	$2,508.81	$2,509	T N & Associates
10	Contingency (10%)	1	lump sum	$8,362.71	$8,363	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$94,499**	
TN&A Labor						
11	Weekly Inspection and Sampling	800	hours	$85.00	$68,000	T N & Associates
12	Project Reporting and Management	520	hours	$65.00	$33,800	T N & Associates
	Subtotal (TN&A Labor)				**$101,800**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$196,299**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$196,299	4.25%	20	**$2,609,594**	Calculated using uniform series present worth factor.

Assumptions:
1. Lab analysis of vapor is based on bi-weekly VOC analysis via EPA Method TO-15.
2. A major blower overhaul or replacement cost is assumed to occur at year 10. This cost has been annualized and included above.
3. Weekly inspections will be performed and reported in conjunction with the remediation system monitoring and compliance sampling.
4. The interest rate used in the present worth calculation (4.25%) is the reported Prime Rate (Nov. 2002).

TABLE 4.3A - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV3
CATALYTIC OXIDATION OF EXTRACTED VAPOR - 1 YEAR LEASE SCENARIO

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections (electric, gas, sewer)	1	lump sum	$6,805.00	$6,805	RS Means
3	Mobilization/Demobilization	2	each	$8,000.00	$16,000	Soleco
4	Installation and Start-Up	1	lump sum	$4,200.00	$4,200	Soleco
5	Discharge Conveyance System	1	lump sum	$12,675.00	$12,675	McMaster-Carr and RS Means
6	Handling Fees (3%)	1	lump sum	$1,516.32	$1,516	T N & Associates
7	Contingency (10%)	1	lump sum	$5,054.40	$5,054	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$57,115**	
TN&A Labor						
8	Mechanical Assembly and Installation	220	hour	$85.00	$18,700	T N & Associates
9	Project Admin. and Management	80	lump sum	$65.00	$5,200	T N & Associates
	Subtotal (TN&A Labor)				**$23,900**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$81,015**	

Assumptions:

1. The contaminant mass and removal rates are based on results of the high-vacuum dual-phase extraction pilot test performed on the perched groundwater zone and the Exposition 'A' and 'B' Zones in December 2002 and Tables 4.5 and 4.6.
2. Estimated system performance is for 98.0 - 99.0% VOC destruction.
3. Surface piping and conveyance systems other than discharge from the CATOX unit are covered under the remedial alternative.

TABLE 4.3A - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV3
CATALYTIC OXIDATION OF EXTRACTED VAPOR - 1 YEAR LEASE SCENARIO

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Electrical Consumption	283,824	kWH	$0.18	$51,088	Soleco and S.C. Edison
2	Water Consumption	24,312	100 c.f.	$1.67	$40,601	Soleco and Maywood Mutual Water Co.
3	Gas Consumption	193,440	therm	$0.86	$166,358	Soleco and S. Cal Gas Company
4	Sodium Hydroxide (25%)	144,540	gal	$1.10	$158,994	Bionomic
5	Soleco CATOX Lease (2) 1,200 scfm	12	month	$15,000.00	$180,000	Soleco
6	ScrubPac 1000 SCFM HCL Scrubber	12	month	$2,200.00	$26,400	Bionomic Industries
7	Soleco CATOX Maintenance Plan	1	lump sum	$13,500.00	$13,500	Soleco
8	Laboratory Analysis of Vapor Discharge	12	month	$7,185.00	$86,220	Air Toxics
9	Laboratory Analysis of Water Discharge	12	month	$500	$6,000	Calscience Environmental Labs.
10	Handling Fees (3%)	1	lump sum	$21,874.85	$21,875	T N & Associates
11	Contingency (10%)	1	lump sum	$72,916.18	$72,916	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$823,953**	
TN&A Labor						
12	Weekly Inspection and Sampling	1,560	hours	$85.00	$132,600	T N & Associates
13	Project Reporting and Management	520	hours	$65.00	$33,800	T N & Associates
	Subtotal (TN&A Labor)				**$166,400**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$990,353**	

Assumptions:

1. Lab analysis of vapor is based on weekly VOC analysis via EPA Method TO-15 and monthly analysis for dioxin/furans via EPA Method 23A (collection) and 8290.
2. Lab analysis of water is based on monthly analysis for VOCs, Metals, and pH via EPA Methods 8260B, 6010B, and 9045, respectively.
3. Weekly inspections will be performed and reported in conjunction with the remediation system monitoring and compliance sampling.
4. Vapor discharge sampling includes dioxin/furan which may be reduced after a demonstration period.

