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February 6, 2004

Mr. Scott O. Seery – Hazardous Materials Specialist
Alameda County Health Care Services Agency
Department of Environmental Health - Hazardous Materials Division
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502

Subject: Bioventing Feasibility at the Redwood Regional Park Service Yard Site
7867 Redwood Road, Oakland, California

Dear Mr. Seery:

This letter report responds to your email request (dated January 28, 2004) for a more thorough, site-specific analysis of the feasibility of bioventing as a corrective action at the site. This project is being conducted for the East Bay Regional Park District (EBRPD), and follows previous site investigation and remediation activities associated with former leaking underground fuel storage tanks (UFSTs) conducted since 1993.

INTRODUCTION

Bioventing as a corrective action was proposed by Stellar Environmental Solutions (SES), on behalf of EBRPD, in our report entitled *Year 2003 Annual Summary Report* (January 2004). That report concluded that while a 2-phase ORC™ injection program resulted in some reductions in contaminant mass and plume extent, residual soil contamination in the unsaturated zone will continue to be a long-term source of contamination to the contaminant plume unless abated, and should be considered the primary focus of additional corrective action. The following discussion of our proposed approach is based on the EPA guidance document *How to Evaluate Alternative Cleanup Technologies for UST Sites* (EPA 510-B-95-007) and its associated flow charts and figures.

The following elements are included in the body of the report:

- Technology screening in the context of the available site data;
- Detailed evaluation of expected bioventing effectiveness; and
- Phased approach toward implementation.

TECHNOLOGY SCREENING

The EPA guidance document includes ten alternative cleanup technologies for UFST sites. Table 1 includes a listing of these technologies, along with a brief explanation of their appropriateness at the subject site. Of the ten EPA technologies, six were immediately eliminated from consideration—three *ex situ* technologies (not applicable to the *in situ* contamination being addressed) and three that involve groundwater remediation. The groundwater remediation technologies are not currently being considered because the current conceptual model for the site considers unsaturated (vadose zone) soil contamination to be the primary source of ongoing groundwater contamination, and should be considered the focus of immediate corrective action. These technologies may be appropriate at a later time when residual soil concentrations are sufficiently reduced.

The four remaining technologies are: 1) soil vapor extraction (SVE); 2) bioventing; 3) natural attenuation; and 4) dual-phase extraction. Because SVE and bioventing are similar, but SVE is more costly and expected to be less effective for the conditions at the subject site, SVE was eliminated during the initial screening process in favor of bioventing. Bioventing, natural attenuation, and dual-phase extraction were then subjected to a more detailed feasibility analysis using the following six generally accepted screening criteria:

costly ?

1. Long-term effectiveness and permanence;
2. Reduction of toxicity, mobility, and volume;
3. Short-term effectiveness;
4. Implementability;
5. Relative cost; and
6. Regulatory and community acceptance.

Table 2 presents a comparison of the three technologies with respect to the screening criteria. While natural attenuation (Alternative 2) may be feasible and implementable, it has limited short-term effectiveness unless combined with a technology that removes residual sources in soil. Therefore, the extended timeframe needed to achieve cleanup using natural attenuation would likely be unacceptable to the regulatory agencies and the community. Dual-phase extraction (Alternative 3) has the advantage of treating both soil and groundwater simultaneously and would be expected to achieve cleanup within the shortest amount of time. However, the cost of dual-phase extraction is significantly higher than alternative approaches and would be highly disruptive to site use. As shown in Table 2, bioventing (Alternative 1) has several distinct advantages over dual-phase extraction: high reliability, ease of implementation, and low cost.

in conformance of EPA guidance

Table 1
Preliminary Screening of Alternative Cleanup Technologies [a]

Technology	Reasonably Applicable to Redwood Site ?	Cost Relative to Competing Technology	Further Evaluation of Technological and Cost Effectiveness Warranted ?	Comments/Discussion
Soil Vapor Extraction (SVE)	Yes	High (relative to bioventing)	No	Primarily a physical *in situ* soil cleanup technology; less effective for silty soils and less volatile components prevalent at Redwood site. Effluent requires treatment and permitting.
Bioventing	Yes	Low (relative to SVE)	Yes	Primarily a biological *in situ* soil cleanup technology; more forgiving for silty soils and less volatile components prevalent at Redwood site. Equipment same as SVE, but no permitting or effluent treatment needed.
Biopiles	No	N/A	No	Excavation is not a viable option. [b]
Landfarming	No	N/A	No	Excavation is not a viable option. [b]
Low-Temperature Thermal Desorption	No	N/A	No	Excavation is not a viable option. [b]
Air Sparging	Yes	High (relative to biosparging)	No	Primarily a physical groundwater cleanup technology; this technology does not reduce residual mass in soil.
Biosparging	Yes	Low (relative to air sparging)	No	Primarily a biological groundwater cleanup technology; this technology does not reduce residual mass in soil.
Natural Attenuation	Yes	Low	Yes	Timeframe probably unacceptable due to impacts to Redwood Creek until residual sources are removed.
In situ Groundwater Bioremediation	Yes	Low	No	Already used at Redwood Regional Park Service Yard (i.e., ORC™ injection) to reduce plume size, but this technology does not reduce residual mass in soil.
Dual-Phase Extraction	Yes	High	Yes	Both soil and groundwater are impacted at Redwood Regional Park Service Yard.

