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## Lawrence Livermore National Laboratory

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# Final Proposed Plan for Environmental Cleanup at Lawrence Livermore National Laboratory Site 300


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## April 20, 2000


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## Environmental Protection Department

**Environmental Restoration Division**

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# 1. Introduction

The United States Department of Energy (DOE) presents this Proposed Plan for site-wide interim remedial actions at Lawrence Livermore National Laboratory (LLNL) Site 300 for public review and comment. DOE is the responsible party and lead agency for environmental investigations and cleanup of Site 300.

This Proposed Plan summarizes DOE's preferred cleanup interim actions for areas at Site 300 where contaminants were released, and includes information previously presented in numerous site investigation reports and the Site 300 Site-Wide Feasibility Study (SWFS) (Ferry et al., 1999). It meets the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, or Superfund). CERCLA regulates past releases but not ongoing operations at a site. At Site 300, the State of California and local agencies regulate ongoing operations.

This expanded, comprehensive version of DOE's Proposed Plan is supplemented by an abbreviated fact sheet version. Both versions are intended to aid the public in commenting on DOE's proposed cleanup plans. Information on how to obtain copies of both versions of the Proposed Plan and who to contact for additional information is presented in Section 7.

DOE encourages members of the local community and other concerned citizens to review and comment on the proposed actions before an interim cleanup strategy is selected and approved. These comments will be considered when DOE selects the interim cleanup measures that will be performed at Site 300.

Following public comment, DOE will describe the cleanup plan in an Interim Record of Decision (ROD), which will be submitted to the regulatory agencies for approval. Public comments on this Proposed Plan will be addressed in a Responsiveness Summary, which will be included with the Interim ROD. The Interim ROD is scheduled to be finalized in December 2000. This ROD will be considered interim because: (1) additional testing and evaluation of technologies is still taking place, (2) final cleanup standards are being negotiated, and (3) some areas of Site 300 still need further investigation. DOE has agreed that ground water cleanup goals will be no higher than drinking water standards or any more stringent State Water Quality Objectives during this interim cleanup. A final ROD, which will set final cleanup levels, will be submitted in 2007. The selected interim remedies are intended to be consistent with the final remedies, although the ultimate decision will be made at the time of the final ROD. Cost estimates are based on a 30 year period of operation for comparison purposes only.

The interim and final cleanup actions will be selected in consultation with the U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB).

DOE believes that implementing the preferred interim remedial actions will protect human health and restore the environment at Site 300 in a responsible, cost-effective manner.

# 2. Site Background

LLNL Site 300 is an 11 square mile DOE facility operated by the University of California. It is located in the Altamont Hills approximately 17 miles east of Livermore and 8.5 miles southwest of Tracy (Figure 1). Most of the site is in San Joaquin County, but the western part is in Alameda County. Access to Site 300 is restricted by perimeter fencing and security guards. Although nuclear weapons have never been tested at Site 300, non-fissile radioactive materials may be included in explosive components that are tested during firing table activities. As a consequence, radioactive debris may be generated from detonation of these test assemblies. Current practices mitigate the environmental impact of these activities.

Site 300 is primarily an experimental test facility that conducts research, development, and testing of high explosives materials. Experiments began at Site 300 in 1955. During site operations, a number of contaminants were released to the environment. These releases primarily occurred from surface spills, leaching from unlined landfills and pits, high explosive test detonations, and past disposal of waste fluids in lagoons and dry wells (sumps).

DOE began environmental restoration at Site 300 in 1981. Prior to 1990, environmental investigations at Site 300 were conducted under the oversight of the California RWQCB. In 1990, the U.S. EPA placed Site 300 on the National Priorities (Superfund) List. Since then, the U.S. EPA and the State of California have jointly regulated the environmental cleanup process.

Environmental investigations identified 23 locations where contaminants were released to the environment. The nature and location of these release sites are shown on Figure 2.

The primary contaminants at Site 300 include the solvent trichloroethylene (TCE) and other volatile organic compounds (VOCs), high explosive (HE) compounds (HMX and RDX), perchlorate, tritium, uranium-238, nitrate, polychlorinated biphenyls (PCBs), silicone-based oil (TBOS/TKEBS), and metals. In some cases, these compounds have migrated into ground water as shown on Figure 3.

## 2.1. Description of Operable Units

All release sites at Site 300 have been assigned to one of eight operable units (OUs) (Figure 2) to more effectively manage the site cleanup. The eight OUs are briefly described below and the seven OUs for which additional remedies are proposed in this Plan are discussed in Section 6.

### 2.1.1. General Services Area (OU 1)

Past disposal of degreasing solvents caused VOC contamination in the subsurface. A ROD for this OU was signed in 1997, and ground water and soil cleanup is underway. The final cleanup remedy was determined by DOE after considering public comments related to the remedial alternatives for this OU. Since the cleanup strategy has been decided for this OU, it is not discussed further in this Proposed Plan.

### 2.1.2. Building 834 (OU 2)

Past TCE spills have resulted in soil and ground water contamination. Silicone-based lubricating oil (TBOS/TKEBS) is also present in ground water. Some TCE-contaminated soil was removed in 1983. An Interim ROD was signed in 1995, and ground water and soil cleanup is underway. Innovative cleanup technologies are also being tested at Building 834.

### 2.1.3. Pit˚6 Landfill (OU 3)

From 1964 to 1973, waste was buried in 9 unlined debris trenches and animal pits at the Pit 6 Landfill. The waste included laboratory equipment, craft shop debris, and biomedical waste. VOCs, tritium, perchlorate, and nitrate are present in ground water near the landfill. DOE excavated the portion of the waste containing uranium-238 in 1971. The landfill was capped in 1997 to prevent infiltrating rain water from further leaching contaminants from the buried waste.

### 2.1.4. HE Process Area (OU 4)

Spills occurred at the former Building 815 steam plant, where TCE was once used to clean pipelines, resulting in soil contamination and a plume of TCE in ground water. High explosives, nitrate, and perchlorate have also been found in the soil and ground water as a result of wastewater discharges to unlined lagoons, which were closed in 1989. Ground water extraction and treatment is underway to prevent TCE in ground water from Building 815 from moving offsite. Similar contaminants were also found in ground water near the former High Explosive Burn Pits, which were capped in 1998.

### 2.1.5. Building 850/Pits 3 & 5 (OU 5)

This OU has been divided into 3 subareas for cleanup evaluation purposes: the Building 850 Firing Table area, the Pit 2 Landfill area and the Pit 7 Complex area (consisting of the Pit 3, 4, 5 and 7 landfills). Each of these subareas is described below.

#### 2.1.5.1. Building 850 Firing Table Area

Tritium, uranium-238, high explosives, metals, and PCBs were found near the Building 850 firing table. PCB-contaminated shrapnel around the firing table from explosive experiments was removed in 1998. A sand pile contaminated with tritium is located on the edge of the firing table.

#### 2.1.5.2. Pit 2 Landfill Area

The Pit 2 Landfill operated from 1956 to 1960 and contains firing table waste from Buildings 801 and 802. There is no evidence of contaminant release from the Pit 2 Landfill. The nearby Pit 1 Landfill, where contamination has been detected only in the soil, was closed by capping in 1992. Therefore, it is not discussed further in this Proposed Plan.

#### 2.1.5.3. Pit 7 Complex Area

From 1958 to 1988, a large volume of gravel and debris was generated by high-explosive firing table operations and placed in four unlined landfills at the Pit 7 Complex. Uranium-238 and tritium have been and continue to be released from the Complex. These releases cause ongoing contamination of the ground water. Several remedial alternatives for the Complex were presented in the SWFS, but DOE and the regulatory agencies have agreed that additional site characterization and evaluation of cleanup options is required prior to selecting a remedy. Significant remaining issues include:

- DOE is continuing to investigate the amount and distribution of tritium and uranium sources in the landfill waste. It is necessary to further characterize the main contaminant sources in the landfills to support modeling needed to make remediation decisions.
- The magnitude and extent of uranium contamination in ground water resulting from DOE activities relative to natural sources of uranium is still being determined.
- The implementability and permanence of permeable reactive barriers, *in situ* stabilization, freezing, or source control technologies other than excavation and/or capping have not been fully evaluated.

The Site 300 Remedial Project Managers agree that DOE should address the Complex separately, and not include a preferred remedy in this Proposed Plan. Proposed future activities include:

1. Continued characterization of the landfill waste;
2. Further investigations into the fate and transport of contaminants;
3. Modeling to predict the future extent of the tritium and uranium plumes with and without source control; and
4. Large and small scale treatability studies to evaluate remedial technologies.

The information obtained during these investigations will be included in a focused, area-specific Remedial Investigation/Feasibility Study (RI/FS) for the Pit 7 Complex. The feasibility study portion of this document will evaluate a wider range of technologies than were presented in the SWFS. Following the focused RI/FS, a preferred remedy will be presented in a Pit 7 Complex Proposed Plan and at a public meeting. DOE will prepare an Interim ROD for the Pit 7 Complex which will be incorporated as an amendment to the Interim Site-Wide ROD. The public will be encouraged to participate throughout the remedy selection process. A document and milestone schedule for the Pit 7 Complex will be determined with the regulatory agencies prior to signing the Site-Wide Interim ROD. DOE believes that considering additional remediation alternatives for the Pit 7 Complex will result in the selection of a permanent, cost-effective solution while remediation activities continue at other OUs at Site 300.

The Pit 7 Complex is not discussed further in this Proposed Plan.

### 2.1.6. Building 854 (OU 6)

TCE was used at Building 854 as a heat-exchange fluid, and was found in soil and ground water. Other contaminants at Building 854 include nitrate, perchlorate, tritium, PCBs, metals, high explosives, and uranium-238. Some of the TCE-contaminated soil was excavated in 1983. Ground water extraction in the source area began in 1999, as a treatability study.

### 2.1.7. Building 832 Canyon (OU 7)

VOCs, nitrate, high explosives, and perchlorate have been found in soil and ground water at Buildings 830 and 832. A treatability study is underway to evaluate whether ground water and soil vapor extraction would be effective cleanup measures for the VOCs.

### 2.1.8. Buildings 801, 833, 845, and 851 and the Pit 9 Landfill (OU 8)

As described below, OU 8 is divided into four subareas for cleanup evaluation purposes: the Building 801 Firing Table area, the Building 833 area, the Building 845 and Pit 9 Landfill area, and the Building 851 Firing Table area.

**Building 801 Firing Table**

The Building 801 firing table was used for explosives testing, and its operation resulted in contamination of adjacent with metals and uranium-238. No contaminants have been found in ground water. Use of this firing table was discontinued in 1998 to accommodate an expanded facility. The firing table gravel and some underlying soil were removed. Waste fluid discharges to the Building 801 dry well resulted in low concentrations of VOCs in soil and ground water. The dry well was decommissioned and filled with concrete in 1984.

Debris from the firing table was buried in the nearby Pit 8 Landfill until 1974, but there is no evidence of contaminant release from the Pit 8 Landfill.

**Building 833**

TCE was used as a heat-exchange fluid at Building 833. Surface discharge of waste fluids caused contamination of soil and ground water.

**Building 845 and Pit 9 Landfill**

The Building 845 firing table was used until 1963 to conduct explosives experiments and continues to be used for explosive waste treatment. As a result, the soil is contaminated with uranium-238 and high explosives.

Debris generated at the Building 845 firing table was buried in the Pit 9 Landfill, but no evidence of release from the landfill has been found.

**Building 851 Firing Table**

This active firing table is still used to conduct experimental high explosives research. These experiments have resulted in uranium-238, high explosives, metals, and VOCs in soil, and uranium-238 in ground water.

# 3. Summary of Site Risks

A baseline risk assessment was conducted for Site 300 (Webster-Scholten, 1994) to evaluate risks to people, plants, and animals that may be exposed to contaminants in soil, air, surface water, or ground water. Risk assessments predict the magnitude, if any, of adverse health effects.

The baseline risk assessment identified the contaminants and potential exposure pathways that may need to be addressed by cleanup actions. The Site 300 baseline risk assessment evaluated present and future risks under the assumption that no cleanup would take place. Selection of cleanup actions will be based in part on the extent to which they can reduce these risks. The Site 300 baseline risk assessment used conservative assumptions that favored protecting public health and the environment. Therefore, actual human or ecological exposure and risk are likely to be much lower than those calculated in the baseline risk assessment. Furthermore, the baseline risk assessment used the historical maximum contaminant concentrations, many of which have decreased over time.

Carcinogenic (cancer) risk for humans is expressed as the probability of developing cancer over a lifetime. For example, an additional cancer risk of one in one million ($1 \times 10^{-6}$) means that there is potential to increase the risk of getting cancer by one in one million in addition to the cancer risk from other causes[1]. An additional cancer risk of one in one million or less is acceptable to the U.S. EPA. An additional cancer risk between one in ten thousand ($1 \times 10^{-4}$) and one in one million ($1 \times 10^{-6}$) may be acceptable provided the risk is properly managed by decreasing exposure potential. U.S. EPA requires that cancer risks above one in one million must be addressed by various risk controls and/or remedial actions, as discussed in the SWFS.

For noncarcinogens, a Hazard Quotient (HQ) is calculated for each individual contaminant. The HQ is the ratio of calculated exposure to acceptable exposure values, as determined by the U.S. EPA and State Agencies. HQs for multiple contaminants are added together to provide a Hazard Index (HI). HIs less than 1 are considered protective of human health. The ecological HI is the ratio of observed exposure to a toxicological benchmark derived from existing scientific literature.

Baseline human health risks and hazards for Site 300 were estimated using industrial adult onsite exposure and offsite residential exposure scenarios. The adult onsite exposure scenario estimates health risk where an adult is assumed to work in the immediate vicinity of worst-case contamination 8 hours a day, 5 days per week for 30 years. The residential exposure scenario estimates the risk to a family living adjacent to the site. The risks associated with ingestion of ground water were calculated for residents drinking water from hypothetical wells at the site boundary and from existing private wells near the site.

Risk estimates for most release sites and contaminants were well below the protective threshold designated by the U.S. EPA. Adult onsite risks above this threshold were generally associated with (1) workers inhaling VOCs and/or tritium volatilizing from the subsurface, or (2) direct skin contact with PCBs and dioxins in the soil. Onsite risks were also associated with

[1] Note: The risk of getting cancer from other causes is one in three for Californians.

drinking contaminated ground water; however, ground water from wells is not currently used for drinking at Site 300.

Estimated offsite residential risks were associated with people potentially drinking contaminated ground water, or inhaling vapors volatilizing from contaminated surface water. However, no members of the public are currently being exposed to any contaminants from Site 300.

The Site 300 ecological assessment evaluated the potential for adverse impact to plants and animals from long-term exposure to contaminants, and focused on potential reproductive damage and reductions in reproductive life span rather than the risk of developing cancer.

The Site 300 baseline ecological risk assessment identified potential impacts to several animal species that could potentially visit or migrate into contaminated areas at Site 300. HQs for individual ground squirrels exceeded 1 for TCE and perchloroethylene (PCE) in the Building 834 and Pit 6 Landfill OUs. In addition, HQs for cadmium exceeded 1 for adult animals in the Building 834, HE Process, and Building 850 areas. However, an evaluation of the percentage of the affected population, as well as the distribution of the ground squirrel population (both in space and time), provides evidence that the Site 300 ground squirrel population has not been adversely impacted by contaminants at the site.

HQs for individual deer exceeded 1 for cadmium in the Building 834, HE Process, Building 850, and Building 801 areas. In 1994, additional soil samples were collected throughout the site and a detailed record of deer sightings was maintained and analyzed. Areas with deer sightings generally had low to non-detectable cadmium levels, indicating that the localized presence of cadmium does not pose a significant threat to the deer populations, as their primary habitat does not exhibit elevated cadmium levels.

HQs for individual kit fox (a State of California and federally-listed endangered species) exceeded 1 for TCE, PCE, and cadmium in the Building 834 OU, and for TCE and PCE in the Pit 6 Landfill OU. While there is no evidence that kit fox currently use these areas, individual kit fox living in dens in these areas in the future are potentially at risk.

A single observation of a Swainson’s Hawk (a threatened species) was made in the California Department of Fish and Game Ecological Reserve, adjacent to Site 300. However, Site 300 is not its preferred habitat. As the Swainson Hawk’s normal territory is from about 2,000 to 10,000 acres, it is unlikely that any single individual would spend significant time at Site 300, and localized contamination at Site 300 is unlikely to cause any adverse impact.

Numerical baseline risk estimates for each area at Site 300 are presented in Section 6 of this Proposed Plan.

# 4. Cleanup Objectives

The preferred remedial alternatives address VOCs, tritium, uranium-238, perchlorate, nitrate, high explosive compounds, PCBs, and other contaminants in surface and subsurface soil/rock, surface water, ground water, and air at the seven Site 300 OUs described in this Proposed Plan. The cleanup objectives for the Interim ROD for the Site 300 contaminants of concern are:

For Human Health Protection:

1. Restore ground water containing contaminant concentrations (single carcinogen) above State and Federal Maximum Contaminant Levels (MCLs) and any more stringent Water Quality Objectives. Prevent futher impacts on ground water above State and Federal MCLs and any more stringent Water Quality Objectives from contaminated soil.
2. Prevent human incidental ingestion and direct dermal contact with contaminants in surface soil that pose an excess cancer risk of $1 \times 10^{-6}$ (one in one million) or a HQ greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of $1 \times 10^{-4}$ (one in ten thousand), or a cumulative HI (all noncarcinogens) greater than 1.
3. Prevent human inhalation of VOCs and tritium volatilizing from subsurface soil to air that poses an excess cancer risk of greater than $1 \times 10^{-6}$ (one in one million), or HQ greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of $1 \times 10^{-4}$ (one in ten thousand), or a cumulative HI (all noncarcinogens) greater than 1.
4. Prevent human inhalation of VOCs and tritium volatilizing from surface water to air that poses an excess cancer risk greater than $1 \times 10^{-6}$ (one in one million), or HQ greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of $1 \times 10^{-4}$ (one in ten thousand), or a cumulative HI (all noncarcinogens) greater than 1.
5. Prevent human inhalation of contaminants bound to resuspended surface soil particles that poses an excess cancer risk greater than $1 \times 10^{-6}$ (one in one million), or HQ greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of $1 \times 10^{-4}$ (one in ten thousand), or a cumulative HI (all carcinogens) greater than 1.
6. Prevent human exposure to contaminants in media of concern that pose a cumulative excess cancer risk (all carcinogens) greater than $1 \times 10^{-4}$ (one in ten thousand), and/or a cumulative HI (all noncarcinogens) greater than 1.

For Environmental Protection:

1. Restore water quality, at a minimum, to Water Quality Objectives that protect beneficial uses within a reasonable time frame. Maintain existing water quality that complies with Water Quality Objectives. This will apply to both individual and multiple constituents that have additive toxicological or carcinogenic effects.
2. Ensure ecological receptors important at the individual level of ecological organization (State of California or federally-listed threatened or endangered species, or State of California species of special concern) do not reside in areas where HIs exceed 1.
3. Ensure existing contaminant conditions do not change so as to threaten wildlife populations and vegetation communities.

To the degree that these cleanup objectives are achieved by interim measures, the interim measures may be selected as the final remedies for the site, pending review of their effectiveness and any needed contingency plans. The Final ROD will make the ultimate determination.

The preferred alternatives will achieve these objectives by managing risk and hazard by implementing exposure controls, extracting and treating contaminated ground water and soil vapor, *in situ* treatment of contaminated ground water, removing contaminated surface soil and subsurface soil and bedrock, monitored natural attenuation and monitoring contaminants in ground water. The preferred alternatives are described for each OU in Section 6 of this Proposed Plan.

# 5. Summary of Remedial Technologies

A number of methods were evaluated to remediate areas where soil and bedrock, ground water, or surface water is currently contaminated, or could become contaminated in the future. The cleanup technologies evaluated in the SWFS are summarized below.

## 5.1. Monitoring

Monitoring is defined as routine, periodic, baseline sampling and analysis of contaminated media not associated with the operation and optimization of remediation systems. Typically this will include ground water and surface water sampling and analysis for all contaminants of concern, and inspection of surface conditions of waste sites. If disruption of waste sites is visible, appropriate maintenance will be conducted. Monitoring will determine if the contaminant plumes are expanding or migrating.

Every five years, physical surveys of plant and wildlife communities will be conducted to determine species composition for the purpose of identifying new species of potential concern (i.e., rare, threatened or endangered) that may be at risk from contamination at Site 300. Should such species be determined to be present in areas of contamination, the appropriate regulatory agency will be consulted (e.g., U.S. Fish and Wildlife Service or California Department of Fish and Game) and a preliminary screening assessment will be conducted as required. Monitoring will be conducted to ensure that the populations of ground squirrels and deer continue to be unimpacted by contaminants at Site 300. Algae and micro-invertebrate bioassays will also be conducted on samples from springs to ensure aquatic organisms remain unimpacted by contaminants at Site 300.

## 5.2. Risk and Hazard Management

The overall goals of risk and hazard management are to control exposure to contaminants and ensure the remedies protect human health and the environment while cleanup objectives are being achieved.

Administrative controls are the basis of risk management, such as restricting building access, ventilation controls, and measures to prevent people from drinking contaminated ground water.

A risk and hazard monitoring and assessment program will be developed and implemented, which will include sample collection and analysis to determine current exposure concentrations, and integrating the data into risk assessment calculations to determine any changes in risk and hazard. These data and analyses will be used to evaluate compliance with Remedial Action Objectives.

In addition, as part of the LLNL program to mitigate impacts to wildlife, biologists will monitor those areas in which the relevant ecological HI exceeds 1. Currently, the only threatened, endangered, or species of special concern that may potentially be exposed to unacceptable levels of contaminants is the San Joaquin kit fox. Thus, areas where the ecological HI for the kit fox exceeds 1 will be monitored. Should kit fox or other similar species of special concern to wildlife agencies (i.e., those that burrow or live in dens) be found in these areas, DOE will consult with the appropriate wildlife agency to develop response actions, such as monitoring or animal relocation. Additionally DOE will annually monitor areas where PCBs/chlorinated dibenzo - dioxins (CDDs) are present in surface soil for any threatened or endangered species, or species of special concern.