TABLE 4.3B - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV3
CATALYTIC OXIDATION OF EXTRACTED VAPOR - 20 YEAR PURCHASE SCENARIO

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections (electric, gas, sewer)	1	lump sum	$6,805.00	$6,805	RS Means
3	Mobilization/Installation/Start-Up	1	lump sum	$12,920.00	$12,920	AdwestTechnologies
4	ADWEST RETOX Thermal Oxidizer (1000 SCFM)	2	lump sum	$113,585.00	$227,170	AdwestTechnologies
5	ScrubPac 1000 SCFM HCL Scrubber	2	lump sum	$36,000.00	$72,000	Bionomic Industries
7	Discharge Conveyance System	1	lump sum	$12,675.00	$12,675	McMaster-Carr and RS Means
8	Handling Fees (3%)	1	lump sum	$10,273.02	$10,273	T N & Associates
9	Contingency (10%)	1	lump sum	$34,243.40	$34,243	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$386,950**	
TN&A Labor						
10	Mechanical Assembly and Installation	280	hour	$85.00	$23,800	T N & Associates
11	Project Admin. and Management	80	lump sum	$65.00	$5,200	T N & Associates
	Subtotal (TN&A Labor)				**$29,000**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$415,950**	

Assumptions:

1. The 20 year cost scenario for ex-situ vapor treatment was created as a basis for comparison with other alternatives. The contaminant mass and removal rates are based on results of the high-vacuum dual-phase extraction pilot test performed on the perched groundwater zone and the Exposition 'A' and 'B' Zones in December 2002 and Tables 4.5 and 4.6.
2. Estimated system performance is for 98.0 - 99.0% VOC destruction.
3. Surface piping and conveyance systems other than discharge from the CATOX unit are covered under the remedial alternative.
4. Assumed that the purchased Adwest unit will depreciate to zero by the end of the project.

TABLE 4.3B - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV3
CATALYTIC OXIDATION OF EXTRACTED VAPOR - 20 YEAR PURCHASE SCENARIO

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Electrical Consumption	94,608	kWH	$0.18	$17,029	Adwest and S.C. Edison
2	Water Consumption	13,070	100 c.f.	$1.67	$21,827	Adwest and Maywood Mutual Water Co.
3	Gas Consumption	64,480	therm	$0.86	$55,453	Adwest and S. Cal Gas Company
4	Sodium Hydroxide (25%)	24,500	gal	$1.10	$26,950	Adwest
5	Adwest Service Contract and Refurbishment Plan	2	lump sum	$8,384.00	$16,768	Adwest
6	Laboratory Analysis of Vapor Discharge	12	month	$7,185.00	$86,220	Air Toxics
7	Laboratory Analysis of Water Discharge	12	month	$500	$6,000	Calscience Environmental Labs.
8	Handling Fees (3%)	1	lump sum	$6,907.41	$6,907	T N & Associates
9	Contingency (10%)	1	lump sum	$23,024.71	$23,025	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$260,179**	
TN&A Labor						
10	Weekly Inspection and Sampling	800	hours	$85.00	$68,000	T N & Associates
11	Project Reporting and Management	520	hours	$65.00	$33,800	T N & Associates
	Subtotal (TN&A Labor)				**$101,800**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$361,979**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$361,979	4.25%	20	**$4,812,152**	Calculated using uniform series present worth factor.

Assumptions:

1. Lab analysis of vapor is based on weekly VOC analysis via EPA Method TO-15 and monthly analysis for dioxin/furans via EPA Method 23A (collection) and 8290.
2. Lab analysis of water is based on monthly analysis for VOCs, Metals, and pH via EPA Methods 8260B, 6010B, and 9045, respectively.
3. Weekly inspections will be performed and reported in conjunction with the remediation system monitoring and compliance sampling.
4. Vapor discharge sampling includes dioxin/furan which may be reduced after a demonstration period.
5. The interest rate used in the present worth calculation (4.25%) is the reported Prime Rate (Nov. 2002).