Notes:

[a] From those listed in EPA 510B-95-007, *How to Evaluate Alternative Cleanup Technologies for UST Sites*

[b] Substantial amount of clean overburden, existing roadway, no available space for onsite treatment.

N/A = Not applicable.

Table 2

Detailed Screening of Alternative Cleanup Technologies [a]

Assessment Criteria	Alternative 1 Bioventing	Alternative 2 Natural Attenuation	Alternative 3 Dual-Phase Extraction
1. Long-term Effectiveness and Permanence			
Magnitude of Residual Risk Onsite	Negligible if effective and combined with a groundwater cleanup technology (e.g., natural attenuation/*in situ* bioremediation).	Potential risk from groundwater plume migration to Redwood Creek until residual sources in soil are removed.	Negligible if effective.
Adequacy and Reliability of Controls	Highly reliable/off-the-shelf components. Low O&M requirements once system is installed and operational. Simple monthly system checks and yearly respiration testing to evaluate effectiveness.	Unreliable in controlling continued input and migration of plume to Redwood Creek, until residual sources in soil are removed.	Frequent O&M checks required to ensure system is operating effectively. Off-gas treatment system and permitting would require frequent testing and system tuning.
2. Reduction of Toxicity, Mobility, and Volume			
	Toxicity will be effectively removed in the vadose zone, although groundwater contamination may remain.	Contaminant mobility and volume are reduced through extraction and treatment; any remaining contaminants are less volatile and less toxic.	Contaminant mobility and volume are reduced through extraction and treatment; any remaining contaminants are less volatile and less toxic.
3. Short-term Effectiveness			
Time Until Remedial Action Objectives are Achieved	Moderately effective in the short-term, compared to competing technologies. More volatile components preferentially degraded. Less volatile components are treatable but require longer-term application.	Not effective in the short-term until residual sources in soil are removed.	Very effective in the short-term, compared to competing technologies, since physical processes are involved. Less volatile components may require longer remediation time frames.
4. Implementability			
Technical Feasibility/ Administrative Feasibility	Straightforward. Off-the-shelf components; no permitting required. Proven technology.	Straightforward. Technical feasibility and regulatory acceptance requires demonstrating mass reductions.	Difficult. Disruptive conditions during both system construction and operation. Most system components are above ground and impact site use.

Table 2 *continued*

Assessment Criteria	Alternative 1 Bioventing	Alternative 2 Natural Attenuation	Alternative 3 Dual-Phase Extraction
5. Relative Cost			
	Low	Low	High
6. Regulatory and Community Acceptance			
Cleanup Goals and Health and Safety Considerations	Effectively removes residual sources, but might need to be combined with a groundwater remediation technology (e.g., natural attenuation/*in situ* bioremediation).	Timeframe probably unacceptable due to impacts to Redwood Creek until residual sourcesin soil are removed.	May effectively reduce both soil and groundwater contamination in the shortest timeframe, but at significantly greater cost than other technologies and with significantly greater site disruption.

DETAILED EVALUATION OF BIOVENTING EFFECTIVENESS

As a result of the detailed screening analysis (see Table 2), bioventing was selected for more detailed evaluation of its effectiveness at the site. The basis for the detailed evaluation is Exhibit III-3 from the EPA guidance document, which specifies that certain criteria be met for site conditions, including soil conditions and contaminant characteristics. If the criteria are met, a pilot test would then be warranted to demonstrate effectiveness and collect information which would be used for full-scale system design.

Table 3 summarizes the criteria using site-specific conditions and data from the subject site. Although precise measurements for each criterion have not been collected (e.g., soil pH, moisture and bacterial plate counts), there are sufficient data to draw a reasonable conclusion. Confirmation data for the criteria listed as "Likely" (rather than "Yes") could be simultaneously conducted with the pilot testing to demonstrate bioventing effectiveness and collect design information.