Biologists will continue to monitor Site 300 for the presence of sensitive species not previously identified. If any such species are found, their life history will be reviewed to determine the potential for unacceptable exposure to contaminants at the site. Should it be determined that species have a potential risk of exposure, their presence in areas where a relevant HI exceeds 1 will be determined. The risk and hazard monitoring and assessment program for Site 300 will be presented in detail in the Site-Wide Compliance Monitoring Plan.

The overall cleanup approach assumes that Site 300 will remain under DOE's control indefinitely, and that the site access restrictions currently in place (fencing and security patrols) will continue for the foreseeable future. CERCLA and the Federal Facility Agreement for Site 300 include provisions for assuring cleanup if ownership were to change. All remedies would be reevaluated if any transfer of ownership or change in land use is anticipated.

## 5.3. Mon itored Natural Attenuation

Natural attenuation consists of natural physical, chemical or biological processes that act without human intervention to reduce the amount of contamination in soil or ground water. For example, tritium decays (or attenuates) naturally to non-toxic helium. As a cleanup approach, monitored natural attenuation relies on these natural processes to achieve cleanup standards. A monitored natural attenuation remedy consists of monitoring and tracking the natural degradation of contaminants in the environment to make sure that there are no damaging effects on human health and the environment. This method has proven effective for certain contaminants (for example, gasoline and radionuclides with short half-lives). Recent studies have demonstrated that under certain conditions monitored natural attenuation may also be appropriate for other Site 300 contaminants, such as VOCs and high explosives.

For this approach to be acceptable, appropriate long-term monitoring must be conducted, there must be no active source of contamination, and human health and the environment must be protected. In addition, it must achieve cleanup goals in a time frame comparable to active remediation.

## 5.4. Ground Water Extraction and Treatment

For this technology, ground water is pumped or siphoned from specially designed wells and treated to remove contaminants before discharge to the ground or returning the treated water to the water table. The extracted water can be treated using granular activated carbon (GAC), bioreactors, or ion exchange systems, depending on the contaminants. The U.S. EPA considers these to be "presumptive technologies" for certain contaminants (U.S. EPA, 1996). This means that these technologies have proven effective at other sites, using them should reduce costs, and a simplified evaluation process is appropriate. EPA expects that presumptive technologies will be used for remedies where ground water extraction and treatment are part of the remedy.

The objectives of ground water extraction may include reducing the amount and concentration of contamination, stopping the spread of contaminants, reducing risk, and/or restoring beneficial uses of ground water.

Extraction of ground water containing tritium may not be easily implementable and may raise safety concerns because (1) no cost-effective technology to remove tritium from water is available, and (2) bringing water containing tritium to the surface and concentrating the tritium during a treatment process could result in increased risk to humans.

The proposed treatment method for removing perchlorate from extracted ground water is a combination of granular activated carbon (GAC) adsorption, followed by biotreatment, and ion exchange polishing. GAC will remove organic compounds and some portion of the perchlorate. Following GAC treatment, biotreatment will either employ plants (phytoremediation), denitrifying bacteria (bioreactor) or a combination of the two (called a cascading modular biotreatment system, which is a containerized wetland). In the bioreactor and other engineered biotechnologies, nutrients are added externally to foster microbial activity. Biotreatment is the primary process for removing perchlorate from ground water. Ion exchange resins are used as the final, polishing step.

## 5.5. Soil Vapor Extraction and Treatment

Under this technology, contaminated vapors in the soil above the water table are pumped from special wells, then treated to remove contaminants before discharge to the atmosphere. This technology is effective only for contaminants that evaporate relatively easily, such as TCE. The extracted vapor is treated using GAC. Soil vapor extraction is often combined with ground water extraction to increase the effectiveness of the cleanup. Extracting soil vapor and ground water at the same time (called dual-phase extraction) is a “presumptive remedy” as defined by EPA (U.S. EPA, 1996). Presumptive remedies have been identified by EPA and commonly selected at various cleanup sites. For this reason, use of presumptive remedies reduces the justification required and streamlines the remedy selection process.

## 5.6. Enhanced *In situ* Bioremediation

*In situ* (in place) bioremediation is a process through which microbes already living in the ground ingest contaminants and break down the contamination into non-toxic compounds. This process can be enhanced by injecting additional nutrients into the subsurface.

## 5.7. *In situ* Reactive Barriers

In this technology, a trench is excavated to a depth below the ground water table. The trench is filled with a permeable material designed to react with and/or remove contaminants from ground water flowing through the material.

*In situ* reactive barriers can be used to control the migration of VOCs, metals, and uranium in ground water.

## 5.8. Excavation and Removal of Surface Soil and Soil and Bedrock Underlying Firing Tables

Though costly, excavating contaminated soil under the firing tables effectively reduces health risks and stops further ground water contamination.

At some firing tables, explosive tests contaminated the adjacent soil. This soil can be removed to prevent worker exposure.

## 5.9. Landfill Waste Characterization, with Contingent Monitoring, Capping, or Excavation

This technology addresses existing or potential releases from the landfills. It begins with detailed investigations of the landfill contents, followed by modeling to estimate potential impacts to ground water, and risk assessment to evaluate potential impacts to humans and the environment.

The results of these activities will be used to help design the most appropriate cleanup. Additional opportunities for stakeholder input, such as workshops and public meetings, would be included throughout the process.

DOE considered five possible approaches to address the Pit 2, 8 and 9 Landfills: (1) monitoring only, (2) capping, (3) partial excavation with capping, (4) partial excavation without capping, or (5) total excavation.

Any excavated waste would be transported to and placed in an approved offsite disposal facility or an engineered onsite containment unit.

## 5.10. Future Work

Sufficient data exist to recommend the preferred cleanup alternatives described in this Proposed Plan. However, additional work is needed to:

- Complete a focused Remedial Investigation/Feasibility Study for the Pit 7 Complex, as described in Section 2.1.5.3.
- Define the nature and extent of contamination, if any, at the Sandia Test Site, the Advanced Test Accelerator (Building 865) and Building 812. Investigations of these facilities have been scheduled.
- Determine the natural background for nitrate at Site 300.
- Understand how PCBs, perchlorate, and high explosive compounds degrade under the Site 300 subsurface conditions.
- Find ways to stabilize landfill waste *in situ* to prevent leaching of contaminants to ground water as a potential alternative to excavating or capping the landfills.
- Develop or evaluate new technologies to treat tritium in ground water since no cost-effective technology currently exists.

- Determine if innovative, environmentally friendly “green” technologies, such as using gravity, solar or wind power to run ground water extraction and treatment facilities, or using plants or microbes to treat ground water contaminants, may be applicable to Site 300.
- Determine cleanup standards for dinitrotoluene and TBOS/TKEBS in ground water since no regulatory standards exist for these compounds.
- Determine how to:
    - Implement any required building and/or land use restrictions;
    - Address PCBs in soil at Building 854; and

DOE will continue to investigate innovative technologies and apply them, if appropriate, to maximize the cost-effectiveness, efficiency, and safety of the cleanup.

# 6. Evaluation and Comparison of Remedial Alternatives

A number of cleanup alternatives were evaluated in the SWFS using the EPA criteria shown in Figure 4. The SWFS compares the remedial alternatives by analyzing how each alternative would perform against the first eight EPA criteria, and by finding the best balance among them. The two most important criteria are providing adequate protection of human health and the environment, and compliance with all federal, state and local applicable or relevant and appropriate requirements (ARARs). Alternatives that do not meet these two criteria, called threshold criteria, are not viable. Community acceptance (criterion 9) will be evaluated after public comments on this Proposed Plan are evaluated.

DOE compared the alternatives discussed in the SWFS and selected the preferred alternative for each area of the site. In most areas at Site 300, the alternatives are a combination of the technologies described in Section 5. DOE's preferred cleanup alternative for each area at Site 300 are shown in Table 1.

The estimated costs shown on Table 1 are the sum of capital, operation, and maintenance costs over 30 years, expressed as present-worth values. The costs of any previous cleanup actions are not included in the estimates. Based on DOE's preferred cleanup alternatives, the estimated 30-year present-worth cost to clean up the Site 300 operable units described in this Proposed Plan is approximately $85,000,000. The 30-year period was used for cost comparison purposes, and does not necessarily represent the time until cleanup is complete. The cleanup decision made in the Interim Site-Wide ROD may be modified by the Final ROD scheduled for 2007.

The major components of DOE's preferred cleanup for Site 300 are:

1. Extract and treat contaminated ground water at Buildings 834, 830, 832, 854, and in three parts of the High Explosives Process Area. This cleanup will restore the beneficial uses of ground water beneath Site 300 and protect offsite ground water supplies. Table 2 summarizes the proposed remedial components and treatment technologies to address specific Site 300 ground water contaminants in each OU.
2. Extract and treat soil vapor containing VOCs at Buildings 834, 830, 832, and 854. Removing VOCs from the soil and bedrock above the water table will reduce risks to humans and protect the underlying ground water from further contamination.
3. Remove the tritium-contaminated sand pile at the Building 850 Firing Table. This will prevent further leaching of tritium into the soil and ground water. Also, remove PCB-contaminated surface soil in the area adjacent to the firing table to reduce health risk to site workers.
4. Allow tritium in soil, bedrock, and ground water to decline naturally through monitored natural attenuation at Building 850. Monitored natural attenuation would be implemented only after any required source control measures have been implemented. DOE also proposes monitored natural attenuation for tritium and TCE at the Pit 6 Landfill, where monitoring data indicate natural breakdown of TCE is occurring.

5. Implement exposure controls in any area where an elevated risk or hazard to humans or the environment remains. During cleanup, DOE will implement a formal risk and hazard management program that will include periodically collecting additional samples, reviewing building occupancy and land use, and refining risk and hazard estimates. Exposure controls will manage risks to site workers, the public, and the environment.
6. Continue conducting periodic monitoring throughout Site 300 and the adjacent offsite area. Monitoring will ensure that the cleanup adequately protects humans and the environment and will help measure the progress of cleanup.
7. Continue to closely monitor the Pit 2, 8, and 9 Landfills. There is no evidence of contaminant release from these landfills. DOE will install additional monitoring equipment at these landfills to ensure early detection of any future releases of contaminants, and will upgrade and formalize the landfill maintenance program. DOE also plans to re-engineer the surface water drainage near Pit 2.
8. Take no further action for contaminants in soil and bedrock at some areas where certain contaminants: (1) are found in low concentrations, (2) pose no risk to humans or the environment, (3) pose no threat to ground water, and (4) cannot be cleaned up cost-effectively. DOE does not propose a no further action remedy for any of the contaminated ground water at Site 300.

If these approaches work as intended, they could become the final remedies, subject to the Final ROD evaluation in 2007.

The time it will take to complete the cleanup of Site 300 will be long, possibly greater than 30 years to achieve interim ground water cleanup goals of MCLs or below. This is primarily due to the difficulty in removing contaminants dissolved in the ground water and the lack of cost-effective treatment technologies for tritium. Qualitative estimates of the time to achieve cleanup are provided in Chapter 7 of the SWFS. Refined cleanup time estimates based on detailed modeling will be provided in the Remedial Design Reports that will be prepared after the Interim ROD. Cleanup time estimates will improve as remediation progresses and cleanup data are evaluated.

In 2002, DOE will prepare a Site-Wide Contingency Plan that will anticipate how DOE might respond if any part of the cleanup does not go as planned. The Contingency Plan will also anticipate how the cleanup might be modified in the event of any future changes in land use at Site 300, or if a transfer of site ownership is anticipated. Significant or fundamental changes to the remedies will be supported and documented in an Explanation of Significant Differences or ROD Amendment, respectively.

The remedial alternatives for each of the seven Site 300 OUs evaluated in the SWFS that are discussed in this Proposed Plan are summarized below, along with background information and a description of the preferred alternative for each OU.

## 6.1. Building 834 Complex (OU 2)

### 6.1.1. Site Background

Since the late 1950s, the Building 834 area facilities were used for materials testing. TCE was the primary heat transfer fluid for these operations until the entire system was dismantled between September 1993 and May 1994. DOE estimates that about 500 gallons of TCE were released to the ground surface between 1962 and 1978, contaminating the subsurface soil/bedrock and shallow ground water in the area.

### 6.1.2. Extent of Contamination

TCE has been identified as the primary contaminant of concern because it has been most frequently detected in soil, bedrock, and ground water, and because of its relatively high historical concentrations in ground water [up to 800 parts per million (ppm)]. Other VOCs have been less frequently detected, at lower concentrations in soil and ground water. A silicon-based lubricant (TBOS/TKEBS) has also been detected floating on the ground water in monitor wells near Building 834, and nitrate has been detected in ground water. Ground water contaminants are present in a shallow perched water-bearing zone. This zone is limited in extent and is underlain by several thick, low permeability rock layers that prevent the downward migration of contaminated ground water into the regional aquifer. The shallow ground water plumes originate at spill locations near the buildings in the northern part of the area and extend approximately 1,500 ft to the south (Figure 5).

### 6.1.3. Ongoing Remedial Actions

Ground water and soil vapor extraction and treatment have been operating at Building 834 since 1995 under an Interim ROD. Remediation has successfully reduced TCE concentrations in ground water from an historical maximum of 800 ppm in 1993 to 120 ppm in 1998, and TBOS/TKEBS concentrations from 7,300 ppm in 1995 to less than 100 ppm in 1998. Nitrate concentrations have decreased from an historical maximum of 480 ppm in 1997 to 280 ppm in 1998. Soil vapor extraction has significantly reduced VOC concentrations, and has removed approximately 48 pounds of VOCs from subsurface soil and rock since 1998. Other remedial activities include excavation of VOC-contaminated soil in 1983 and installation of a surface water drainage diversion system in 1998 to prevent rainwater infiltration in the contaminant source area.

### 6.1.4. Summary of Site Risks for the Building 834 Complex

The Building 834 Complex baseline risk assessment prepared as part of the Site-Wide Remedial Investigation (Webster-Scholten, 1994) determined that the only exposure route that could potentially result in unacceptable risk is for on-site workers exposed to VOC vapors evaporating from subsurface soil in and around facility buildings. Based on soil sample analyses made in 1983, an excess human cancer risk from inhalation of VOC vapors inside of Building 834D was calculated as $1 \times 10^{-3}$ (one in one thousand) with an HI of 36. This means that a person spending 8 hours a day, 5 days a week, for 30 years inside Building 834D could have a one in one thousand additional chance of contracting cancer and a high likelihood of experiencing a non-cancerous medical affliction. This potential exposure route is limited to employees working within Building 834D. Building 834D is currently used as a storage facility, without any regular occupants.

The baseline risk assessment also indicated a human cancer risk of $6 \times 10^{-4}$ (six in ten thousand) and an HI of 21 for inhalation of TCE by workers outdoors in the vicinity of Building 834D. This potential exposure is limited to employees working on-site in the vicinity of Building 834D.

These risk calculations assumed no remedial action would occur. Full scale ground water extraction began in 1995 and soil vapor extraction began in August 1998 to mitigate VOC inhalation risk in the Building 834 area.

Although the perched ground water in the Building 834 area contains high concentrations of contaminants, there is no current exposure to human or ecological receptors from ground water. Modeling indicates that contaminants from the Building 834 Complex would not impact off-site water-supply wells. Ground water cleanup in this area is based on the applicable Water Quality Objectives in the Central Valley RWQCB's Water Quality Control Plan for Region 5 (Basin Plan).

The Building 834 area is isolated and access is restricted by full-time security patrols and fencing that surrounds Site 300. DOE plans to maintain and operate Site 300 for the foreseeable future. Thus, public exposure is unlikely given the DOE land-use commitment at Site 300.

The Building 834 Complex baseline ecological assessment prepared as part of the Site-Wide Remedial Investigation (Webster-Scholten, 1994) determined a potential risk from TCE, PCE and cadmium existed for the following biota: ground squirrels, deer and kit fox. Individual juvenile ground squirrels and individual kit fox are potentially at risk from inhalation of TCE and PCE (the combined inhalation HI exceeded 1 for these species). Individual adult ground squirrels, kit fox and deer are also potentially at risk from oral ingestion of cadmium (the combined oral and inhalation pathway HQ exceed 1 for these species, which was driven by the oral pathway). Site-wide population surveys and area-specific presence/absence surveys to identify the true risk to these biota found no current adverse impact. For special-status, threatened or endangered species, such as the kit fox, which must be protected on an individual basis, monitoring as described in Sections 5.1, 5.2 and 6.1.7 will be conducted to ensure continued protection of the species.

#### 6.1.5. Summary of Cleanup Alternatives for the Building 834 Complex

Three remedial alternatives were assembled and evaluated to address contaminants in the Building 834 Complex, as summarized in Table 3**.**

#### 6.1.6. Evaluation of Alternatives

The no-action alternative (Alternative 1) is required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) to provide a baseline for comparison to other remedial alternatives and is the basis of the baseline risk assessment. Under a no-action response, all remedial and monitoring activities in the Building 834 complex would cease. There are no costs associated with the no-action alternative.

Alternative 1 may not protect human health and the environment. Alternatives 2 and 3 both address all risks to human health and the environment through active remediation of soil, bedrock, and ground water. Alternative 3 provides additional mass removal and plume control by enhanced *in situ* bioremediation of VOCs in ground water downgradient of the Building 834 Complex. Alternative 3 would be expected to achieves cleanup objectives somewhat faster than Alternative 2. However, additional removal of TCE through *in situ* bioremediation would provide no significant quantifiable health risk benefit compared to Alternative 2 because the perched water-bearing zone is not currently being used for drinking water.

Because the rate of contaminant degradation through enhanced *in situ* biodegradation is not yet known, the ability to further reduce contaminant mobility and volume above that attained through pumping and treating ground water under Alternative 2 is not certain. Ongoing studies are expected to provide data on the viability of *in situ* biodegradation to further reduce contaminant mobility and volume. Although DOE intends to continue research on bioremediation technologies, and may in the future wish to propose adding its use, this alternative is not yet suitable for implementation.

Alternative 3 costs exceed those of Alternative 2 by $2.4 million.

### 6.1.7. The Preferred Remedial Alternative for the Building 834 Complex

DOE believes that, among the three proposed remedial alternatives, Alternative 2 provides the best balance of trade-offs with respect to the EPA evaluation criteria.

The primary components of the preferred remedial Alternative 2 are:

1. Monitoring soil vapor and ground water to determine if the ground water plumes are migrating or expanding, evaluate the effectiveness of the remedial action in reaching remediation goals, and for post-remediation monitoring.

2. Risk and hazard management to prevent contaminant exposure to humans and impacts to ecological receptors. As part of the hazard management program, ecological monitoring will be conducted as discussed in Sections 5.1 and 5.2.

3. Soil vapor extraction and treatment by carbon adsorption at the VOC source area. Soil vapor extraction would be conducted to reduce VOC concentrations in soil to levels protective of ground water (drinking water standards or below), and to mitigate VOC inhalation risk in and around Building 834.

4. Ground water extraction and treatment by air stripping with GAC for the air stream, and phytoremediation (remediation of nitrate using plants) at the source area and in downgradient portions of the plume. Ground water extraction will be conducted to reduce contaminant concentrations to drinking water standards or below.

These components are described in detail in the SWFS. The ground water contaminant plumes and the components of the preferred remedial Alternative 2 that address contaminants in the Building 834 OU are shown in Figure 5.

Alternative 2 protects human health and the environment. The risk reduction components of this alternative are readily implementable with modifications to the existing ground water and soil vapor extraction and treatment systems at Building 834. In addition, these remediation systems would reduce contaminant concentrations in soil, bedrock, and ground water

Ground water and soil vapor extraction (dual-phase extraction) is an established remedial technology, considered by EPA to be a presumptive remedy for the cleanup of VOCs in soil and ground water. Since functioning interim treatment systems are already in place, Alternative 2 will readily fulfill the first eight EPA evaluation criteria in Figure 4.

The only human health risks under Alternative 2 are possible ingestion of ground water containing contaminants in concentrations exceeding drinking water standards, and inhalation of VOC vapors above health-based concentrations in and around Building 834D. There are no existing exposure pathways for ground water with concentrations above drinking water standards. Modeling indicates that contaminants from the Building 834 Complex would not impact offsite water-supply wells. Soil vapor extraction and treatment will protect human health by reducing VOC concentrations in subsurface soil and rock, thereby mitigating inhalation risk. Alternative 2 also includes measures such as building use restrictions and monitoring indoor air with ventilation controls, if necessary, to prevent VOC exposure to humans.

As part of the hazard management program to mitigate impacts to special-status, threatened or endangered species, such as the kit fox, which must be protected on an individual basis, biologists will monitor the Building 834 area. If kit fox or similar (i.e., burrowing or denning) special-status species are found to be inhabiting the site and could be exposed to TCE or PCE, the DOE will notify and consult with the California Department of Fish and Game and the U.S. Wildlife Service to determined the proper course of action to protect the kit fox from short- and long-term impacts. Additional biological monitoring is discussed in Sections 5.1 and 5.2.

The present-worth cost of Alternative 2 for the Building 834 OU is $12,095,000 based on 30 years of monitoring, exposure control and remediation.

## 6.2. Pit 6 Landfill (OU 3)

### 6.2.1. Site Background

From 1964 to 1973, approximately 1900 cubic yards of solid waste was buried in nine unlined trenches and animal pits within the Pit 6 Landfill. The buried material included laboratory and shop debris, and biomedical waste. Low concentrations of TCE and other VOCs, tritium, perchlorate, and nitrate have been released from the buried debris to the environment. These releases have migrated to shallow ground water about 30 ft below the Pit 6 Landfill. The main contaminant of concern in ground water is TCE. Tritium has also been found at activities well below its drinking water standard, and perchlorate and nitrate have each been found in one well.

### 6.2.2. Extent of Contamination

A ground water TCE plume extends southeast from the Pit 6 Landfill as shown in Figure 6. VOC concentrations in ground water have decreased significantly over the past few years, and are close to or below drinking water standards in all wells. VOC concentrations in ground water have declined from an historical TCE maximum of 250 parts per billion (ppb) in 1988 to concentrations below 6 ppb in 1998. The drinking water standard for TCE is 5 ppb. All indications are that TCE is degrading naturally.