TABLE 4.4A - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV4
FLAMELESS THERMAL OXIDATION OF EXTRACTED VAPOR - 1 YEAR LEASE SCENARIO

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections (electric, gas, sewer)	1	lump sum	$6,805.00	$6,805	RS Means
4	Mobilization/Demobilization	2	each	$8,000.00	$16,000	Alzeta
5	Installation and Start-Up	1	lump sum	$10,400.00	$10,400	Alzeta
6	Discharge Conveyance System	1	lump sum	$12,675.00	$12,675	McMaster-Carr and RS Means
7	Handling Fees (3%)	1	lump sum	$1,702.32	$1,702	T N & Associates
8	Contingency (10%)	1	lump sum	$5,674.40	$5,674	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$64,121**	
TN&A Labor						
9	Construction Manager	220	hour	$85.00	$18,700	T N & Associates
10	Project Admin. and Management	80	lump sum	$65.00	$5,200	T N & Associates
	Subtotal (TN&A Labor)				**$23,900**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$88,021**	

Assumptions:

1. The contaminant mass and removal rates are based on results of the high-vacuum dual-phase extraction pilot test performed on the perched groundwater zone and the Exposition 'A' and 'B' Zones in December 2002 and Tables 4.5 and 4.6.
2. Estimated system performance is for 99.0 - 99.9999% VOC destruction.
3. Assumed that the purchased Alzeta FTO unit will depreciate to zero by the end of the project.
4. Surface piping and conveyance systems other than discharge from the FTO are covered under the remedial alternative.

TABLE 4.4A - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV4
FLAMELESS THERMAL OXIDATION OF EXTRACTED VAPOR - 1 YEAR LEASE SCENARIO

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Electrical Consumption	346,896	kWH	$0.18	$62,441	Alzeta and S.C. Edison
2	Water Consumption	24,312	100 c.f.	$1.67	$40,601	Alzeta and Maywood Mutual Water Co.
3	Gas Consumption	304,848	therm	$0.69	$210,345	Alzeta and S. Cal Gas Company
4	Sodium Hydroxide Additive	144,540	gal	$1.10	$158,994	Alzeta
5	Alzeta 2000 scfm FTO - Lease	12	month	$18,750.00	$225,000	Alzeta
6	Alzeta Service Contract Plan	1	lump sum	$10,356.00	$10,356	Alzeta
7	Laboratory Analysis of Vapor Discharge	12	month	$6,587.00	$79,044	Air Toxics
8	Laboratory Analysis of Water Discharge	12	month	$500	$6,000	Calscience Env. Labs.
9	Handling Fees (3%)	1	lump sum	$23,783.44	$23,783	T N & Associates
10	Contingency (10%)	1	lump sum	$79,278.14	$79,278	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$895,843**	
TN&A Labor						
11	Weekly Inspection and Sampling	1,040	hours	$85.00	$88,400	T N & Associates
12	Project Reporting and Management	520	hours	$65.00	$33,800	T N & Associates
	Subtotal (TN&A Labor)				**$122,200**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$1,018,043**	

Assumptions:

1. Lab analysis of vapor is based on weekly VOC analysis via EPA Method TO-15.
2. Lab analysis of water is based on monthly analysis for VOCs, Metals, and pH via EPA Methods 8260B, 6010B, and 9045, respectively.
3. Weekly inspections will be performed and reported in conjunction with the remediation system monitoring and compliance sampling.
4. Dioxin/furan sampling is not considered a necessary requirement for this system.

TABLE 4.4B - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV4
FLAMELESS THERMAL OXIDATION OF EXTRACTED VAPOR - 20 YEAR PURCHASE SCENARIO

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections (electric, gas, sewer)	1	lump sum	$6,805.00	$6,805	RS Means
3	Mobilization/Demobilization	2	each	$1,750.00	$3,500	Alzeta
4	Alzeta 2000 scfm FTO - Purchase	1	lump sum	$365,000.00	$365,000	Alzeta
5	Heat Exchanger (for 40% fuel savings, included below)	1	lump sum	$120,000.00	$120,000	Alzeta
6	Installation and Start-Up	1	lump sum	$10,400.00	$10,400	Alzeta
7	Discharge Conveyance System	1	lump sum	$12,675.00	$12,675	McMaster-Carr and RS Means
8	Handling Fees (3%)	1	lump sum	$15,877.32	$15,877	T N & Associates
9	Contingency (10%)	1	lump sum	$52,924.40	$52,924	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$598,046**	
TN&A Labor						
10	Construction Manager	120	hour	$85.00	$10,200	T N & Associates
11	Project Admin. and Management	80	lump sum	$65.00	$5,200	T N & Associates
	Subtotal (TN&A Labor)				**$15,400**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$613,446**	