PHASED APPROACH

Because all criteria received either a "Yes" or "Likely," SES proposes that a phased approach be used for the Redwood Regional Park Service Yard. This phased approach would consist of:

1. Install one vent well (VW) and at least two vapor monitoring points (VMPs);
2. Conduct soil vapor sampling for TPH/BTEX and oxygen/carbon dioxide concentrations;
3. Conduct a bioventing pilot test (estimated 72-96 hours) including an air permeability test and a respiration test; the test will use temporary, rented equipment (i.e. the piping and blower systems will not be installed); and
4. Prepare and submit to ACEH a work plan for full-scale implementation using pilot test results to refine the system design.

The pilot test well network (one VW and at least two VMPs) would overlap any anticipated full-scale design well network; therefore, the same wells could be used during full-scale implementation to avoid duplication of drilling/sampling. During well installation, soil samples would be collected for analysis of soil pH and soil moisture content, as those measurements have not been previously made at the site. In our professional opinion, heterotrophic bacterial plate counts are not necessary to demonstrate bioventing effectiveness; literature sources indicate that most environments, including those with characteristics similar to the subject site are likely to have adequate microorganism

Table 3
Detailed Evaluation of Bioventing Effectiveness [(a)]

Criteria	Yes/No ?	Comments/Discussion
Site/Soil Characteristics		
Intrinsic permeability $>10^{-10}$ cm^2?	Yes	Contaminated soils described as silty clay/clayey silt. As long as some silt fraction is present, intrinsic permeability is likely to be at least 10^{-10} cm^2.
Soil free of impermeable layers/air flow disruptions?	Yes	Based on site boring logs and analytical results, remaining residuals in soil are generally within the same soil type (i.e., silty clay/clayey silt).
Groundwater depth >3 feet?	Yes	Groundwater historically is at least 13 feet below ground surface in all site monitoring wells, and may be confined/semiconfined at a lower depth in some areas of the site.
Background heterotrophic bacteria >1000 CFU/gram?	Likely	Reductions in TPH and BTEX concentrations from ORC™ injection and low dissolved oxygen in groundwater provide strong evidence that bacteria are present and active at the site. Heterotrophic plate counts are not considered to be as reliable an indicator of bioventing effectiveness as low dissolved oxygen concentrations and field respiration testing.
Soil pH between 6 and 8?	Likely	Site conditions are not so unusual as to expect abnormal pH. In addition, historically groundwater pH is between 6 and 8.
Soil moisture content between 40% and 85% of saturation?	Likely	Residual contamination is in soils just above the capillary fringe or soils which are seasonally saturated; too low moisture content is unlikely. Although moisture content may be seasonally too high in some locations, during seasonal lows moisture content should return to the optimum range.
Soil temperature between 10°C and 45°C?	Likely	Site conditions are not so unusual as to expect abnormal soil temperature. In addition, historically groundwater temperature is between 10°C and 20°C.
Contaminant Characteristics		
Constituents aerobically biodegradable?	Yes	TPH and BTEX are considered to be readily aerobically biodegradable.
TPH ≤25,000 ppm and heavy metals ≤ 2,500 ppm?	Yes	Historical maxima: 12,000 ppm TPH; 8 ppm lead (in source area).
Vapor pressures of constituents <0.5 mm Hg?	N/A	Only applicable for bioventing in air extraction mode.
Boiling range of constituents <250°C to 300°C?	N/A	Only applicable for bioventing in air extraction mode.
Henry's Law constant <100 atm?	N/A	Only applicable for bioventing in air extraction mode.

Notes:

[(a)] Based on Exhibit III-3 (see Attachment A) from EPA 510B-95-007, *How to Evaluate Alternative Cleanup Technologies for UST Sites*

N/A = Not Applicable.

populations. However, upon your request, SES will collect at least one sample for heterotrophic bacteria plate count analysis as confirmation.

The pilot test will be conducted according to established EPA protocols, and will result in measurements of soil air permeability, oxygen utilization rate, and biodegradation rate. Pressure response in the VMPs will be used to calculate a reasonably conservative design radius of influence for the full-scale system.

We trust that this submittal meets your request for additional information on our approach, and we look forward to your concurrence so that we may begin preparatory work on the pilot test. If you have any questions regarding this submittal, or if you feel that a pre-work meeting with involved parties is necessary, please contact Mr. Neal Fujita of the East Bay Regional Park District, or contact us directly at (510) 644-3123.

Sincerely,

Bruce M. Rucker, R.G., R.E.A.
Project Manager

Michael B. Phelps, P.E.
Principal Engineer

cc: Michael Rugg, California Department of Fish and Game
Roger Brewer, California Regional Water Quality Control Board
Neal Fujita, East Bay Regional Park District

ATTACHMENT A

Exhibit III-3, EPA 510-B-95-007
"Bioventing Evaluation Process Flow Chart"

Exhibit III-3
Bioventing Evaluation Process Flow Chart