Tritium activities are above background levels in four monitor wells, suggesting a past localized release, possibly due to infiltration of rain through areas of subsidence in the landfill before it was capped. Detected activities are well below the 20,000 picoCuries per liter (pCi/L) drinking water standard. No evidence of releases of other radioactive contaminants from the landfill has been detected in soil or ground water.

Perchlorate has been detected in ground water in one well at a maximum concentration of 47 ppb. Nitrate has also recently been detected in ground water at 228 ppm but may have a source other than the landfill. The only surface water contaminant found in 1998 was TCE at 0.77 ppb at Spring 7, where concentrations have been declining.

Contaminants are present in ground water in shallow gravel and bedrock in the vicinity of the Pit 6 Landfill. No contaminants associated with releases from the landfill have been detected south of the Site 300 boundary.

#### 6.2.3. Previous Remedial Actions

A cap was installed over the Pit 6 Landfill as a CERCLA Removal Action in 1997 to prevent infiltrating rain water from further leaching contaminants from the buried waste. Other remedial activities performed at the Pit 6 Landfill include: (1) removal of waste containing uranium-238 in 1971, and (2) extraction and treatment of about 71,000 gallons of ground water containing TCE as a treatability study in late 1998.

#### 6.2.4. Summary of Site Risks for the Pit 6 Landfill

The baseline risk assessment for the Pit 6 Landfill area determined that there was a potential risk to on-site workers who may inhale TCE vapors evaporating from subsurface soil in the vicinity of the landfill. An excess human cancer risk from inhalation of TCE vapors in the landfill area was calculated as $5 \times 10^{-6}$ (five in one million). This means that a person spending 8 hours a day, 5 days a week, for 30 years at the landfill near a release site may have a five in one million additional chance of contracting cancer. This potential exposure route is limited to employees working on-site in the immediate vicinity of the landfill. The landfill cap, installed as part of a CERCLA Removal Action in 1997, mitigates this inhalation risk. Furthermore, based on the marked decrease in TCE concentrations in ground water, DOE expects that the subsurface soil concentrations have also substantially decreased from those used in the risk assessment.

A potential cancer risk of $4 \times 10^{-5}$ (four in one hundred thousand) was also identified for onsite workers inhaling VOC vapors from surface water at Spring 7. Since it has been dry for several years, there is currently no potential for VOC inhalation from this spring. However, if the spring were to become active again, VOC analyses of shallow ground water suggest that VOC concentrations will be below levels of concern.

The baseline risk assessment also identified a future cancer risk for offsite residents inhaling TCE volatilizing from the surface of the State Vehicle Recreational Area residence pond located east of the landfill (Figure 6). This risk scenario assumed no cleanup actions would be taken and that VOCs would migrate to the water supply wells used to fill the pond. However, VOCs have not migrated to the water-supply wells, the landfill cap was installed to prevent further releases of VOCs, and ground water VOC concentrations upgradient have substantially diminished.

The Pit 6 Landfill baseline ecological assessment prepared as part of the Site-Wide Remedial Investigation (Webster-Scholten, 1994) determined a potential risk from VOCs (primarily TCE and PCE) existed for the following biota: ground squirrels and kit fox. Individual ground squirrels and individual kit fox are potentially at risk from inhalation of VOCs (the combined inhalation HI exceeded 1 for these species). An engineered layer was installed as part of the landfill cap to prevent exposure of squirrels and kit fox to contaminants in the pit. Site-wide population surveys and area-specific presence/absence surveys to identify the true risk to these biota found no current adverse impact. For special-status, threatened or endangered species, such as the kit fox, which must be protected on an individual basis, monitoring as described in Sections 5.1, 5.2 and 6.2.7 will be conducted to ensure continued protection of the species.

#### 6.2.5. Summary of Cleanup Alternatives for the Pit 6 Landfill

Three remedial alternatives were assembled and evaluated to address contaminants of concern in environmental media in the Pit 6 Landfill area, as summarized in Table 4.

#### 6.2.6. Evaluation of Alternatives

The no-action Alternative 1 is required by the NCP to provide a baseline for comparison to other alternatives and is the basis of the baseline risk assessment. Under a no-action response, all monitoring activities in the Pit 6 Landfill would cease. There are no costs associated with the no-action alternative.

Alternative 1 may not protect human health and the environment. Alternatives 2 and 3 both address risk to human health and the environment and include measures to restore the beneficial uses of ground water. Ground water contaminants may be reduced more rapidly through extraction and treatment of ground water in Alternative 3 than by natural attenuation in Alternative 2. However, the more rapid contaminant removal provided in Alternative 3 would provide no significant quantifiable health risk benefit compared to Alternative 2, because ground water in this area is not currently used for drinking water. Alternative 3 poses additional short-term risks to humans compared to Alternative 2 if water containing tritium is brought to the surface during ground water extraction. Alternatives 2 and 3 can be readily implemented, although Alternative 3 would require additional time, labor, and expense to construct, operate, and monitor the treatment system.

Alternative 3 costs exceed those of Alternative 2 by $3.6 million.

#### 6.2.7. The Preferred Remedial Alternative for the Pit 6 Landfill

DOE believes that, among the three proposed remedial alternatives, Alternative 2 provides the best balance of trade-offs with respect to the EPA evaluation criteria.

The primary components of the preferred remedial Alternative 2 are:

1. Monitoring ground water to: (1) determine if the plumes are migrating or expanding and ensure there is no impact to people living downgradient, (2) evaluate the effectiveness of natural attenuation of contaminants in ground water to meet cleanup goals, (3) identify any potentially toxic by-products resulting from biodegradation, and (4) verify attainment of cleanup standards. Ground water monitoring will also continue for nitrate and perchlorate to further understand their extent, sources (natural and man-made), and fate in the environment.

2. Risk and hazard management to prevent contaminant exposure to humans and impacts to ecological receptors until cleanup standards are achieved in surface water and ground

water. As part of the hazard management program, ecological monitoring will be conducted as discussed in Sections 5.1 and 5.2.

3. Monitoring and modeling ground water flow to verify the effectiveness of natural processes (or natural attenuation) in continuing to decrease VOC and tritium concentrations to drinking water standards or below. The landfill cap was installed in 1997 to prevent further releases of contaminants from the buried waste.

These components are described in detail in the SWFS.

Alternative 2 protects human health and the environment through monitored natural attenuation. EPA defines natural attenuation as "the naturally occurring process in soil and ground water that act, without human intervention, to reduce the mass, toxicity, mobility, volume, or concentration of contaminants." Ground water data from monitor wells in the Pit 6 Landfill area indicate that TCE and other VOCs are naturally degrading or attenuating to drinking water standards and below, as demonstrated by the steady decrease in VOC concentrations over time, and the presence of the degradation product cis-1,2-dichloroethlyene, which is present in concentrations below its MCL. Another possible TCE degradation product, vinyl chloride, has never been detected in the Pit 6 Landfill area. This could be because vinyl chloride is not created by the degradation in this area, or because it further degrades very quickly, never reaching detectable concentrations. Tritium decays to a stable, non-toxic daughter product (helium), and has a short (about 12-year) half-life. This means that half of the tritium in the subsurface will be gone in 12 years.

Current maximum levels of tritium in ground water (about 2,000 pCi/L) in the Pit 6 Landfill area are well below the 20,000 pCi/L drinking water standard. EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17 (1997) states that monitored natural attenuation may be appropriate as a remedial approach where it can be demonstrated to be capable of achieving the site's cleanup objectives in a time period that is reasonable compared to that offered by other methods. Monitored natural attenuation for VOCs and tritium in ground water at the Pit 6 Landfill in preferred Alternative 2 meets the EPA criteria to establish this type of remedy. These include: (1) the contamination does not currently pose an unacceptable risk, (2) source control measures have been implemented, and (3) chemical data suggest that natural attenuation mechanisms are operating to reduce contaminant concentrations.

The water-bearing zone affected by VOCs and tritium is not currently a drinking water source, and there is no current risk of ingesting contaminated ground water. Natural processes should continue to reduce contaminant concentrations to restore the beneficial uses of ground water. Risk and hazard management would be applied to prevent human health impacts until cleanup standards are achieved. All components of the preferred alternative are readily implementable. Alternative 2 will readily fulfill the first eight EPA evaluation criteria in Figure 4.

As part of the hazard management program to mitigate impacts to special-status, threatened or endangered species, such as the kit fox, which must be protected on an individual basis, biologists will monitor the Pit 6 landfill area. If kit fox or similar (i.e., burrowing or denning) special-status species are found to be inhabiting the site and could be exposed to VOCs, DOE will notify and consult with the California Department of Fish and Game and the U.S. Fish and

Wildlife Service to determine the proper course of action to protect the kit fox from short- and long-term impacts. Additional biological monitoring is discussed in Sections 5.1 and 5.2.

The estimated present-worth cost of Alternative 2 for the Pit 6 Landfill OU is $2,377,000 based on 30 years of monitoring, exposure control and monitored natural attenuation of VOCs and tritium in ground water.

A Contingency Plan will be prepared for Site 300 in 2002 that will describe how DOE plans to address foreseeable technical and logistical issues and problems that may arise during remediation of Site 300. For example, the Contingency Plan will include plans for analysis of trends in contaminant concentrations in ground water. If monitoring indicates that 1) contaminants have significantly increased above MCLs, 2) unanticipated plume migration or expansion occurs, or 3) releases are occurring from the landfill, changes to the remedial action will be considered in consultation with the regulatory agencies. These changes could include implementing active remedial measures where monitored natural attenuation was the preferred remedy, and installing and operating extraction wells and treatment facilities, if appropriate.

## 6.3. High Explosives (HE) Process Area (OU 4)

### 6.3.1. Site Background

The HE Process Area consists of surficial release sites at Building 815, Building 810, the former HE rinsewater lagoons, the former HE Burn Pits, and the related ground water plumes. Building 815 served as a central steam plant for the HE Process Area from 1958 to 1986. Surface spills at the drum storage and dispensing area for the steam plant resulted in TCE releases to the ground surface. In addition, from 1959 to 1985, waste fluids were discharged to dry well 810A, resulting in VOC releases to the subsurface.

From the mid- to late-1950s to 1985, wastewater containing HE and associated compounds was discharged to former unlined rinsewater lagoons, and subsequently leached to the subsurface. Three Resource Conservation and Recovery Act (RCRA) regulated burn pits were located in the vicinity of Building 829 in which HE particulates and cuttings, explosive chemicals, and explosives-contaminated debris were burned. This facility was operated from the late 1950s until 1998. HE compounds and VOCs were released to the environment in the vicinity of the HE Burn Pits.

### 6.3.2. Extent of Contamination

Contaminants in ground water in the vicinity of Building 815 have been detected in shallow soil and bedrock. TCE concentrations in ground water in the Building 815 area have decreased over time from an historical high of 450 ppb in 1992 to 330 ppb in 1998. Other VOCs have also decreased, with most concentrations below the level detectable in the laboratory. All other VOCs are below the drinking water standards and State Water Quality Objectives.

HE compounds, nitrate, and perchlorate have also been detected in ground water in the vicinity of the HE rinsewater lagoons and in shallow soil and bedrock. The HE compounds in ground water are decreasing or stable in concentration. Contaminants originating from the HE rinsewater lagoons have, to an extent, mixed with VOCs in ground water originating from the Building 815 and 810 area. The HE Process Area ground water plumes are shown in Figures 7 and 8. TCE has been detected at relatively low concentrations in subsurface soil and bedrock in the vicinity of the HE rinsewater lagoons.

VOCs, nitrate, and perchlorate have been detected in ground water in shallow bedrock in the vicinity of the HE Burn Pit area. The HE Burn Pit area is geologically isolated from other contaminated areas in the HE Process Area. Low levels of HE compounds and VOCs are present in shallow subsurface soil in the vicinity of the burn pits.

TCE has been detected in a well adjacent to Spring 5, located approximately 800 ft south of Building 815. Ground water from this well feeds the spring, which supports wetland-type vegetation, but there is no measurable surface water flow at Spring 5. The TCE detected near the spring is believed to originate at Building 815.

#### 6.3.3. Ongoing Remedial Actions

In 1989, the HE rinsewater lagoons were excavated and capped to prevent further releases of VOCs, HE compounds, nitrate, and perchlorate to the subsurface. The HE Burn Pits were also capped and closed in 1998 under RCRA to prevent releases of contaminants to the subsurface.

In June 1999, a ground water extraction and treatment system was installed at the Site 300 boundary, south of Building 815 and the HE rinsewater lagoons, as part of a CERCLA Removal Action. The purpose of this system is to prevent the offsite migration of the TCE originating from these release sites.

#### 6.3.4. Summary of Site Risks for the HE Process Area

The baseline risk assessment for the HE Process Area determined that there was a potential risk to on-site workers who may inhale VOC vapors evaporating from subsurface soil in the vicinity of Building 815. The excess human cancer risk from inhaling VOC vapors in the Building 815 area was calculated as $5.1 \times 10^{-6}$ (about five in one million). This means that a person spending 8 hours a day, 5 days a week, for 30 years in the vicinity of Building 815 may have a five in one million additional chance of contracting cancer. The potential exposure route is limited to employees working on-site in the immediate vicinity of Building 815. The maximum historical VOC concentration detected in shallow subsurface soil was TCE at 0.05 ppm in 1987. An active remedy, such as soil vapor extraction, is generally not warranted or very effective when VOC concentrations are this low.

A potential excess cancer risk of $1 \times 10^{-5}$ (one in one hundred thousand) was also identified for onsite workers inhaling VOC vapors from surface water at Spring 5. This risk was calculated from VOC concentrations in an adjacent well, since the actual flow in Spring 5 is too low to measure, and the spring consists of moist soil with wetland vegetation. It was assumed for risk assessment purposes that the same water-bearing unit in which the well is completed feeds the spring. The baseline assessment also assumed that the concentrations in the shallow ground water were the same as in the spring. Since no actual standing water exists at Spring 5, the calculated risk levels are extremely conservative. In addition, no one regularly works in the vicinity of Spring 5 and VOC concentrations in ground water that feeds the spring have decreased over time. More than half of the calculated risk resulted from the presence of 1,1-DCE, which has not been detected in ground water in the area since 1987.

Although the ground water in the HE Process Area contains high concentrations of contaminants, there are no other exposure pathways from ground water to human or ecological receptors. Cleanup of the ground water in this area is based on the applicable Water Quality Objectives of the Central Valley RWQCB's Water Quality Control Plan for Region 5 (Basin Plan).

The HE Process Area baseline ecological assessment prepared as part of the Site-Wide Remedial Investigation (Webster-Scholten, 1994) determined a potential risk from copper and cadmium existed for the following biota: aquatic organisms, ground squirrels, and deer. Aquatic organisms are potentially at risk from copper in the shallow, near surface ground water at a location designated as Spring 5 (the Toxicity Quotient using California Applied Action Levels exceeded 1 for copper in ground water samples from this location). Individual adult ground squirrels and individual adult and juvenile deer are potentially at risk from oral ingestion of cadmium (the combined oral and inhalation pathway HQ exceed 1 for these species, which was driven by the oral pathway). Surveys for the presence of surface water at Spring 5, and algae and micro-invertebrate bioassays conducted to identify the true risk to aquatic organisms found no current adverse impact. Similarly, site-wide population surveys to identify the true risk to deer and ground squirrels found no current adverse impact. Monitoring as described in Sections 5.1 and 5.2 will be conducted to ensure continued protection of these populations and any special-status species identified in the future.

### 6.3.5. Summary of Cleanup Alternatives for the HE Process Area

Two alternatives, a no action alternative required by EPA guidance and a remedy using presumptive technologies that have proven effective at Site 300, were presented in the SWFS, as summarized in Table 5.

### 6.3.6. Evaluation of Alternatives

The no-action Alternative 1 is required by the NCP to provide a baseline for comparison to other alternatives, and is the basis of the baseline risk assessment. Under a no-action response, all monitoring and remediation activities in the HE Process Area would cease. Alternative 1 may not protect human health and the environment or meet all ARARs. There are no costs associated with the no-action alternative.

The treatment methods incorporated into Alternative 2 include presumptive technologies as defined by EPA. Alternative 2 is described below.

### 6.3.7. The Preferred Remedial Alternative for the HE Process Area

DOE believes that, among the two proposed remedial alternatives, Alternative 2 provides the best balance of trade-offs with respect to the EPA evaluation criteria.

The primary components of the preferred remedial Alternative 2 are:

1. No further action for VOCs in subsurface soil and bedrock at the HE rinsewater lagoon release sites, and VOCs and HE compounds in subsurface soil and bedrock at the HE burn pit release sites.

2. Ground water monitoring to: (1) determine if the contaminant plumes are migrating or expanding as remediation progresses, (2) evaluate the effectiveness of the remedial action, and (3) determine when cleanup standards are met.

3. Risk and hazard management to prevent contaminant exposure to humans and impacts to ecological receptors until cleanup standards are achieved through active remediation. As part of the hazard management program, ecological monitoring will be conducted as discussed in Sections 5.1 and 5.2.
4. Restoring aquifer contaminant concentrations to MCLs or below and controlling contaminant migration by extracting and treating ground water using carbon adsorption (a presumptive technology for VOCs) at the leading edge of the Building 815 TCE plume.
5. Restoring the aquifer contaminant concentrations to MCLs or below and controlling contaminant migration from the source area by extracting and treating ground water using carbon adsorption (presumptive technologies for VOCs) and biodegradation to remove VOCs, HE compounds, nitrate, and perchlorate released from Building 815 and the HE rinsewater lagoons.
6. Restoring the aquifer contaminant concentrations to MCLs or below and controlling contaminant migration from the source area by extracting and treating ground water using carbon adsorption (presumptive technologies for VOCs) and biodegradation in a bioreactor to remove VOCs, nitrate, and perchlorate released from the HE Burn Pits.

These components are described in detail in the SWFS. The ground water contaminant plumes and the components of the preferred remedial Alternative 2 which address contaminants in the HE Process Area are shown in Figures 7 and 8.

Alternative 2 uses ground water extraction and treatment to control the migration of contaminant plumes originating from sources in the HE Process Area and to restore the aquifer. Ground water extraction has proven effective for controlling plume migration in a Removal Action in the HE Process Area, and at several other source areas at Site 300, including the General Services Area and Building 834. Presumptive technologies (i.e., carbon adsorption and biodegradation) would be used to treat contaminants in ground water under Alternative 2.

Alternative 2 protects human health and the environment. No further action is proposed for contaminants in subsurface soil and bedrock at the HE rinsewater lagoon and the HE burn pit release sites because (1) source control measures have already been implemented to prevent further impact to ground water, (2) there is no risk or hazard to human health or ecological receptors currently posed by these contaminants, (3) the existing ground water contamination is addressed through ground water extraction and treatment, and (4) there is no practical treatment for non-volatile substances in bedrock except excavation, which would be costly at the depths where some of the HE compounds occur.

The risk and hazard management program will prevent exposure to humans and impacts to ecological receptors until active cleanup reduces contaminant concentrations to cleanup standards. Extraction and treatment of ground water at the site boundary will prevent the offsite migration of the VOC plume while cleanup of the source areas at Building 815, the HE rinsewater lagoons, and the HE Burn Pits reduces contaminant concentrations to drinking water standards, any more stringent Water Quality Objectives, or below.

All components of Alternative 2 are implementable and readily fulfill the first eight EPA evaluation criteria in Figure 4.

The estimated present-worth cost of Alternative 2 for the HE Process Area is $27,621,000 based on 30 years of monitoring, exposure control and extracting and treating ground water.

## 6.4. Building 850 Area (OU5)

### 6.4.1. Site Background and Extent of Contamination

High-explosives experiments have been conducted at the Building 850 firing table since 1960. Leaching of contaminants from firing table debris has resulted in tritium and uranium-238 in subsurface soil and ground water (Figures 9 and 10). Nitrate has also been identified in ground water in this area. Surface soil has also been contaminated with various metals, PCBs, HMX, and uranium-238. Dioxins and furans are also present in surface soil in the vicinity of the firing table. Gravel was removed from the firing table in 1988 and placed in the Pit 7 Landfill.

Uranium-238 has been identified in ground water in the vicinity of Building 850 at a maximum historical activity of 18.4 pCi/L in 1996. Figure 10 shows the total uranium activity for each well, and a calculated value for uranium activity attributed to LLNL operations. These values were calculated by comparing the ratios of different uranium isotopes to those found in nature, and to those characteristic of the depleted uranium used historically at Site 300. The maximum total uranium activity in the Building 850 area was 5.1 pCi/L in 1999, about one quarter of the 20 pCi/L uranium MCL.

A large volume of sand used in the experiments and stockpiled near the Building 850 firing table gradually became contaminated with tritium. Leaching from this sand pile resulted in release of tritium to the vadose zone and the ground water. Tritium was detected at activities of up to 204,000 picoCuries per Liter in soil moisture ($pCi/L_{sm}$) in the sand pile in 1990.

Tritium was detected at a maximum activity of 11,000,000 $pCi/L_{sm}$ in 1988 in subsurface soil at a 5 ft depth beneath the Building 850 firing table gravel. Tritium activities up to 2,790,000 $pCi/L_{sm}$ were detected in subsurface bedrock in boreholes directly adjacent to the firing table at depths up to 20 ft below ground surface. Tritium from the subsurface bedrock could pose a potential threat to ground water. Uranium-238 was also detected in subsurface soil at a maximum activity of 28.2 picoCuries per gram (pCi/g).

Ground water contaminants have been detected in shallow streambed sediments and in bedrock. The tritium plume emanating from the Building 850 source area extends east of the building and commingles with the Pit 7 Complex tritium plume (Figure 9). Tritium activities in ground water in the Building 850 source area have significantly decreased from 1985 to 1999, and the portion of the tritium plume with activities exceeding the 20,000 pCi/L MCL has decreased over this period.

Nitrate concentrations in ground water have decreased from an historical maximum of 140 ppm in 1995 to 97 ppm in 1998. No water-supply wells are currently contaminated with tritium, uranium-238, or nitrate originating from the Building 850 area.