Assumptions:

1. The 20 year cost scenario for ex-situ vapor treatment was created as a basis for comparison with other alternatives. The contaminant mass and removal rates are based on results of the high-vacuum dual-phase extraction pilot test performed on the perched groundwater zone and the Exposition 'A' and 'B' Zones in December 2002 and Tables 4.5 and 4.6.
2. Estimated system performance is for 99.0 - 99.9999% VOC destruction.
3. Assumed that the purchased Alzeta FTO unit will depreciate to zero by the end of the project.
4. Surface piping and conveyance systems other than discharge from the FTO are covered under the remedial alternative.

TABLE 4.4B - DETAILED COST SUMMARY FOR TREATMENT ALTERNATIVE TV4
FLAMELESS THERMAL OXIDATION OF EXTRACTED VAPOR - 20 YEAR PURCHASE SCENARIO

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Electrical Consumption	113,530	kWH	$0.18	$20,435	Alzeta and S.C. Edison
2	Water Consumption	12,156	100 c.f.	$1.67	$20,301	Alzeta and Maywood Mutual Water Co.
3	Gas Consumption	240,080	therm	$0.69	$165,655	Alzeta and S. Cal Gas Company
4	Sodium Hydroxide Additive	19,272	gal	$1.10	$21,199	Alzeta
5	Alzeta Service Contract and Refurbishment Plan	1	lump sum	$10,356.00	$10,356	Alzeta
6	Laboratory Analysis of Vapor Discharge	12	month	$6,587.00	$79,044	Air Toxics
7	Laboratory Analysis of Water Discharge	12	month	$500	$6,000	Calscience Env. Labs.
8	Handling Fees (3%)	1	lump sum	$9,689.71	$9,690	T N & Associates
9	Contingency (10%)	1	lump sum	$32,299.02	$32,299	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$364,979**	
TN&A Labor						
10	Weekly Inspection and Sampling	800	hours	$85.00	$68,000	T N & Associates
11	Project Reporting and Management	520	hours	$65.00	$33,800	T N & Associates
	Subtotal (TN&A Labor)				**$101,800**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$466,779**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$466,779	4.25%	20	**$6,205,360**	Calculated using uniform series present worth factor.

Assumptions:
1. Lab analysis of vapor is based on weekly VOC analysis via EPA Method TO-15.
2. Lab analysis of water is based on monthly analysis for VOCs, Metals, and pH via EPA Methods 8260B, 6010B, and 9045, respectively.
3. Weekly inspections will be performed and reported in conjunction with the remediation system monitoring and compliance sampling.
4. Dioxin/furan sampling is not considered a necessary requirement for this system.
5. The interest rate used in the present worth calculation (4.25%) is the reported Prime Rate (Nov. 2002).

TABLE 4.5

VAPOR EXTRACTION SYSTEM DESIGN SUMMARY FOR UPPER VADOSE AND PERCHED GROUNDWATER REMEDIATION ZONE (3 TO 35 FEET BGS)

MASS REMOVAL ESTIMATE

Application	Design Number of Wells in Perched Zone[1]	Number of Wells Simultaneously On-Line in Perched Zone[2]	Measured VOC Removed Per Well (lbs/day)[3]	Measured Air Flow Per Well (scfm)[3]	Design Air Flow Per Well (scfm)[4]	Design Total Air Flow (scfm)[4]	Estimated Total VOC Removed Per Day (lbs/day)[5]	Comments
Upper Vadose and Perched Groundwater	32	16	0.016	68	62	1,000	0.51	Pilot test was performed on SVE-01 which was located in the perched zone outside the area of highest VOC concentration.
Totals						**1,000**	**5.1**	Total estimated VOC influent conc. = 5.1 ppmv. [5]

Notes:

1. Based on ROI of 54 feet, to provide overlapping coverage to the MCL throughout perched zone.
2. SVE system design can extract from all wells at 30 scfm; or extract from wells in cycles with 50% of the wells on-line (at 62 scfm) per extraction event, depending on influent concentrations.
3. Indicates data from the pilot study.
4. The Design Air Flow has been reduced to accommodate a 1,000 scfm blower.
5. Since pilot test was not performed in the area of highest concentration, the Estimated Total VOCs Removed Per Day and influent concentration was increased by 1 order of magnitude.