Tritium was detected at the Well 8 Spring at activities as high as 770,000 pCi/L in the early 1970s, but has declined to less than 40,000 pCi/L in 1998.

### 6.4.2. Previous Remedial Actions

Contaminated gravel from the Building 850 firing table was removed and replaced in 1988. In 1998, PCB-contaminated debris from the vicinity of the Building 850 firing table was also removed.

### 6.4.3. Summary of Site Risks for the Building 850 Area

The baseline risk assessment calculated a risk of $5.3 \times 10^{-4}$ (about 5 in ten thousand) associated with potential inhalation of resuspended particulates, and incidental ingestion and direct dermal exposure with surface soil contaminated with PCBs, at the Building 850 firing table area. In addition, a risk of $9.5 \times 10^{-5}$ (about 9 in one hundred thousand) was calculated for potential inhalation of suspended particulates, and incidental ingestion and direct dermal contact with surface soil contaminated with chlorinated dibenzo-p-dioxins (CDDs) and dibenzofurans (CDFs).

Tritium in the sand pile could pose a potential threat to ground water.

No risk or hazard associated with tritium and uranium-238 in subsurface soil/rock in the Building 850 area has been identified. Ground water in this area is not used as drinking water and thus there is no current risk from ingestion of contaminated ground water.

The Building 850 Area baseline ecological assessment prepared as part of the Site-Wide Remedial Investigation (Webster-Scholten, 1994) and the SWRI addendum (Taffet et. al, 1996) determined a potential risk from copper, zinc, cadmium and PCBs/CDDs/CDFs existed for the following biota: aquatic organisms, ground squirrels, deer, and kit fox. Aquatic organisms are potentially at risk from copper and zinc in Spring 6 (the Toxicity Quotient using California Applied Action Levels exceeded 1 for zinc, and exceeded 1 for copper using the Federal Ambient Water Quality criteria). Individual adult ground squirrels are potentially at risk from the ingestion of combined copper and cadmium at Spring 6. At Building 850, individual adult ground squirrels and individual adult and juvenile deer are potentially at risk from oral ingestion of cadmium (the combined oral and inhalation pathway HQ exceed 1 for these species, which was driven by the oral pathway). Individual ground squirrels, deer, and kit fox were determined to be potentially at risk from PCBs/CDDs/CDFs due to the capacity of these contaminants to bioaccumulate and biomagnify in the environment. Algae and micro-invertebrate bioassays conducted to identify the true risk to aquatic organisms at Spring 6 found no current adverse impact (Building 850 Addendum to the SWRI, Appendix J). Similarly, site-wide population surveys and area-specific presence/absence surveys to identify the true risk to vertebrate biota found no current adverse effect. For special-status, threatened or endangered species, such as the kit fox, which must be protected on an individual basis, monitoring as described in Sections 5.1, 5.2 and 6.4.6 will be conducted to ensure continued protection of the species.

### 6.4.4. Summary of Cleanup Alternatives for the Building 850 Area

Four remedial alternatives, were presented and evaluated in the SWFS to address contaminants in surface soil, subsurface soil/bedrock, surface water, and ground water in the Building 850 area, as summarized in Table 6.

### 6.4.5. Evaluation of Alternatives

The no-action Alternative 1 is required by the NCP to provide a baseline for comparison to other alternatives, and is the basis of the baseline risk assessment. Under a no-action response, all monitoring and remediation activities in the Building 850 area would cease. Alternative 1 may not protect human health and the environment. There are no costs associated with the no-action alternative

Alternatives 2, 3, and 4 all address human health risks from potential ingestion and direct dermal contact with contaminated surface soil and the potential threat to ground water, by removing the contaminated sand pile and surface soil. Alternative 4 includes active extraction and *in situ* treatment of uranium and nitrate to reduce these contaminants to levels protective of human health and the environment. Alternatives 3 and 4 may not provide a significant increase in the protection of human health and the environment posed by contaminated subsurface soil/rock over Alternative 2, because, although tritium in subsurface bedrock could pose a potential risk to ground water, there is no significant human health risk or ecological hazard associated with tritium or uranium in subsurface soil/rock in the vicinity of the firing table.

Alternatives 2, 3 and 4 would all meet chemical and action-specific ARARs.

Alternatives 2, 3, and 4 would all be effective and permanent in the long term. The sand pile/surface soil excavation component of Alternative 2 would reduce contaminant mobility through waste removal, but would not reduce contaminant toxicity or volume. The soil/bedrock excavation component of Alternative 3 further reduces contaminant mobility compared to Alternative 2. Alternative 4 would reduce contaminant volume and mobility in ground water by using an *in situ* reactive barrier.

Alternatives 3 and 4 may present higher short term risk to onsite workers due to exposure to a larger volume of currently buried contaminated media compared to Alternative 2. Alternative 4 also poses short-term and possibly long term exposure risk to onsite workers since tritium could be brought to the surface during ground water extraction.

All of the alternatives are implementable. However, implementation of Alternatives 3 and 4 would pose additional engineering and logistical difficulties for excavation of subsurface bedrock beneath the Building 850 firing table. Specifically, (1) excavating bedrock in the steep terrain of the Building 850 firing table would be extremely difficult, (2) this firing table is currently active and in use for high explosive experiments, and (3) there are a number of subsurface conduits for diagnostic equipment that would have to be avoided or removed/replaced during excavation. The implementability of the *in situ* reactive barrier component of Alternative 4 is limited by engineering challenges to install the barrier in unconsolidated sediment and rock, removal/replacement of spent resins in the barriers, and permitting requirements for the long term storage or disposal of uranium-containing resins.

Alternative 3 costs exceed those of Alternative 2 by over $4 million and Alternative 4 costs exceed those of Alternative 2 by over $ 12 million.

### 6.4.6. The Preferred Remedial Alternative for the Building 850 Area

DOE believes that Alternative 2 provides the best balance of activities with respect to the EPA evaluation criteria. The components of Alternative 2 are described in detail in the SWFS.

The ground water plumes and locations of the sand pile and surface soil to be removed are shown on Figures 9, 10, and 11.

The primary components of Alternative 2 are:

1. Risk and hazard management to prevent contaminant exposure to humans and impacts to ecological receptors until cleanup standards are achieved through active remediation.
2. Monitoring contaminants in ground water to:
   - Track changes in plume concentrations/ activities to (1) evaluate the effectiveness of source control measures and natural attenuation of contaminants in ground water and surface water to health- and environmentally-protective levels, and (2) determine if plumes are migrating or expanding, and
   - Ensure there is no impact to downgradient receptors.
3. Monitored natural attenuation of tritium in ground water. A hazard management program will include biological monitoring as discussed in Sections 5.1 and 5.2.
4. Removing PCB, dioxin, and furan-contaminated surface soil.
5. Removing the tritium-contaminated sand pile and contaminated surface soil to a depth sufficient to meet EPA Region 9 Preliminary Remediation Goals (PRGs) in the vicinity of Building 850 to prevent further releases to ground water, reduce inhalation risks, and mitigate risks to ecological receptors. (The PRG for PCBs is 1 mg/kg, and for dioxins/furans it is $2.7 \times 10^{-5}$ mg/kg.)

Alternative 2 should adequately protect human health and the environment by preventing exposure to contaminants while source control measures prevent future impacts to the environment, and natural attenuation of tritium reduces activities in ground water to health-protective levels. Access control measures would be implemented, if necessary, to prevent inhalation exposure at the Well 8 Spring until tritium activities attenuate to health-protective levels.

Removal of contaminated surface soil and the sand pile would permanently prevent further releases of contaminants to ground water, and prevent long-term exposure to surface soil containing PCBs, dioxins, and furans. The decreasing ground water concentrations suggest that there is a diminishing tritium source in the subsurface soil and bedrock.

Because the volume of contaminated soil and sand pile to be removed is relatively small (1,260 $yd^3$), this component should be fairly easy to implement.

The maximum uranium-238 activity in ground water at Building 850 in 1998 was below the drinking water standard and background level for total uranium. Uranium-238 activities in ground water would continue to be monitored to detect any changes in activities that could impact human health or the environment.

As part of the hazard management program to mitigate impacts to special-status, threatened or endangered species, such as the kit fox, which must be protected on an individual basis, biologists will monitor the Building 850 area. If kit fox or similar (i.e., burrowing or denning) special-status species are found to be inhabiting the site and could be exposed to PCBs/CDDs/CDFs, DOE will notify and consult with the California Department of Fish and Game and the U.S. Fish and Wildlife Service to determine the proper course of action to protect the kit fox from short- and long-term impacts. Additional biological monitoring is discussed in Sections 5.1 and 5.2.

The estimated present-worth cost for Alternative 2 is $4,029,000 for removal of the sand pile and contaminated surficial soil, monitored natural attenuation of tritium in ground water, and monitoring for 30 years.

## 6.5. Pit 2 Landfill (OU 5)

### 6.5.1. Site Background

The Pit 2 Landfill (Figure 12) was used from 1956 to 1960 to dispose firing table debris and gravel from Buildings 801 and 802. The Pit 2 Landfill, which was covered in 1960, is 12 to 14 ft deep, encloses an area of 6,000 square yards, and contains about 25,400 cubic yards of firing table waste. Some of the waste buried in the landfill may have contained uranium-238, beryllium, thorium, and tritium. VOCs and heavy metals may also have been buried in the Pit 2 Landfill. Several contaminants including uranium-238 and metals were detected in the gravel from the Building 845 firing table; and potentially contaminated gravel from that firing table was disposed in the Pit 2 Landfill.

### 6.5.2. Extent of Contamination

Low concentrations of VOCs were detected in ground water in 1989-90 near the Pit 2 Landfill but have not been detected since then. Although tritium has been detected in subsurface soil/rock, its distribution and depth indicate that it has probably migrated in ground water from the Building 850 area to the Pit 2 Landfill area.

No contaminants have been identified in surface soil, subsurface soil/bedrock, ground water or surface water associated with the Pit 2 Landfill. Although ground water rose in the vicinity of Pit 2 Landfill during the wet winters of 1997 and 1998, the water table is more than 65 ft below the landfill and there is no risk of ground water contacting the landfill contents.

### 6.5.3. Summary of Site Risks for the Pit 2 Landfill Area

No contaminants of concern have been identified in any environmental media associated with the Pit 2 Landfill, and no risk or hazard to human health or ecological receptors was identified in the baseline risk assessment.

### 6.5.4. Summary of Cleanup Alternatives for the Pit 2 Landfill Area

Three remedial alternatives were assembled to address the Pit 2 Landfill area, as summarized in Table 7.

### 6.5.5. Evaluation of the Alternatives

The no-action Alternative 1 is required by the NCP to provide a baseline for comparison to other alternatives, and is the basis of the baseline risk assessment. Under a no-action response, all monitoring and remediation activities in the Pit 2 Landfill area would cease. There are no costs associated with the no-action alternative.

Alternatives 2 and 3 both include measures to monitor for continued compliance with ARARs. Alternatives 2 and 3 include the same measures to monitor for potential future impacts to ground water and any changes to risk or hazard that could affect human health and the environment. Thus both would provide long-term and effective protection of human health and the environment. Alternative 3 would provide additional protection if the Pit 2 Landfill waste were found to contain contaminants that could impact human health and the environment. Under Alternatives 2 and 3, monitoring would determine the long-term effectiveness and permanence of the remedies. Alternative 3 would provide additional long-term effectiveness and permanence, and would reduce contaminant mobility, if the Pit 2 Landfill waste were found to contain contaminants that could impact human health and the environment.

Alternative 2 would have minimal impact to onsite workers in the short term. There would be increased risk of exposure to contaminants for onsite workers and ecological receptors in the short term if capping under Alternative 3 were implemented, and even higher similar risk if waste excavation were conducted under Alternative 3. Excavation could cost up to $22 million – capping or partial excavation could be considerably less.

Alternative 2 is readily implementable. Capping or excavation under Alternative 3 would be significantly more difficult to implement compared to the monitoring activities of Alternative 2.

Alternative 3 costs could exceed those of Alternative 2 by $21.7 million to cover the costs of waste characterization, monitoring and total excavation of the landfill waste, if needed.

### 6.5.6. The Preferred Remedial Alternative for the Pit 2 Landfill Area

DOE believes that Alternative 2 provides the best balance of activities for the Pit 2 Landfill area with respect to the EPA evaluation criteria. Ground water monitoring in the vicinity of the Pit 2 Landfill would indicate if any contaminants are released from the landfill that would impact human health or the environment. Monitoring for ground water contaminants that may be present in the pit waste should protect human health and the environment, and provide a tool for detecting new releases, if any, from the Pit 2 Landfill that could pose a risk or hazard to human health or ecological receptors, or impact ground water.

A Contingency Plan will be prepared for Site 300 which will include actions to be proposed in the event that contaminants are detected in ground water that originate from the Pit 2 Landfill. Additional future work is planned for re-engineering the surface drainage in this area, and upgrading and formalizing the regular maintenance program for the Pit 2 Landfill cover. Details of that program will be described in the Site-Wide Compliance Monitoring Plan.

The estimated present-worth cost to implement Alternative 2 is $515,000.

## 6.6. Building 854 (OU 6)

### 6.6.1. Site Background and Extent of Contamination

TCE was released to subsurface soil and ground water in the Building 854 area through leaks and discharges of TCE-based heat exchange fluid from a brine system that was removed in 1989. The extent of TCE in ground water is shown in Figure 13. TCE concentrations in ground water have decreased from an historical maximum of 2,900 ppb in 1997 to 410 ppb in 1998.

Other contaminants in ground water include tritium, uranium-238, nitrate and perchlorate. The maximum historical activity of tritium in ground water (410 pCi/L) slightly exceeds the 300 pCi/L regional background activity. Uranium-238 has been detected in one well in the Building 854 area at an historical maximum of 2.6 pCi/L in 1996. Nitrate was reported at an historical maximum of 180 ppm in 1996. Perchlorate (State Action Limit of 18 ppb) was detected for the first time in July 1998, at 6.5 ppb.

Contaminants in ground water occur in a 10- to 20- ft thick, shallow water-bearing zone. This zone appears to be perched as there is unsaturated permeable material below the low permeability siltstone/claystone confining layer located at its base. No contamination has been detected in the deeper water-bearing zone, which is located at least 50 ft below the first water-bearing zone.

TCE was also reported in the unsaturated zone in concentrations up to 1,000 ppm. This concentration was reported in a sample collected in the vicinity of the Building 854H drain outfall where contaminated soil was excavated and removed in 1983. The highest soil/rock TCE concentration that may remain in this area is 30.7 ppm.

Contaminants in surface soil include lead, zinc, HMX, tritium, and PCBs. Lead, zinc, and HMX have been detected at 98 ppm, 1,400 ppm, and 150 ppm, respectively. Tritium was detected at 317 $pCi/L_{sm}$. PCB 1242 and 1248 were detected in surface soil at concentrations of 34 ppm and 52 ppm, respectively, in a single sample.

### 6.6.2. Previous Remedial Actions

TCE-contaminated soil was removed at the northeast corner of Buildings 854H and 854F in 1983. This was the area of the highest measured TCE concentrations in soil.

### 6.6.3. Summary of Site Risks for the Building 854 Area

No risk or hazard to human health or ecological receptors has been identified in this area associated with lead, zinc, HMX, or tritium. A baseline human health risk of $6.6 \times 10^{-5}$ (about seven in one hundred thousand) results from potential incidental ingestion and direct dermal contact with PCB-contaminated soil. This was based on PCB concentrations reported from a single sample; PCBs were not reported in any other sample. The calculated risk means that an onsite worker exposed 8 hours a day, 5 days a week for 30 years could have a seven in one hundred thousand additional chance of developing cancer. The Building 854 facility is no longer used, so the exposure scenario used to calculate this risk is not currently valid, and the actual risk to humans is much lower.

Baseline risk assessment inhalation risks of $8.7 \times 10^{-6}$ (about nine in one million) and $5.1 \times 10^{-6}$ (about five in one million) for adult onsite workers were calculated for VOCs volatilizing from subsurface soil to air inside Buildings 854F and 854A, respectively. The maximum historical TCE concentration in subsurface soil was 30.7 ppm in 1983, but TCE in almost 200 soil samples from the Building 854 area analyzed since 1983 was below 0.06 ppm. Neither Building 854F nor 854A is currently used for daily operations. Therefore, there is currently no human exposure to VOCs volatilizing from subsurface soil into the buildings.

Although the ground water in the Building 854 Area contains high concentrations of contaminants, there is no current exposure from ground water to human or ecological receptors.

Cleanup of the ground water in this area is based on the applicable Water Quality Objectives of the Central Valley RWQCB's Water Quality Control Plan for Region 5 (Basin Plan).

No hazard to ecological receptors in the Building 854 area has been identified. Furthermore, there are no exposure pathways for ecological receptors, as the affected portions of the Building 854 area are paved and thus do not provide sufficient ecological habitat.

#### 6.6.4. Summary of Cleanup Alternatives for the Building 854 Area

A presumptive remedy, dual-phase extraction, has been identified for the Building 854 area. Therefore, only two alternatives, a no-action alternative required by EPA guidance and the presumptive remedy, were presented in the SWFS, as summarized in Table 8.

#### 6.6.5. Evaluation of Alternatives

The no-action Alternative 1 is required by the NCP to provide a baseline for comparison to other alternatives, and is the basis of the baseline risk assessment. Under a no-action response, all monitoring and remediation activities in the Building 854 area would cease. There are no costs associated with the no-action alternative.

The preferred Alternative 2, which is considered a presumptive remedy by EPA, is described below.

#### 6.6.6. The Preferred Remedial Alternative for the Building 854 Area

DOE believes that Alternative 2 provides the best balance of activities for site cleanup with respect to the EPA evaluation criteria. The components of Alternative 2 are described in detail in the SWFS. The ground water plumes and conceptual placement of extraction wells and treatment facilities are shown on Figure 13. The major components of Alternative 2 are:

1. No further action for metals, HMX, PCBs and tritium in surface soil.
2. Monitoring ground water to determine if plumes are migrating or expanding, track plume concentration and size as remediation progresses, evaluate the effectiveness of the remedial action, and determine when cleanup standards are met.
3. Risk and hazard management to prevent contaminant exposure to humans until cleanup standards are achieved through active remediation.
4. Restoring the aquifer contaminant concentrations to MCLs or below and controlling plume migration. Dual phase extraction of VOC-contaminated ground water and soil vapor (a presumptive remedy) will be used to control plume migration. Extracted ground water and soil vapor will be treated with GAC. Perchlorate and nitrate in ground water will be extracted and treated by GAC, biotreatment and/or ion exchange technology.

Alternative 2 uses exposure control methods and administrative controls to provide initial protection to human health and ecological receptors. This alternative also protects human health by restoring and protecting the beneficial uses of ground water in the shallow water-bearing units through active remediation of contaminants in ground water and the vadose zone. Soil vapor extraction also mitigates future exposure by inhalation of VOCs in the vicinity of Buildings 854A and 854F.

All components of Alternative 2 are implementable and readily fulfill the first eight EPA evaluation criteria in Figure 4.

No further action for metals, HMX, and tritium in surface soil is proposed because there are no risks or hazards to human health or ecological receptors posed by these contaminants in surface soil, and no significant impact to ground water is indicated by modeling of these contaminants. There is no current exposure pathway or potential impact to ground water posed by PCBs in surface soil. However, further investigations will be conducted, and if PCBs in surface soil are found above health-protective levels, they will be removed, as will be addressed in the Site-Wide Contingency Plan, if not sooner.

The estimated present-worth cost to implement Alternative 2 is $9,150,000.

## 6.7. Building 832 Canyon (OU 7)

### 6.7.1. Site Background and Extent of Contamination

TCE and other contaminants were released from Buildings 830 and 832 through piping leaks and surface spills during testing activities at these buildings. TCE in ground water in the Building 830 area has decreased over time from an historical maximum of 30,000 ppb in 1997 to 7,900 ppb in 1998. TCE has also been detected in ground water at Building 832, at an historical maximum of 1,800 ppb in 1998. Figure 14 shows the Building 832 Canyon contaminant plumes. Shallow ground water feeds Spring 3, where TCE concentrations have decreased from an historical maximum of 200 ppb in 1985 to 27 ppb in 1998. TCE has also been detected in subsurface soil and bedrock in the vicinity of Buildings 830 and 832 at 6 ppm and 0.16 ppm, respectively.

Nitrate has been detected at a maximum of 13.5 ppm in subsurface soil/bedrock at Building 830. Nitrate and perchlorate are present in ground water at Buildings 830 and 832 (Figure 14). Nitrate in ground water may be the result of explosives-related testing, septic system releases, and naturally occurring nitrate from local geologic units. Although the source of perchlorate is not known, it may have been a component of explosive test assemblies. Contaminants in ground water near Buildings 830 and 832 are present in the shallow alluvium and underlying sandstone and siltstone/claystone bedrock. However, no water-supply wells are currently contaminated with VOCs, nitrate, or perchlorate originating from the Building 830 or 832 areas.

Rinsewater containing HE compounds was discarded via floor drains in Building 830 which discharged to the ground surface outside the building. As a result, HMX has been detected at extremely low concentrations in surface soil at Building 830 and subsurface bedrock at Building 832. The maximum HMX concentration was 0.2 ppm in 1994 in Building 830 surface soil, and 0.07 ppm in a duplicate sample. The maximum HMX concentration in subsurface soil/bedrock at Building 832 was 0.2 ppm in 1994. Modeling of HMX at Building 832 indicates that it will not significantly impact ground water.

HE compounds have not been detected in ground water near Building 830 or 832.

### 6.7.2. Planned Interim Remedial Action

A treatability study was started in the fall of 1999 to evaluate dual-phase (ground water and soil vapor) extraction near Building 832.

### 6.7.3. Summary of Site Risks for the Building 832 Canyon Area

A baseline cancer risk of $2.8 \times 10^{-6}$ (about three in one million) was calculated for inhalation of VOCs by onsite workers inside Building 830 (Ziagos and Ko, 1997). The risk was calculated using data from ambient air samples collected within Building 830. The total VOC inhalation risk was based on a calculated cancer risk of $2.6 \times 10^{-7}$ for TCE and $2.5 \times 10^{-6}$ risk for vinyl chloride. The vinyl chloride inhalation risk was based on one of two air flux measurements in which vinyl chloride was detected. Vinyl chloride is not a contaminant of concern in the Building 832 Canyon OU, and has not been detected in either ground water or the vadose zone in the Building 830 area. In addition to the collection of ambient air samples, air flux measurements were made concurrently at Building 830 to better quantify VOC vapor concentrations and help eliminate possible contributions from sources other than subsurface soil. Vinyl chloride was not detected in any of the air flux measurements, suggesting that there is probably no source related to subsurface soil contamination.

A baseline risk of $9.6 \times 10^{-6}$ (about one in one hundred thousand) was calculated for onsite workers inhaling VOCs evaporating from subsurface soil outside Building 830. The risk was calculated using data from ambient air samples collected outside in the vicinity of Building 830. The total VOC inhalation risk was based on a calculated cancer risk of $3.3 \times 10^{-7}$ for TCE, $4.5 \times 10^{-6}$ for chloroform, $3.5 \times 10^{-6}$ for 1,2-DCA, and $1.6 \times 10^{-6}$ risk for vinyl chloride. The risks for chloroform, 1,2-DCA, and vinyl chloride were based on single detections. These three compounds were not detected in ambient air samples collected in the vicinity of Building 830 the following day. Vinyl chloride and 1,2-DCA are not contaminants of concern at Site 300, and these compounds have not been detected in the vadose zone in the Building 830 area. As discussed previously, air flux measurements were made concurrently with the ambient air sampling to better quantify VOC vapor concentrations and help eliminate possible contributions from sources other than subsurface soil. Vinyl chloride, 1,2-DCA, and chloroform were not detected in any of the air flux measurements, suggesting that there is probably no source of these compounds in subsurface soil.

The baseline risk assessment also identified an inhalation risk of $6.5 \times 10^{-5}$ (about six in one hundred thousand) for adult workers onsite for TCE volatilizing from surface water at Spring 3 to ambient air. There are no site employees that currently work in the vicinity of Spring 3, so the exposure assumptions on which the baseline risk calculation was based (that a worker would be inhaling VOCs volatilizing from the spring for 8 hours a day, 5 days a week for 30 years), do not currently apply. TCE concentrations in Spring 3 have decreased from a maximum of 200 ppb in 1985 to 27 ppb in 1998. Therefore, the actual risk is probably lower than calculated in the baseline risk assessment.

Although the ground water in the Building 832 Canyon Area contains high concentrations of contaminants, there are no other exposure pathways from ground water to human or ecological receptors. Cleanup of the ground water in this area is based on the applicable Water Quality Objectives of the Central Valley RWQCB’s Water Quality Control Plan for Region 5 (Basin Plan).

No risk or hazard associated with HMX in the subsurface soil/bedrock in these areas have been identified.

The baseline ecological assessment determined that there were no impacts from VOCs to ecological receptors at Buildings 830 and 832.

#### 6.7.4. Summary of Cleanup Alternatives for the Building 832 Canyon Area

A presumptive remedy (dual-phase extraction) has been identified for the Building 832 Canyon area. Therefore, only two alternatives, a no action alternative required by the NCP and the presumptive remedy, were presented in the SWFS, as summarized in Table 9.

#### 6.7.5. Evaluation of Alternatives

The no-action Alternative 1 is required by the NCP to provide a baseline for comparison to other alternatives, and is the basis of the baseline risk assessment. Under a no-action response, all monitoring and remediation activities in the Building 832 Canyon area would cease. There are no costs associated with the no-action alternative.

The preferred Alternative 2, which is considered a presumptive remedy by EPA, is described below.

#### 6.7.6. The Preferred Remedial Alternative for the Building 832 Canyon Area

DOE believes that Alternative 2 provides the best balance of activities for cleanup of the Building 832 Canyon area with respect to the EPA evaluation criteria. The components of Alternative 2 are described in detail in the SWFS. The ground water plumes and conceptual placement of extraction wells and treatment facilities are shown on Figure 14. The primary components of Alternative 2 are:

1. No further action for HMX in surface soil and nitrate in subsurface soil/rock at Building 830, and for HMX in subsurface soil/rock at Building 832.
2. Monitoring ground water and surface water to determine if plumes are expanding or migrating, track plume concentration and size as remediation progresses, evaluate the effectiveness of the remedial action, and determine when cleanup standards are met.
3. Risk and hazard management to prevent contaminant exposure to humans and impacts to ecological receptors until cleanup standards are achieved through active remediation.
4. Restoring the aquifer contaminant concentrations to MCLs or below and controlling plume migration, both in the source area (for VOCs, nitrate and perchlorate) and at the leading edge of the Building 832 VOC, and nitrate plumes. Dual-phase extraction of VOC-contaminated ground water and soil vapor (a presumptive remedy for VOCs) will be used to control migration of the plume. Extracted ground water and soil vapor will be treated by GAC. Perchlorate and nitrate in extracted ground water will be treated by GAC, biotreatment and/or ion exchange technology.
5. Restoring the aquifer contaminant concentrations to MCLs or below and controlling plume migration at Building 830. Dual-phase extraction of VOC-contaminated ground water and soil vapor (a presumptive remedy for VOCs) will be used to control migration

of the plume. Extracted ground water and soil vapor will be treated by GAC. Perchlorate and nitrate in extracted ground water will be treated by GAC, biotreatment and/or ion exchange technology.

6. Downgradient plume control by ground water extraction using a siphon and *ex situ* treatment by iron filings for the Building 830 area.

No further action is proposed for HMX in surface soil and nitrate in subsurface soil/bedrock at Building 830, and for HMX in subsurface soil/bedrock at Building 832, because they pose no risk or hazard to human health or ecological receptors. In addition, there is no significant impact to ground water indicated by modeling of HMX.

Alternative 2 uses exposure control methods and administrative controls to protect human health and ecological receptors. As part of the risk and hazard management component, access control measures would be implemented, if necessary, to prevent VOC inhalation exposure at Spring 3 until concentrations are reduced to health-protective levels.

Alternative 2 prevents potential inhalation of VOCs above health-based concentrations in the vicinity of Building 830 by reducing VOC concentrations in subsurface soil through soil vapor extraction, access control, and ventilation controls, as necessary. This alternative also protects human health by restoring and protecting the beneficial uses of ground water through extraction of contaminants in ground water and the vadose zone. Ground water and soil vapor extraction and treatment would be implemented at both the Building 830 and Building 832 source areas to reduce contaminant mass. Additional ground water extraction and treatment systems would be installed downgradient of Building 832 and Building 830 to prevent migration of the VOC plume. The siphon (using natural ground water pressure to bring ground water to the surface) with iron filing treatment approach would use low cost technologies to prevent further plume migration.

Although the ground water in the Building 832 Canyon contains high concentrations of contaminants, there is no current exposure from ground water to human or ecological receptors. Cleanup of the ground water in this area is based on the applicable Water Quality Objectives of the Central Valley RWQCB’s Water Quality Control Plan for Region 5 (Basin Plan).

All components of Alternative 2 are implementable and readily fulfill the first eight EPA evaluation criteria in Figure 4.

The present-worth cost of Alternative 2 is estimated to be $26,766,000 based on 30 years of ground water and soil vapor extraction and treatment, and ground water monitoring.

## 6.8. Building 801 Dry Well and the Pit 8 Landfill (OU 8)

### 6.8.1. Site Background

Explosives testing was conducted at the Building 801 firing table from 1955 to 1998. No contaminants of concern have been identified in the Building 801 firing table area. A dry well, located under Building 801D, was active from the late 1950s until about 1984, and was once connected to a sink in the machine shop at Building 801D. Waste fluid discharges to the dry well resulted in VOC contamination in subsurface soil and ground water.

The Pit 8 Landfill, an unlined landfill constructed in 1958, is located northeast of the Building 801 Complex. Debris from the Building 801 firing table was disposed in the Pit 8 Landfill until 1974 when an earthen cover was installed. The total estimated volume of material disposed in the Pit 8 Landfill is about 24,700 cubic yards. No contaminants of concern have been identified in surface soil, subsurface soil/bedrock, ground water or surface water in the Pit 8 Landfill area.

#### 6.8.2. Extent of Contamination

TCE has been detected in subsurface soil below the Building 801 dry well at extremely low concentrations. The highest TCE in subsurface soil was 0.057 ppm in 1989. VOCs, including TCE, were also detected at low concentrations (4 ppb in 1998) in ground water (Figure 15). VOC concentrations in ground water are decreasing over time. In 1998, VOCs in ground water near Building 801 were near levels considered safe for drinking water. Nitrate was also detected in ground water in one well downgradient of Building 801, slightly above the drinking water standard. Soil, rock, and ground water chemical data indicate that contaminants have not been released from the Pit 8 Landfill.

#### 6.8.3. Previous Remedial Actions

The Building 801 dry well was excavated and closed in 1984.

#### 6.8.4. Summary of Site Risks for the Building 801 Dry Well and Pit 8 Landfill

No risk or hazard associated with contaminants in subsurface soil and bedrock, or in ground water, were identified in the Building 801 dry well or Pit 8 Landfill areas in the baseline risk assessment.

#### 6.8.5. Summary of Cleanup Alternatives for the Building 801 Dry Well and Pit 8 Landfill

Three remedial alternatives were assembled and evaluated to address contamination in environmental media in the Building 801 dry well and Pit 8 Landfill area, as summarized in Table 10.

#### 6.8.6. Evaluation of Alternatives

The no-action Alternative 1 is required by the NCP to provide a baseline for comparison to other alternatives and is the basis of the baseline risk assessment. Under a no-action response, all monitoring activities in the Building 801 dry well and Pit 8 Landfill area would cease. There are no costs associated with the no-action alternative.

Alternative 1 may not protect human health and the environment. Alternatives 2 and 3 both address risk to human health from potential ingestion of contaminated ground water. Alternatives 2 and 3 include monitoring for changes that could impact human health and the environment. Thus, both alternatives would provide long-term and effective protection of human health and the environment.

Alternative 3 includes active measures to reduce contaminant concentrations and mass in ground water to meet cleanup standards. Contaminant concentrations are naturally attenuating and will be at or below cleanup standards in a reasonable timeframe as proposed under Alternative 2.

If only the characterization and monitoring components of Alternative 3 were implemented, there would not be a significant difference in the short-term effectiveness of Alternatives 2 and 3. The risk of exposure for onsite workers and ecological receptors in the short-term increases if the capping component of Alternative 3 is implemented. The excavation component of Alternative 3 poses the highest short-term risk of exposure and potential impact to human and ecological receptors during implementation of the remedy. Previously buried waste and associated contamination would be brought to the surface, handled, transported, and redeposited at a new location, thereby increasing the number of exposure pathways to humans and possibly disrupting plant and animal habitat. Measures would need to be implemented to prevent the exposure of onsite workers, transport personnel, the public, and ecological receptors to contaminants.

If characterization data for the Pit 8 Landfill waste were to show that contaminants associated with the waste could impact human health and/or the environment, the capping and excavation components of Alternative 3 would provide additional long-term protection for human health and the environment. If the waste characterization results indicate that human health and the environment would not be impacted by contaminants in the landfill waste, Alternative 3 would provide no significant quantifiable health risk benefit compared to Alternative 2.

Alternative 3 would be significantly more difficult to implement than Alternative 2 if the landfill capping or waste excavation options were implemented. Capping of the landfill presents additional challenges to prevent onsite worker exposure during construction. Excavation of landfill waste would require extensive provisions to prevent exposure and protect the safety of onsite workers, transport personnel, and the public during transport of the waste.

Alternative 3 costs exceed those of Alternative 2 by $841,000 for waste characterization and capping, and up to $21.1 million for (1) waste characterization, (2) monitoring, and (3) total excavation of the pit waste.

### 6.8.7. The Preferred Remedial Alternative for the Building 801 Dry Well and Pit 8 Landfill

DOE believes that, among the three proposed remedial alternatives, Alternative 2 provides the best balance of trade-offs with respect to the EPA evaluation criteria.

The primary components of the preferred remedial Alternative 2 are:

1. No further action for VOCs in subsurface soil and rock for the Building 801 dry well.
2. Monitoring ground water to (1) determine if the VOC plume is migrating or expanding, (2) track nitrate concentrations in ground water that could impact human health or the environment, and (3) detect any future releases of contaminants from the Pit 8 Landfill.

These components are described in detail in the SWFS.

No further action is proposed for TCE in subsurface soil and rock at the Building 801 dry well because: (1) there is no risk or hazard to human health or ecological receptors posed by TCE in subsurface soil/rock, (2) the dry well source has been removed and closed, and (3) TCE concentrations in ground water are below drinking water standards and are declining, indicating a diminishing source of TCE in subsurface soil and bedrock.

Ground water monitoring in the Building 801 dry well and Pit 8 Landfill areas would protect human health and the environment by detecting future releases, if any, to ground water from (1) contaminants in subsurface soil and bedrock at the Building 801 dry well, or (2) waste buried in the Pit 8 Landfill. Monitoring would also indicate any changes in VOC and/or nitrate concentrations in ground water that could impact human health or the environment. Monitoring would also provide a tool for demonstrating the continued decrease in TCE and nitrate concentrations in ground water to meet cleanup standards, and verifying when cleanup standards are reached.

A Contingency Plan will be prepared for Site 300 which will include actions to be proposed in the event that contaminants from the Pit 8 Landfill are detected in ground water. The Contingency Plan would also include actions to address increases in VOC and/or nitrate concentrations in ground water, or any unanticipated migration or expansion of contaminant plumes such as implementing active cleanup measures, if necessary.

All components of the preferred alternative are readily implementable. Alternative 2 will readily fulfill the first eight EPA evaluation criteria in Figure 4.

The estimated present-worth cost of Alternative 2 for the Building 801 dry well and Pit 8 Landfill is $535,000 based on 30 years of ground water monitoring.

## 6.9. Building 833 (OU 8)

### 6.9.1. Site Background

TCE was used at Building 833 from 1959 to 1982 as a heat-transfer fluid during thermal and mechanical tests of various mixtures of HE compounds. Surface discharge of waste fluids containing TCE occurred through spills, building washdown, rinsewater release from the test cell and settling basin, and rinsewater disposal in a lagoon adjacent to Building 833. As a result, TCE contamination of the shallow soil/bedrock and perched ground water has occurred.

### 6.9.2. Extent of Contamination

TCE has been identified in shallow subsurface sand and gravel at a maximum concentration of 1.5 ppb. After rainfall events, precipitation and some surface runoff infiltrate and migrate downward into the permeable sand and gravel. As a result, shallow ground water contains TCE (Figure 16). Ground water rarely occurs in these sediments and has been encountered periodically in only two wells in this area, primarily after periods of rainfall. Underlying the sand and gravel is a low-permeability claystone which prevents ground water and any contamination from migrating further downward. When ground water is present, the thickness of the shallow, perched water-bearing zone is approximately one to four feet. TCE concentrations in ground water in this water-bearing zone have generally decreased from an historical maximum of approximately 2,000 ppb in 1992 to 1,000 ppb or lower in 1998. The total mass of TCE in ground water is estimated to be less than a pound. Approximately 250 ft of unsaturated rock separates this shallow, perched water-bearing zone from the underlying regional aquifer. No contamination has been detected in the underlying regional aquifer.

### 6.9.3. Summary of Site Risks for the Building 833 Area

The baseline risk assessment for the Building 833 area determined that there was a potential risk to on-site workers who may inhale VOC vapors evaporating from subsurface soil in Building 833. An excess human cancer risk from inhalation of VOC vapors was calculated as $1 \times 10^{-6}$ (one in one million) inside of Building 833. This means that a person spending 8 hours a day, 5 days a week, for 30 years inside Building 833 may have a one in one million additional chance of contracting cancer. This potential exposure route is limited to employees working on-site inside Building 833. The baseline risk assessment also determined that no other Site 300 workers are affected or potentially affected by contaminated soil or soil vapor at this facility.

The perched ground water in the Building 833 area is not likely to present a human health risk. There are no existing exposure pathways for ground water containing contaminants above drinking water standards. Modeling indicates that VOCs from Building 833 would not impact offsite water-supply wells. In addition, exposure, use, or ingestion of the contaminated ground water is highly unlikely because the perched water-bearing zone is naturally unsuitable for drinking water, contaminants are geologically isolated from the regional aquifer, and a San Joaquin County ordinance prohibits installation of shallow water-supply wells. Additionally, the Building 833 area is isolated and access is restricted by full-time security patrols and fencing that surrounds Site 300. DOE plans to maintain and operate the Site 300 experimental test facility for the foreseeable future. Thus, public exposure is unlikely given DOE's commitment to retaining Site 300 as a controlled access facility for the foreseeable future. CERCLA and the Federal Facility Agreement for Site 300 include provisions for assuring cleanup if ownership were to change; thereby precluding the release of any lands that pose an unmitigated human health risk or environmental hazard.

The baseline ecological assessment determined that contaminants in the Building 833 area do not pose a threat to plants or animals.

### 6.9.4. Summary of Cleanup Alternatives for the Building 833 Area

Three remedial alternatives were assembled and evaluated to address contamination in environmental media in the Building 833 area, as summarized in Table 11.

### 6.9.5. Evaluation of Alternatives

The no-action Alternative 1 is required by the NCP to provide a baseline for comparison to other alternatives and is the basis of the baseline risk assessment. Under a no-action response, all monitoring activities in the Building 833 area would cease. There are no costs associated with the no-action alternative. Alternative 1 may not protect human health and the environment.

Alternatives 2 and 3 both protect human health because the perched aquifer in the Building 833 area is not a feasible source of drinking water. Alternative 3 includes measures to reduce contaminant concentrations and mass in ground water. Alternative 2 relies on monitoring to confirm the current trend of decreasing VOC concentrations, and to better understand natural attenuation mechanisms. Thus, both alternatives would provide long-term and effective protection of human health and the environment.

Alternative 3 provides for more rapid contaminant mass removal and concentration reduction through the extraction and treatment of contaminated ground water than by the natural attenuation of contaminants in Alternative 2. However, the additional mass removal provided in Alternative 3 would provide no significant quantifiable health risk benefit compared to Alternative 2 because ground water in this area is not, and could not, be used for drinking water.

Both alternatives include the same measures to prevent exposure to contamination by humans while contaminant concentrations are being reduced, such as administrative controls to prevent access to contaminated ground water and building use restrictions, and monitoring indoor air with ventilation controls, if necessary.

Only Alternative 3 includes active measures to reduce contaminant concentrations and mass in ground water to meet cleanup standards (ARARs). TCE concentrations are ~~is~~ naturally decreasing in the Building 833 area and are projected to fall below cleanup standards in a reasonable timeframe as proposed under Alternative 2. However, cleanup standards may be achieved in a shorter timeframe through active remediation presented in Alternative 3.

Alternative 2 could be readily implemented by continuing and enhancing the existing ground water monitoring programs and continuing administrative controls to prevent exposure. Alternative 3 can be implemented, although additional time, labor and expense would be necessary both in the short- and long-term to construct, operate and monitor the treatment system.

Alternative 3 costs exceed those of Alternative 2 by an estimated $3.4 million.

### 6.9.6. The Preferred Remedial Alternative for the Building 833 Area

DOE believes that, among the three proposed remedial alternatives, Alternative 2 provides the best balance of trade-offs with respect to the EPA evaluation criteria.

The primary components of the preferred remedial Alternative 2 are:

1. Ground water monitoring to (1) determine if the VOC plume is migrating or expanding, (2) evaluate the effectiveness of the remedial action, and (3) determine when cleanup standards are met.
2. Risk and hazard management to prevent exposure of onsite workers to TCE volatilizing from subsurface soil.

These components are described in detail in the SWFS.

A monitoring only approach is considered an appropriate remedial alternative based on the following subsurface characteristics of the Building 833 area:

1. Impacts by contaminants on soil are limited.
2. Limited infiltration of rainwater occurs.
3. The occurrence of ground water in the shallow, perched zone is only periodic, occurring primarily following rainfall events.
4. The total mass of TCE in ground water is very small (less than a pound), and TCE concentrations in perched ground water are decreasing.
5. Perched ground water is contained by low permeability materials that prevent downward contaminant migration.

6. A thick unsaturated zone is present between the perched ground water and the regional aquifer.
7. The water-bearing zone affected by the contamination is not a drinking water source.
8. The regional aquifer has not been impacted and modeling estimates that it will not be impacted in the future.

Monitoring VOCs in ground water would indicate any changes in plume size or concentration and enable assessment of changes in risk or hazard that would affect human health and the environment. Monitoring would also provide a tool for (1) demonstrating the continued decrease in TCE concentrations to meet cleanup standards, (2) detecting if new releases from the Building 833 source area occur, and (3) determining when cleanup standards are met. For these reasons, monitoring of VOCs in ground water should protect human health and the environment in the long-term.

Risk and hazard management would be applied to prevent health impacts until cleanup goals are met. The risk and hazard management program would prevent VOC inhalation exposure for onsite workers by monitoring indoor air, and implementing restrictions and ventilation controls in Building 833, if necessary.

A Contingency Plan will be prepared for Site 300 which will include actions to be proposed in the event that contaminants from the shallow perched zone significantly migrate or expand within the perched aquifer or are detected in ground water in the regional aquifer.

The preferred Alternative 2 could be readily implemented by continuing and enhancing the existing ground water monitoring programs and continuing administrative controls to prevent exposure. Alternative 2 will readily fulfill the first eight EPA evaluation criteria in Figure 4.

The estimated present-worth cost of Alternative 2 for Building 833 is $820,000 based on 30 years of ground water monitoring, and risk and hazard management.

## 6.10. Building 845 Firing Table and the Pit 9 Landfill (OU 8)

### 6.10.1. Site Background

The Building 845 firing table was used from 1958 until 1963 to conduct experimental high explosives experiments. The Pit 9 Landfill was used prior to 1968 to dispose debris generated at the Building 845 firing table. In 1988, a total of 1,942 cubic yards of firing table gravel and 390 cubic yards of soil from the firing table berm were removed and disposed in the Pit 1 Landfill. The location of the Building 845 firing table and the Pit 9 Landfill are shown Figure 17.