lbs - pounds
lbs/day - pounds per day
scfm - standard cubic feet per minute

VAPOR PHASE CARBON USAGE

Item	First Year Removal	Second Year Removal	Third Year Removal	Fourth Year Removal	Fifth Year Removal	Totals	Comments
Percent of Total Mass Removed	60%	25%	10%	4%	1%	100%	Percent removed distribution is based on T N & Associates experience with similar remediation projects.
VOC Removal Rate (lbs/day)	5.10	2.10	0.80	0.30	0.05	NA	The first year removal rate was determined from the above table.
Estimated VOC Mass Removed (lbs)	1,862	767	292	110	18	3,048	Total mass considered for vapor phase carbon absorbtion from 3' to 35' bgs is based on 3,048 lbs.
Carbon Usage (lbs)	24,615*	7,665	2,920	1,095	183	36,478	Assumed vapor phase carbon retention factor = 10% for TCE.

Notes:

1. Refer the Conceptual Designs for additional notes and assumptions.
2. Wells in the vicinity of the W.W. Henry property may contribute significant amounts of additional VOCs, resulting in additional carbon demand, depending on when the Pemaco remedial action is implemented.

***** Based on the uncertainty discussed in Note 2, a contingency of 6,000 lbs of carbon has been added to the first year removal column.

lbs/day - pounds per day

TABLE 4.6

VAPOR EXTRACTION SYSTEM DESIGN SUMMARY FOR LOWER VADOSE SOIL AND EXPOSITION GROUNDWATER REMEDIATION ZONE (35 TO 100 FEET BGS)

MASS REMOVAL ESTIMATE

Application	Design Number of Vacuum Wells in Lower Vadose and Exposition Groundwater	Number of Wells Simultaneously On-Line	Measured VOC Removed Per Well (lbs/day)	Measured Air Flow Per Well (scfm)	Design Air Flow Per Well (scfm)	Design Total Air Flow (scfm)	Estimated Total VOC Removed Per Day (lbs/day)	Comments
Lower Vadose and Exposition Groundwater	20	20	5.350	68	75	1,500	107.00	Pilot test was performed on source area wells RW-01-70 in the 'A' Zone and RW-01-95 in the 'B' Zone.

Notes:

1. Total estimated VOC influent conc. = 315 ppmv.
2. Well spacing is based on ROI of 54 feet, to provide overlapping coverage throughout source area (> 1,000 ppb composite TCE plume contour).
3. Mass removal estimate is an average of mass removed during the pilot test.
4. The Design Air Flow has been increased to accommodate a 1,500 scfm blower.

lbs - pounds
lbs/day - pounds per day
scfm - standard cubic feet per minute

VAPOR PHASE CARBON USAGE

Item	First Year Removal	Second Year Removal	Third Year Removal	Fourth Year Removal	Fifth Year Removal	Years 6 - 9 Removal	Years 10 - 15 Removal	Totals	Comments
Percent of Total Mass Removed - Period Basis	44%	21%	10%	8%	6%	8%	2%	100%	Percent removed distribution is based on TN & Associates experience with similar remediation projects.
Percent of Total Mass Removed - Yearly Basis	44%	21%	10%	8%	6%	2%	0%	100%	Columns with multiple year periods were multiplied by the number of years in the period in order to equal 100%.
VOC Removal Rate (lbs/day)	107.0	50.0	25.0	20.0	15.0	5.0	1.0	NA	The first year removal rate was determined from the Mass Removal Estimate Worksheet (above).
Estimated VOC Mass Removed (lbs)	39,055	18,250	9,125	7,300	5,475	7,300	1,825	88,330	Total mass considered for vapor phase carbon adsorbtion from 35 to 100 feet bgs is based on 88,330 lbs.
Carbon Usage (lbs)	390,550	182,500	91,250	73,000	54,750	73,000	18,250	883,300	Assumed vapor phase carbon retention factor equals 10% for TCE.

Notes:

1. Refer the Conceptual Designs for additional notes and assumptions.
2. Wells in the vicinity of the W.W. Henry property may contribute significant amounts of additional VOCs, resulting in additional carbon demand, depending on when the Pemaco remedial action is implemented

lbs/day - pounds per day