### 6.10.2. Extent of Contamination

Leaching of contaminants from the Building 845 firing table has resulted in the contamination of soil and bedrock with uranium-238 and HMX. Up to 1.2 pCi/g uranium-238 and 0.054 ppm HMX have been detected in shallow subsurface clay, silt, gravel, and bedrock underlying the firing table. No contaminants have been detected in ground water under the

Building 845 firing table. Soil, rock, and ground water data indicate that contaminants have not been released from the Pit 9 Landfill.

### 6.10.3. Summary of Site Risks for the Building 845 Firing Table and Pit 9 Landfill

No risk or hazard associated with contaminants in surface soil, subsurface soil and bedrock were identified in the Building 845 firing table or the Pit 9 Landfill area in the baseline risk assessment.

### 6.10.4. Summary of Cleanup Alternatives for the Building 845 Firing Table and Pit 9 Landfill

Three remedial alternatives were assembled and evaluated to address contamination in environmental media in the Building 845 firing table and the Pit 9 Landfill area, as summarized in Table 12.

### 6.10.5. Evaluation of Alternatives

The no-action Alternative 1 is required by the NCP to provide a baseline for comparison to other alternatives and is the basis of the baseline risk assessment. Under a no-action response, all monitoring activities in the Building 845 firing table and the Pit 9 Landfill area would cease. There are no costs associated with the no-action alternative.

If characterization data for the Pit 9 Landfill waste were to show that contaminants associated with the waste could impact human health and/or the environment, the capping and excavation components of Alternative 3 would provide additional long-term protection of human health and the environment. If waste characterization results indicate that human health and the environment would not be impacted by contaminants in the landfill waste, Alternative 3 would provide no significant quantifiable health risk benefit compared to Alternative 2.

There would not be a significant difference in the short-term effectiveness of Alternatives 2 and 3 if only the characterization and monitoring components of Alternative 3 were implemented. The risk of exposure for onsite workers and ecological receptors in the short term increases if the capping component of Alternative 3 is implemented. The excavation component of Alternative 3 poses the highest short-term risk of exposure and potential impact to human and ecological receptors during implementation of the remedy. Previously buried waste and associated contamination would be brought to the surface, handled, transported, and redeposited at a new location, increasing the number of exposure pathways to humans and possibly disrupting plant and animal habitat. A high level of exposure control measures would need to be implemented to prevent exposure of onsite workers, transport personnel, the public, and ecological receptors to contaminants.

Alternative 3 includes characterization of the waste in the Pit 9 Landfill, with contingent monitoring, capping, or excavation. Alternatives 2 and 3 include the same measures to monitor for potential future impacts to ground water and any associated changes in risk or hazard that could affect human health and the environment. Thus, both alternatives would provide long-term and effective protection of human health and the environment. Alternatives 2 and 3 both include measures to monitor for continued compliance with state and federal laws and regulations.

Alternative 3 would be significantly more difficult to implement than Alternative 2 if the landfill capping or waste excavation options are selected, as described above.

The maximum Alternative 3 costs exceed those of Alternative 2 by an estimated $6.6 million.

### 6.10.6. The Preferred Remedial Alternative for the Building 845 Firing Table and Pit 9 Landfill

DOE believes that, among the three proposed remedial alternatives, Alternative 2 provides the best balance of trade-offs with respect to the EPA evaluation criteria.

The primary components of the preferred remedial Alternative 2 are:

1. No further action for the HMX and uranium-238 in subsurface soil and rock.
2. Monitoring ground water for future releases of HMX and uranium-238 from subsurface soil and rock and contaminants that may be present in the Pit 9 Landfill waste.

These components are described in detail in the SWFS.

Under Alternative 2, monitoring would be conducted in the Building 845 firing table and the Pit 9 Landfill areas to detect any future potential releases to ground water from (1) contaminants in subsurface soil and bedrock at the Building 845 firing table, or (2) waste buried in the Pit 9 Landfill.

No further action for contaminants of concern in surface soil and subsurface soil/rock and monitoring should protect human health and the environment because (1) there is no risk or hazard associated with these contaminants in subsurface soil or rock, (2) there is no impact or threat to ground water, and (3) ground water monitoring would detect any future releases to ground water and enable the assessment of changes in risk or hazard that could affect human health and the environment.

A Contingency Plan will be prepared for Site 300 which will include actions to be proposed in the event that contaminants are detected in ground water indicating that (1) uranium-238 or HMX in subsurface soil and bedrock at the Building 845 firing table have migrated to and impacted ground water, and/or (2) contaminants in the Pit 9 Landfill are released to ground water, and/or (3) any unanticipated migration or expansion of contaminant plumes is observed.

All components of Alternative 2 are readily implementable and will fulfill the first eight EPA evaluation criteria in Figure 4.

The estimated present-worth cost of Alternative 2 for the Building 845 firing table and Pit 9 Landfill is $488,000 based on 30 years of ground water monitoring.

## 6.11. Building 851 Firing Table (OU 8)

### 6.11.1. Site Background

The Building 851 firing table has been used since 1962 to conduct experimental research on high explosives materials and radiography of explosives devices during destructive testing. Some of the firing table gravels are periodically removed and replaced. Prior to 1988, the gravel and debris were disposed in various landfills at Site 300. Starting in 1989, all gravel and debris removed from the firing table are placed in containers and shipped to an offsite disposal facility.

### 6.11.2. Extent of Contamination

Explosives experiments have resulted in the release of VOCs and uranium-238 to subsurface soil. In addition, cadmium, copper, zinc, RDX, and uranium-238 were released to surface soil surrounding the Building 851 firing table. Modeling indicates that the RDX, cadmium, copper, and zinc in surface soil would not reach ground water at concentrations above the drinking water standards.

VOCs, including up to 2.7 ppb TCE, were detected at low concentrations in ground water in 1992. However, no VOCs were detected in ground water in 1998. Uranium-238 has been detected in ground water in the shallow gravel and bedrock in the vicinity of the Building 851 firing table (Figure 18). The maximum historical activity of uranium-238 in ground water was 1.3 pCi/L; considerably less than the 20 pCi/L drinking water standard for total uranium.

Figure 18 shows the total uranium activity for each well, and a calculated value for uranium activity attributed to LLNL operations. These values were calculated by comparing the ratios of different uranium isotopes to those found in nature, and to those characteristic of the depleted uranium used historically at Site 300. The maximum total uranium activity in the Building 851 area is 0.29 pCi/L, about one seventieth of the 20 pCi/L MCL.

### 6.11.3. Summary of Site Risks for the Building 851 Firing Table

No risk or hazard associated with contaminants in surface soil and subsurface soil and bedrock was identified in this area in the baseline risk assessment. Uranium-238 in ground water is below the drinking water standard and the levels at which uranium naturally occurs in ground water in this area. The water-bearing zone in the Building 851 firing table area that is affected by the contamination is not used for drinking water. No risk or hazard to human health or ecological receptors was identified for VOCs, uranium-238, RDX, cadmium, copper, and zinc in surface or subsurface soil/rock.

### 6.11.4. Summary of Cleanup Alternatives for the Building 851 Firing Table

Three remedial alternatives were assembled and evaluated to address contamination in environmental media in the Building 851 firing table area, as summarized in Table 13.

### 6.11.5. Evaluation of Alternatives

The no-action Alternative 1 is required by the NCP to provide a baseline for comparison to other alternatives and is the basis of the baseline risk assessment. Under a no-action response, all monitoring activities in the Building 851 firing table would cease. There are no costs associated with the no-action alternative.

Both Alternatives 2 and 3 would monitor uranium-238 in ground water to indicate any changes in plume size or activities, and enable assessment of changes in risk or hazard that could affect human health and the environment. Monitoring for VOCs, metals, and RDX in ground water would determine if these soil and rock contaminants impact human health or the environment in the future. For these reasons, Alternatives 2 and 3 should protect human health and the environment.

Alternative 3 provides additional long-term protection from exposure due to ingestion of ground water containing uranium-238 through extraction and treatment of contaminated ground water at the Building 851 source area. However, since uranium-238 activities are below the drinking water standard and ground water is not currently used as drinking water, Alternative 3 may not provide a significant quantifiable health risk benefit compared to Alternative 2.

Under Alternative 2, there would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 safety procedures to prevent exposure during monitoring. Alternative 3 poses short-term and possibly long-term exposure risk to onsite workers because uranium-238 would be brought to the surface through ground water extraction. Workers could be exposed during installation, operation and maintenance of the treatment systems and the handling and storage of resin containing uranium-238. This is due to the fact that uranium is removed and concentrated in ion exchange resins as part of the treatment process. Exposure control measures would be needed to prevent exposure until the uranium is safely disposed.

Alternative 3 costs exceed those of Alternative 2 by $3.7 million.

### 6.11.6. The Preferred Remedial Alternative for the Building 851 Firing Table

DOE believes that, among the three proposed remedial alternatives, Alternative 2 provides the best balance of trade-offs with respect to the EPA evaluation criteria.

The primary components of the preferred remedial Alternative 2 are:

1. No further action for the VOCs and uranium-238 in subsurface soil and rock and for RDX, cadmium, copper, zinc, and uranium-238 in surface soil.
2. Monitoring ground water to determine if the uranium plume is migrating or expanding, or if vadose zone contaminants impact ground water in the future.

These components are described in detail in the SWFS.

Ground water in the Building 851 firing table area would be sampled and analyzed to determine if cadmium, copper, zinc, and RDX in surface soil and subsurface soil and rock migrate to and impact ground water. In addition, uranium-238 would be monitored in ground water to track changes in activities that could result in an unacceptable risk.

No further action for these contaminants of concern in surface soil and subsurface soil/rock should protect human health and the environment because (1) there is no risk or hazard associated with these contaminants in surface soil and subsurface soil/rock, (2) there is no significant impact or threat to ground water, (3) monitoring of uranium-238 would detect any changes in activities and enable the assessment of changes in risk or hazard that could affect human health and the environment, and (4) monitoring for VOCs, metals, and RDX in ground water would determine if these soil and rock contaminants impact human health or the environment in the future. For these reasons, monitoring VOCs, metals, RDX, and uranium-238 in ground water should adequately protect human health and the environment.

A Contingency Plan will be prepared which will include actions that will be proposed in the event that contaminants are detected in ground water, indicating that the contaminants in soil and bedrock at the Building 851 firing table have migrated to and impacted ground water.

All components of Alternative 2 are easily implemented and will readily fulfill the first eight EPA evaluation criteria in Figure 4.

The estimated present-worth cost of Alternative 2 for the Building 851 firing table is $530,000 based on 30 years of ground water monitoring.

# 7. Community Participation

## 7.1. Comment Period and Public Meeting

A 30-day public review and comment period on this document begins on April 20, 2000, and ends on May 20, 2000. All interested members of the public are encouraged to review and comment on the proposed cleanup actions, and on all alternatives considered. Comments can be submitted verbally at the public meeting or in writing. Written comments should be received by May 22, 2000 by:

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Site 300 Remedial Project Manager
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DOE Oakland Operations Office
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DOE encourages the public to attend a meeting at 6:00 p.m. on May 4 at the Tracy Community Center, 300 East Tenth Street, Tracy, CA. Representatives from DOE, LLNL, U.S. EPA, and the state of California will discuss the proposed cleanup plan and answer questions during the meeting. For further information contact the following:

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Sacramento, CA 95827-3098 (916) 255-3057

## 7.2. Information Repositories

Copies of the Site-Wide Remedial Investigation, Site-Wide Feasibility Study, the Fact Sheet version of this Proposed Plan, and other technical documents for LLNL Site 300 are available at:

LLNL Visitors Center
Enter from Greenville Road
Livermore, CA 94551 (925) 422-9797

Tracy Public Library
20 East Eaton Avenue
Tracy, CA 95376 (209) 835-2221

Both the fact sheet and technical versions of this Proposed Plan are available on the LLNL Environmental Public Information website: http://www-envirinfo.llnl.gov.

# 8. References

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# 9. Acknowledgements

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Kim Heyward of the LLNL Environmental Restoration Division prepared the graphics.

Jenny Kelley of the LLNL Environmental Restoration Division provided clerical support.

# Appendix A

# Glossary and Acronyms/Abbreviations

# A.1. Glossary

**Aquifer:** Underground rock or sediment that can store and supply usable quantities of water to wells or springs for agricultural, industrial, and domestic use.

**Applicable or Relevant and Appropriate Requirements (ARARs):** Federal or state standards, criteria or limitations that are relevant to the proposed cleanup.

**Baseline Risk Assessment:** An assessment of the potential for adverse health effects of human and non-human species to environmental hazards.

**Carcinogen:** A cancer-causing substance or agent.

**Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund):** A law passed in 1980 that authorized the federal government to respond directly to releases of hazardous substances that may endanger human health or the environment.

**Contaminant:** A chemical that degrades the natural quality of a substance or environmental media such as ground water, surface water, soil or air.

**Cumulative Risk:** A total cancer risk that is calculated by adding all of the individual risks for each chemical of concern through all realistic exposure pathways.

**Depleted Uranium:** Uranium that has had the fissile isotope, U-235, removed. See definition of Uranium-238.

**Downgradient direction:** The direction of ground water flow.

**Dry well:** A shallow dry borehole, usually filled with gravel, used to dispose process fluids.

**Exposure route:** The means by which a chemical may enter the body. The three main exposure routes generally evaluated are ingestion (eating or drinking), inhalation (breathing), and dermal contact (absorbed through the skin).

**Federal Facility Agreement:** A document that specifies the required actions at a federal facility like LLNL Site 300 as agreed upon by various federal and state agencies.

**Firing table:** An area next to building or bunker where high explosives are detonated for experimental purposes.

**Fissile:** Refers to an elemental isotope (form) whose nucleus can split into two new elements of lesser mass by a low-energy neutron (an uncharged particle of the nucleus). Fissile material can sustain a chain reaction and is used in reactor fuel or weapons. The isotope U-235 is the only naturally occurring fissile material.

**Granular activated carbon:** A well-established technology that is generally effective for removing volatile organic compounds and some inorganic compounds from fluids such as water or air.

**Ground water extraction:** The process of removing ground water from the ground, usually accomplished by pumping from wells. It can be used to remove dissolved contaminants, lower the water table and/or control ground water movement.

**Half-life:** The time necessary for a substance to lose half of its radioactivity by the process of radioactive decay.

**Hazard Index (HI):** The sum of Hazard Quotients for a given exposure pathway or group of pathways. A Hazard Index above 1 indicates the potential for adverse health effects.

**Hazard Quotient (HQ):** The HQ is the ratio of calculated exposure to accaptable exposure values, as determined by the U.S. EPA and State Agencies. It is a measure of the estimated maximum chronic daily intake of a chemical that is used to determine whether adverse health effects other than cancer may result.

**HMX:** A high explosive compound called High Melting Explosive, also known as octogen or homocyclonate.

**Ion Exchange:** A proven technology for removing certain charged substances, such as metals, from water.

**Maximum additional cancer risk:** The maximum risk of developing cancer in addition to the one in three risk for Californians from other causes.

**Maximum Contaminant Level (MCL):** The maximum allowable concentration of a contaminant in drinking water. MCLs are set by the Federal and State governments.

**Parts per billion (ppb):** A way to report the concentration of a substance in the surrounding material. For example, one billion liters (946,400,000 gallons) of water containing one gram of TCE has a concentration of one part per billion. This may be compared to one penny in ten million dollars or one inch in 16,000 miles.

**Parts per million (ppm):** A way to report the concentration of a substance in the surrounding material. For example, one thousand liters (946,400 gallons) of water containing one gram of TCE has a concentration of one part per million. This may be compared to one penny in ten thousand dollars or one inch in 16 miles.

**Perched water-bearing zone:** Soil or rock containing ground water that is above the regional water table. Water moving downward through the ground collects (is "perched") above a layer (such as clay) that does not allow water to pass through, creating the perched zone.

**PicoCurie (pCi):** A unit of measure of radioactivity. A Curie is the amount of a radionuclide which has a decay rate of $2.22 \times 10^{12}$ disintegrations per minute ($3.7 \times 10^{10}$ disintegrations per second), which is the decay rate of about 1 gram of pure radium. One picoCurie is one trillionth ($1 \times 10^{-12}$) of a Curie.

**PicoCuries per liter (pCi/L):** The number of picoCuries in one liter (1.06 quarts) of water.

**PicoCuries per liter of soil moisture ($pCi/L_{sm}$):** The number of picoCuries in one liter (1.06 quarts) of water from the pore spaces of unsaturated soil or rock.

**Plume:** A welldefined area of contamination in ground water.

**Present-worth cost:** A method to evaluate the total costs for projects that vary in duration by discounting all costs to a common base year (1999) to adjust for the time value of money (interest and inflation). The present-worth cost is the amount of money, if invested in the initial year (1999) of the Site 300 remedial action and dispersed over the life of the project (30 years), that would be sufficient to cover all associated costs. The discount rate is based on the anticipated difference between income return and inflation. A discount rate of 5% was used calculate the present-worth costs of the Site 300 remedial alternatives.

**Presumptive Remedy:** Cleanup technologies, such as dual-phase extraction, that are preferred by the U.S. EPA because they have been repeatedly selected and have proven effective at cleanup sites with similar contaminants and conditions. Use of presumptive remedies accelerates the remedy selection process.

**Presumptive Technology:** Technologies, such as granular activated carbon for treatment of contaminants dissolved in ground water, that are preferred by U.S. EPA because they have proven effective for certain contaminants. Use of presumptive technologies simplifies the remedy selection process.

**Record of Decision (ROD):** A document prepared under CERCLA (Superfund) that documents the selection of a remedial alternative and the strategy for its implementation. Responses to all comments received on the Proposed Plan are included in the Responsiveness Summary of the ROD.

**Regional aquifer:** The primary aquifer that supplies water to a particular region.

**RDX:** A high explosive compound called Research Department Explosive, also known as cyclonite or hexogen.

**Siphon:** Removing ground water from the subsurface using its natural pressure or elevation difference without using a pump.

**Soil vapor:** Air (or other vapor) in the pore spaces of soil or rock in the unsaturated zone.

**Soil vapor extraction:** Removing soil vapor from the ground, usually by applying a vacuum to one or more wells. Typically used to cleanup chemicals that readily evaporate that are present in soil or rock above the water table.

**Superfund:** The common name used for the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980.

**Toxicity Quotient: The ratio between a measured concentration of an ecological contaminant in environmental media, such as surface water, to a standard, such as ambient water quality criteria. A ratio above 1 indicates potential for an adverse ecological effect.**

**Unsaturated zone:** The region in the ground above the water table where the pore spaces in soil and rock are only partially filled with water. Also called the vadose zone.

**Uranium-238 (U-238):** The most abundant natural isotope (form) of uranium. Natural uranium is composed of approximately 99.3% uranium-238, 0.7% uranium-235, and 0.006% uranium-234. Uranium-235 is the fissile component (that which can sustain a chain reaction) and is removed during processing for use in either reactor fuel or weapons. The residue after separation is known as depleted uranium. The uranium used at Site 300 contains less than 0.2% uranium-235 and over 99.8% uranium-238. Uranium is usually measured by isotope, so it is possible to estimate the percentage of uranium that is natural and that portion that has been added from the use of depleted uranium. Because over 99% of all uranium is U-238, the text of this Proposed Plan uses U-238 to represent uranium activities.

**Vadose zone:** See unsaturated zone.

**Volatile organic compounds (VOCs):** Organic compounds that evaporate easily at room temperature. Examples are solvents, gasoline, paint thinner and nail polish remover. Trichloroethylene (TCE) is a VOC.

**Water table:** The level to which a shallow well screened in the uppermost water-bearing zone would fill with water.

# A-2. Acronyms and Abbreviations

| | |
|---|---|
| $1 \times 10^{-3}$ | One in one thousand |
| $1 \times 10^{-4}$ | One in ten thousand |
| $1 \times 10^{-5}$ | One in one hundred thousand |
| $1 \times 10^{-6}$ | One in one million |
| 1,1-DCE | 1,1-Dichloroethylene |
| ARARs | Applicable or relevant and appropriate requirements |
| CDDs | Chlorinated dibenzo-p-dioxins |
| CDFs | Chlorinated dibenzofurans |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act of 1980 |
| DCA | Dichloroethane |
| DOE | Department of Energy |
| DTSC | Department of Toxic Substances Control |
| EPA | U. S. Environmental Protection Agency |
| GAC | Granular Activated Carbon |
| HE | High explosives |
| HI | Hazard index |
| HMX | High Melting Explosive |
| HQ | Hazard quotient |
| LLNL | Lawrence Livermore National Laboratory |
| MCL | Maximum Contaminant Level |
| MDA | Method Detection Limit |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| OU | Operable unit |
| OSWER | Office of Solid Waste and Emergency Response |
| PCE | Perchloroethylene |
| PCB | Polychlorinated biphenyl |
| pCi/L | Picocuries per liter |
| PRGs | Preliminary Remediation Goals |
| RCRA | Resource Conservation and Recovery Act |
| RDX | Research Department Explosive |
| RI/FS | Remedial Investigation/Feasibility Study |
| ROD | Record of Decision |

| | |
|---|---|
| RWQCB | Regional Water Quality Control Board |
| SWFS | Site-Wide Feasibility Study |
| TBOS/TKEBS | Tetra-butyl-orthosilicate/tetra-kis-2-ethylbutylorthosilicate |
| TCA | Trichloroethane |
| TCE | Trichloroethylene |
| VOCs | Volatile Organic Compounds |

# Figures

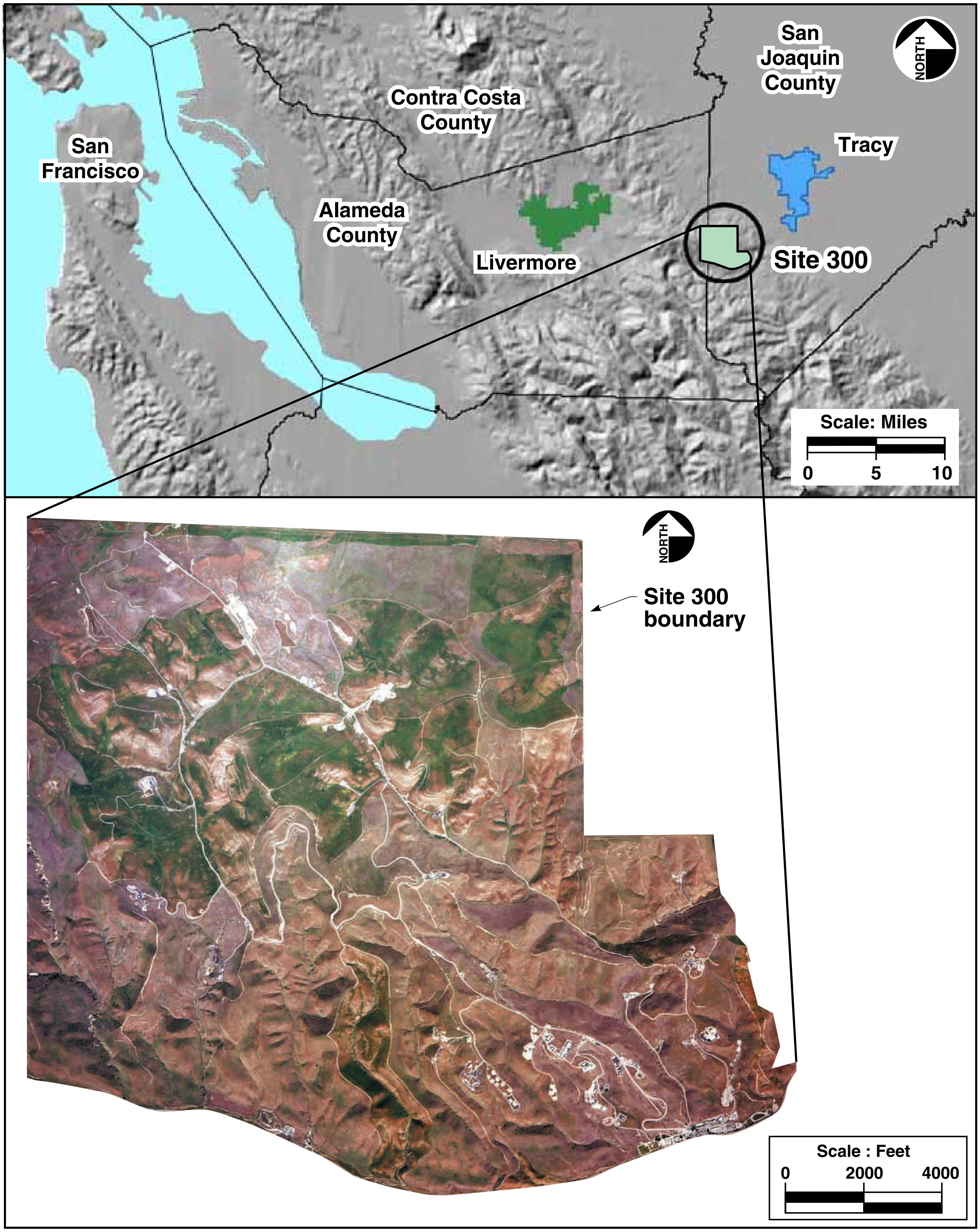


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**Figure 1. Location of LLNL Site 300.**

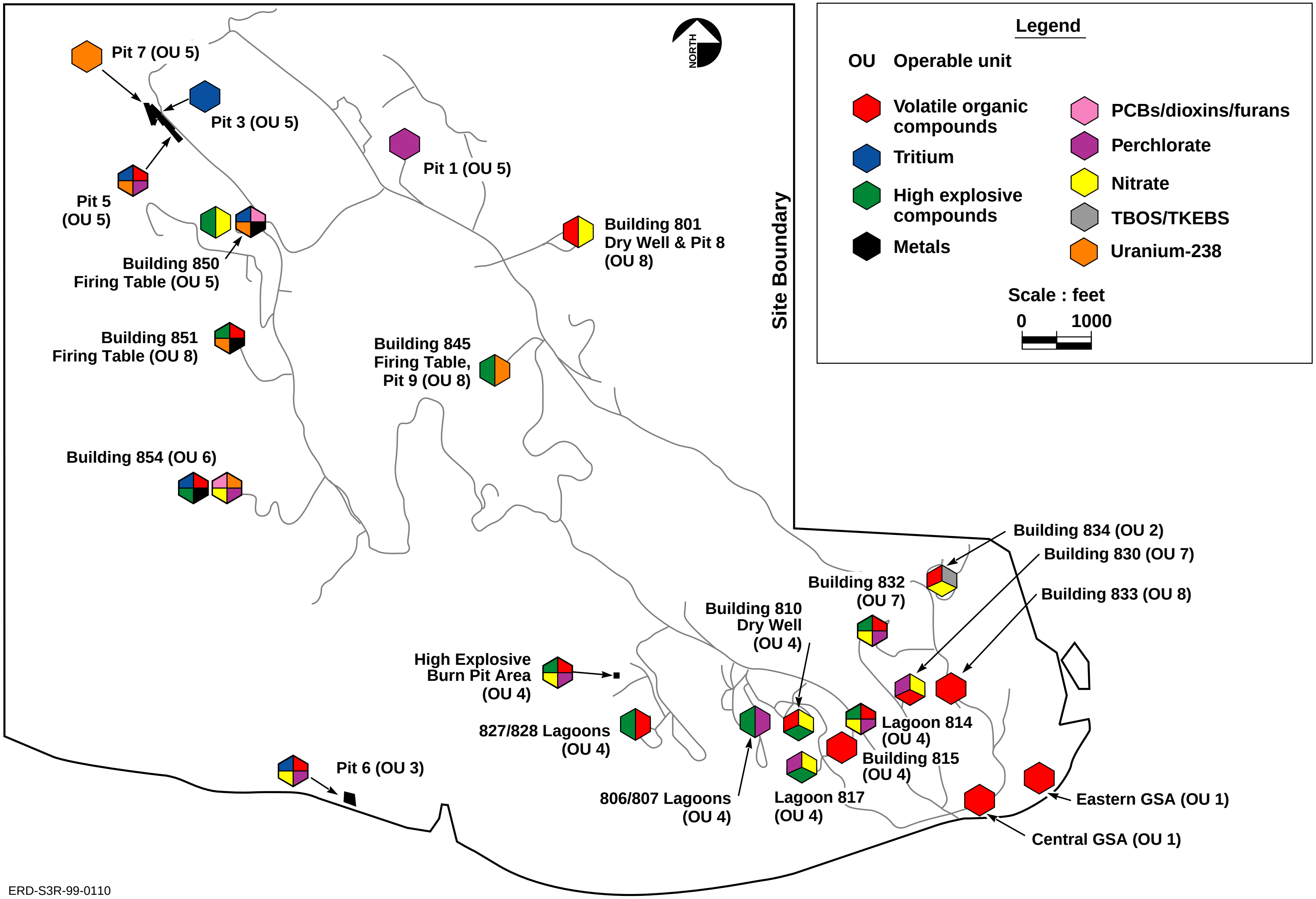



**Figure 2. Site 300 contaminant release sites.**

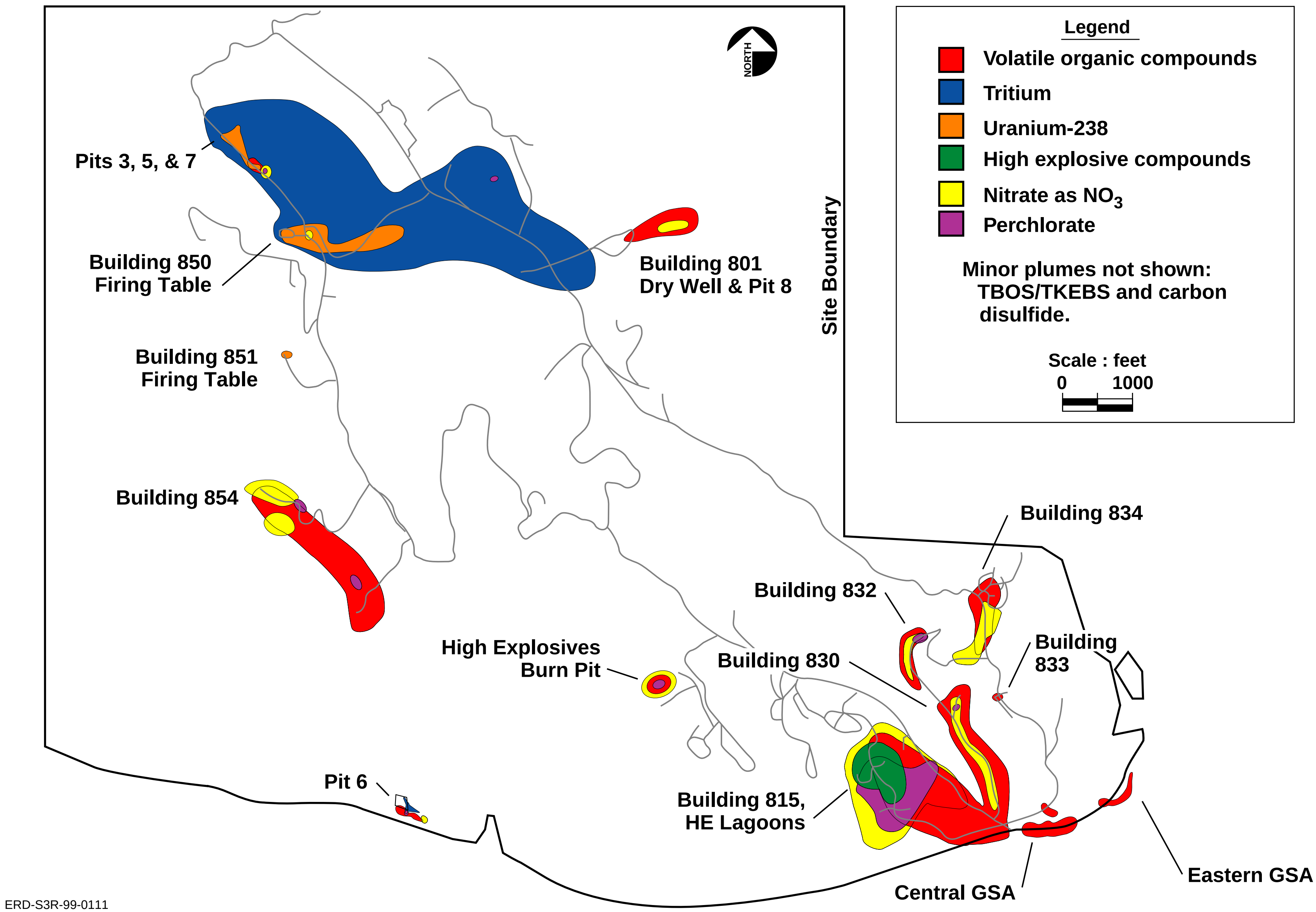
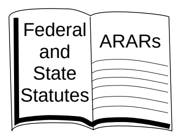



**Figure 3. Site 300 ground water contaminant plumes.**

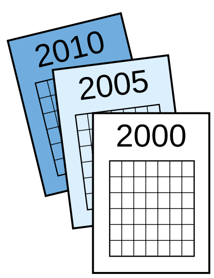
**Each alternative was assessed against the nine CERCLA evaluation criteria described below. Using results of this assessment, DOE/LLNL compared the alternatives and selected a preferred alternative for the site.**

1. **Overall Protection of Human Health and the Environment:** Addresses whether a remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

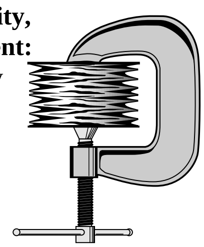
2. **Compliance with Applicable or Relevant and Appropriate Requirements (ARARs):** Addresses whether a remedy will meet all ARARs of federal and state environmental statutes.



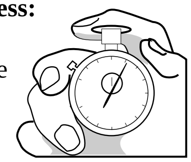

3. **Long-term Effectiveness and Permanence:** Refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup goals have been met.



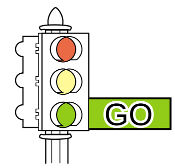

4. **Reduction of Toxicity, Mobility, or Volume Through Treatment:** Refers to the anticipated ability of a remedy to reduce the toxicity, mobility, or volume of the hazardous components present at the site.



5. **Short-term Effectiveness:** Addresses the period of time needed to complete the remedy, and any adverse impact on human health and the environment that may be posed during the construction and implementation period.



6. **Implementability:** Refers to the technical and administrative feasibility of a remedy, including the availability of materials and services needed to carry out a particular option.




7. **Cost:** Evaluates the estimated capital, and operation and maintenance costs of each alternative.

8. **State Acceptance:** Indicates whether, based on its review of the information, the state concurs with, opposes, or has no comment on the preferred alternatives.


9. **Community Acceptance:** Indicates whether community concerns are addressed by the remedy and whether the community has a preference for a remedy. Although public comment is an important part of the final decision, DOE is compelled by law to balance community concerns with all of the previously mentioned criteria.

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**Figure 4. The nine EPA evaluation criteria.**

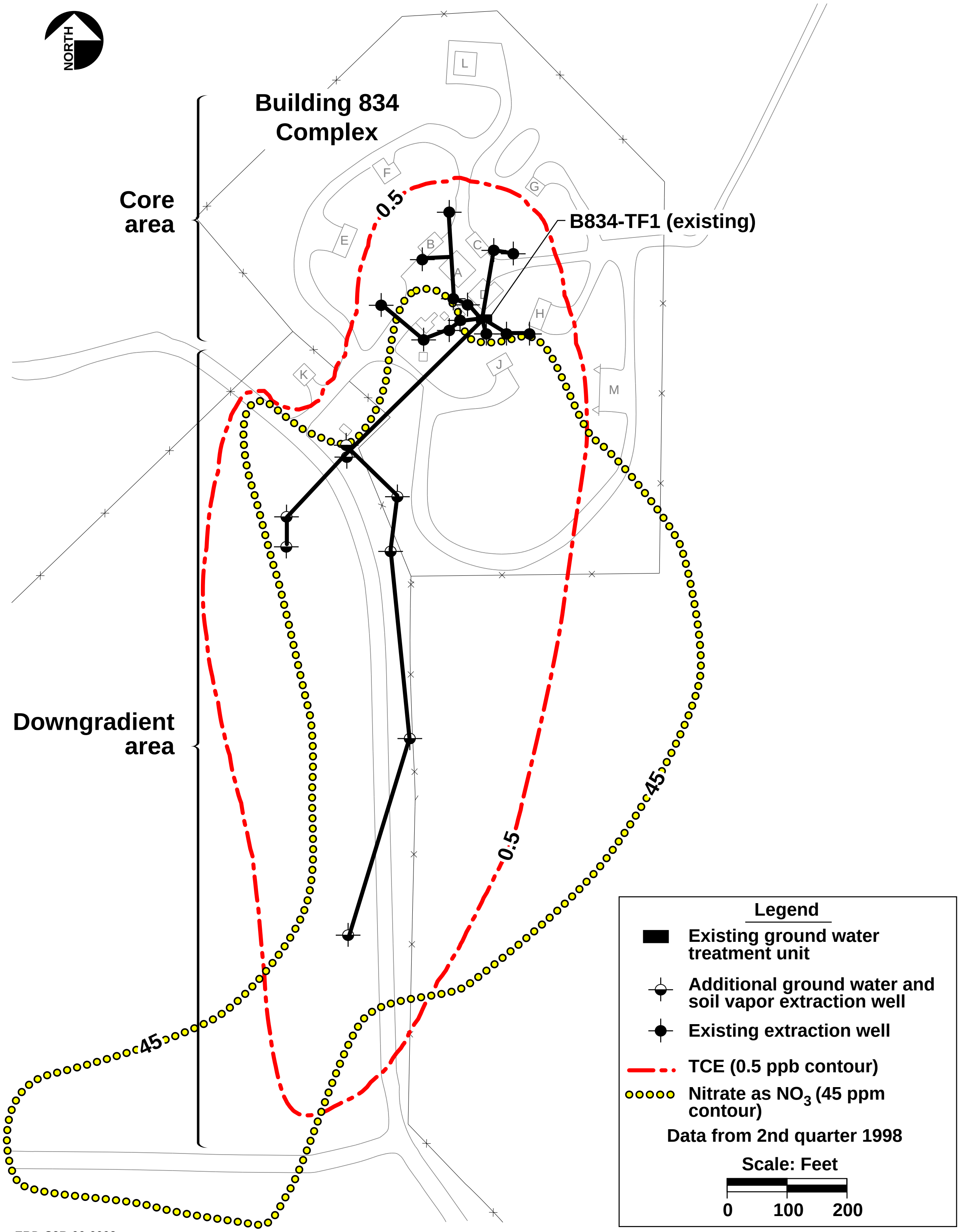


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**Figure 5. Locations of the ground water plumes and the components of the preferred remedial Alternative 2 for Building 834 (OU 2).**

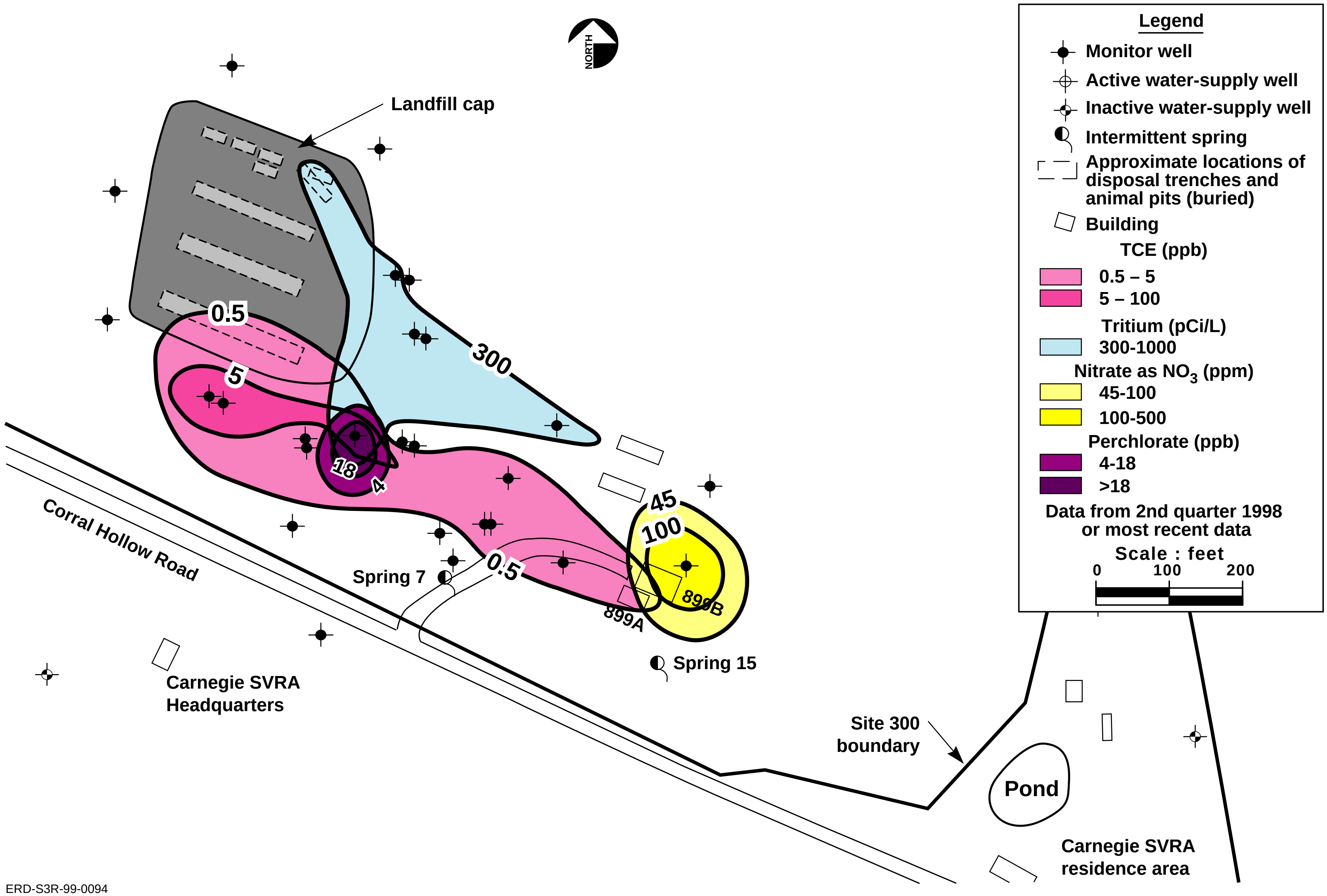


**Figure 6. Distribution of contaminants in ground water and the monitoring network for the Pit 6 Landfill area (OU 3).**

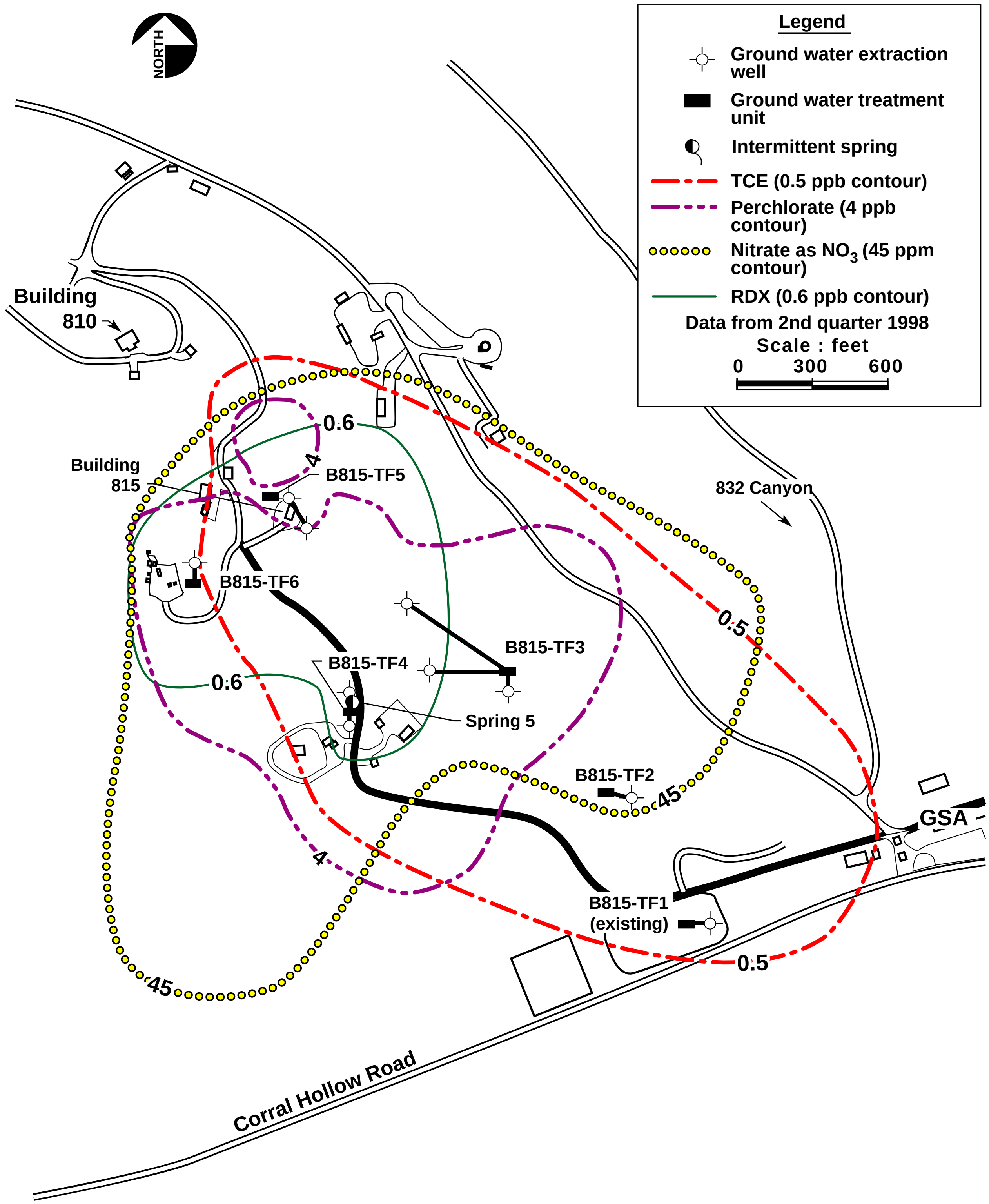


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**Figure 7. Locations of the ground water plumes and the components of the preferred remedial Alternative 2 for the HE Process Area (OU 4).**

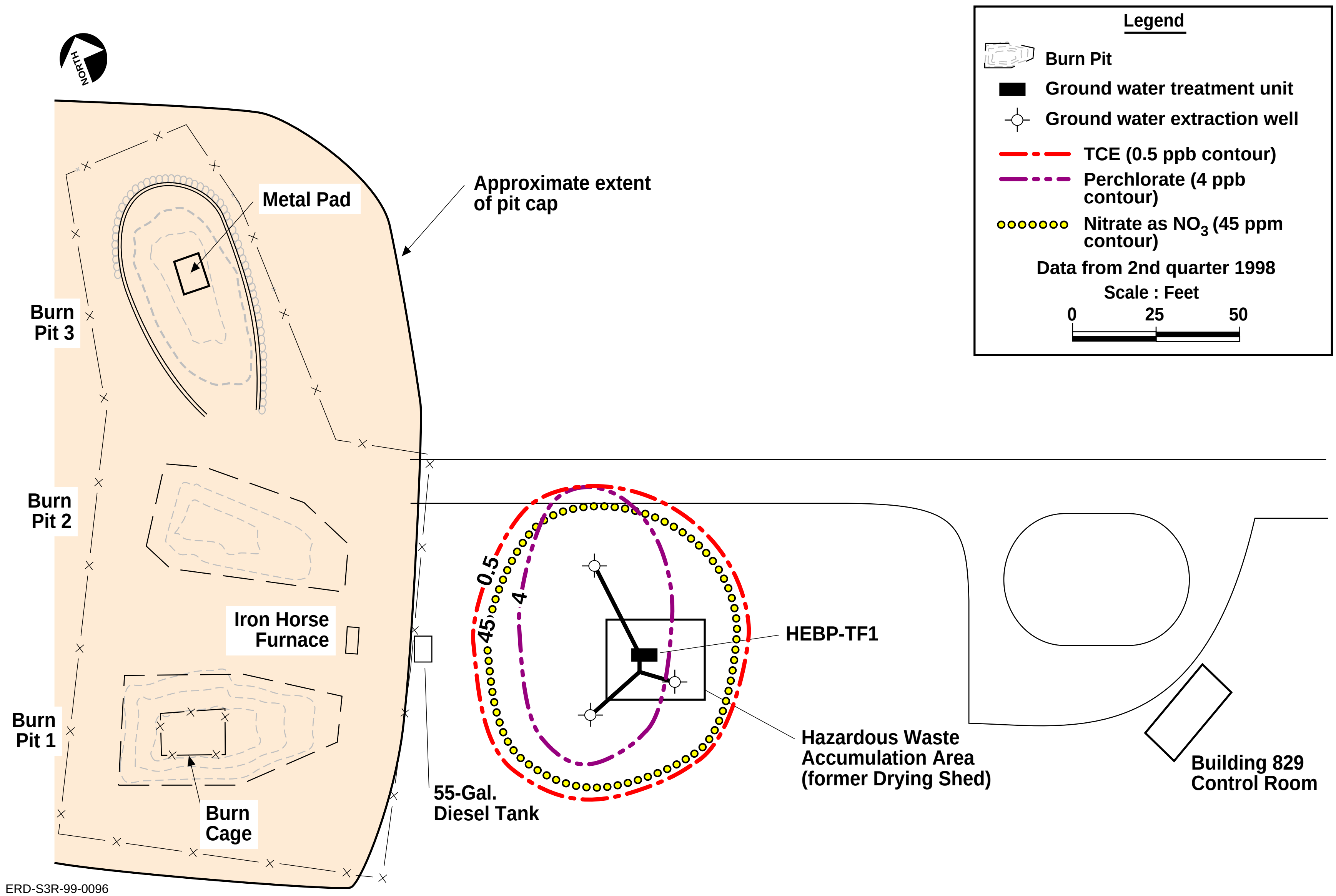


**Figure 8. Locations of the ground water plumes and the components of the preferred remedial Alternative 2 for the HE Burn Pit portion of the HE Process Area (OU 4).**

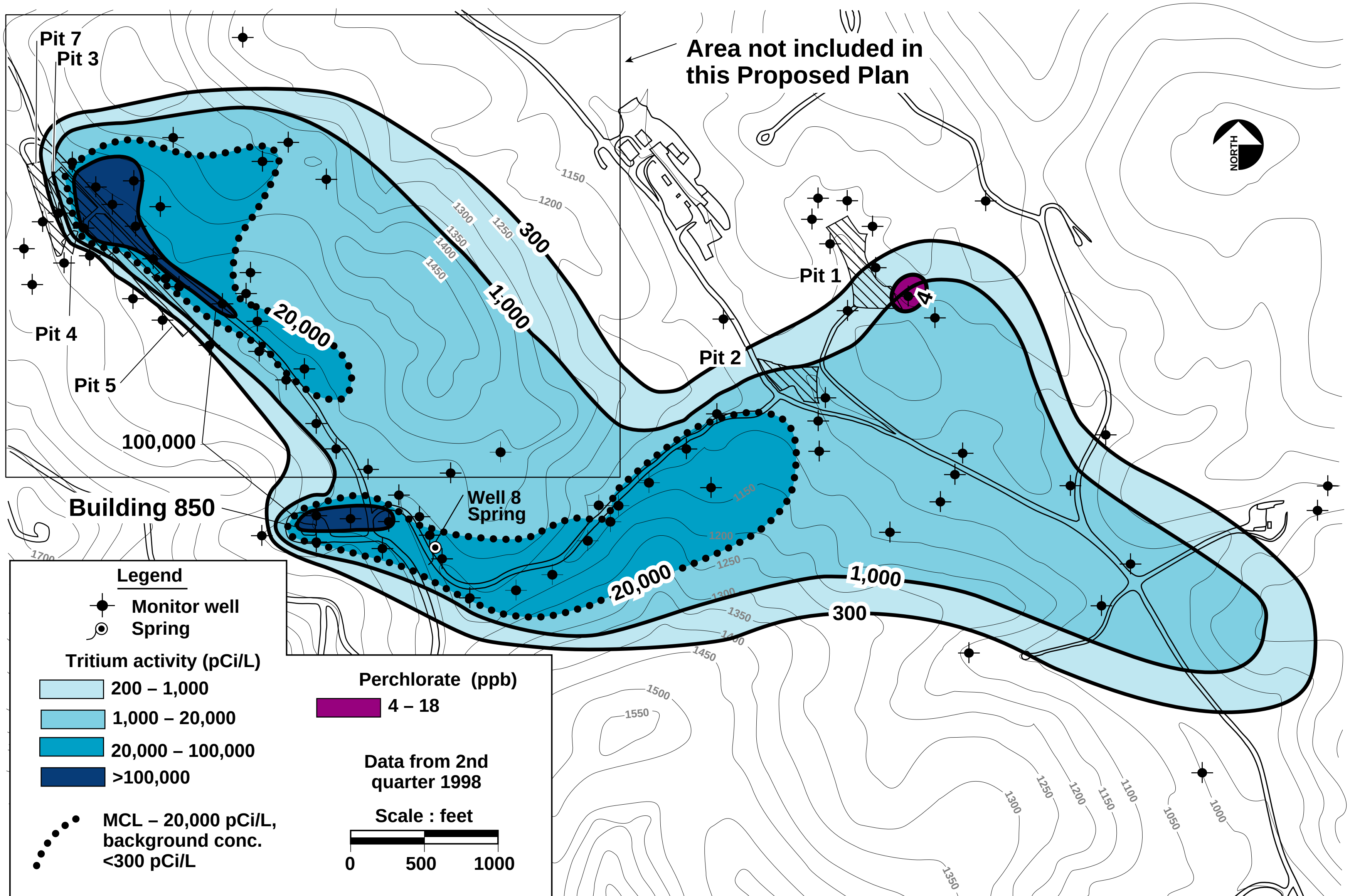


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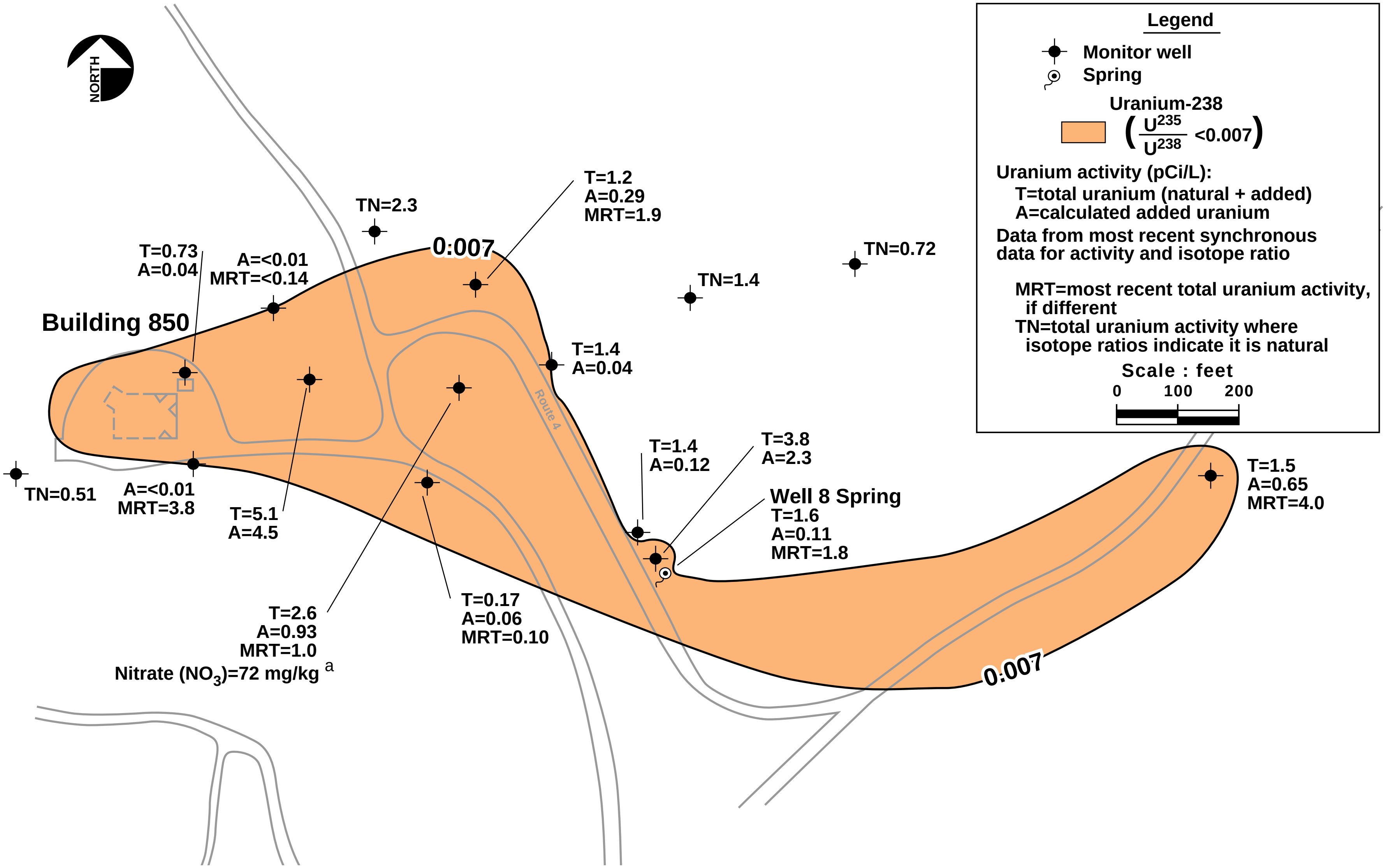
**Figure 9. Distribution of tritium and perchlorate in ground water in the first water-bearing zone and location of the monitoring network in the Building 850/Pits 3 & 5 area (OU 5).**




[a] Nitrate only detected in one well in the area above background.

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Figure 10. Distribution of uranium-238 and nitrate in ground water and location of the monitoring network in the Building 850 area (OU 5). Range of total uranium in ground water at the Building 850 Firing Table is from <0.01 pCi/L to 5.1 pCi/L, which is within the 0-9.5 pCi/L background range for total uranium.

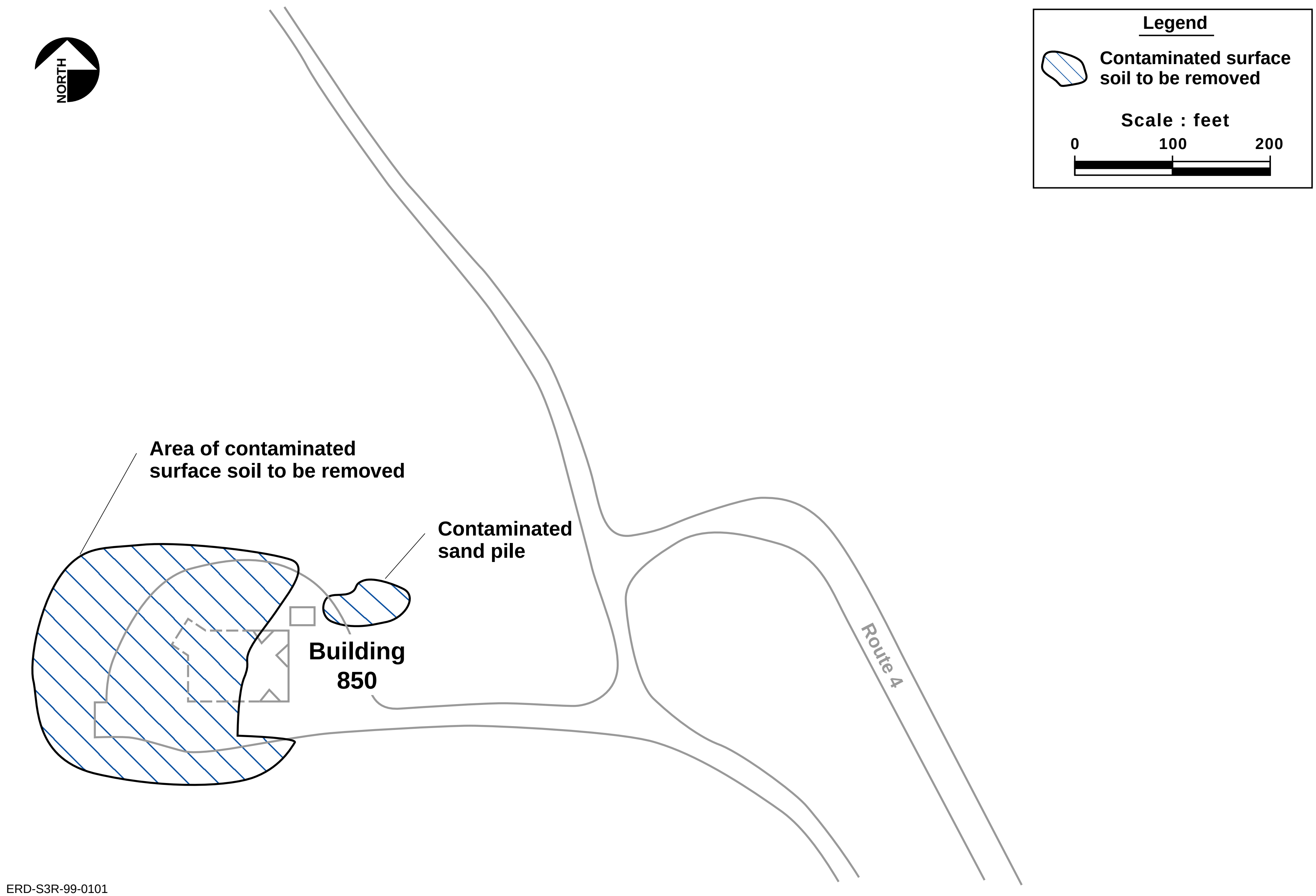


**Figure 11. Location of contaminated soil to be removed for the Building 850 firing table preferred remedial Alternative 2 (OU 5).**

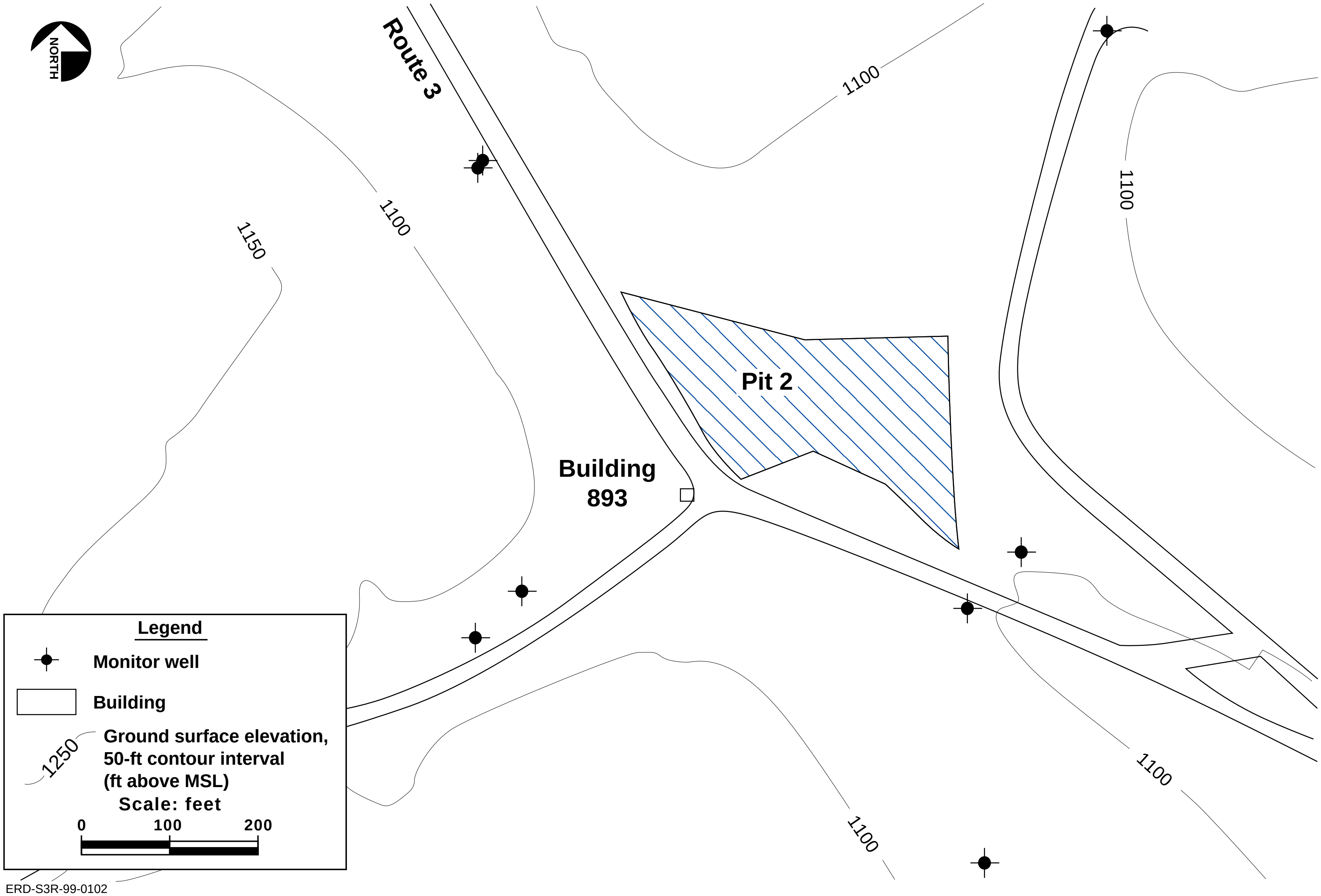


**Figure 12. Location of the Pit 2 Landfill area (OU 5).**

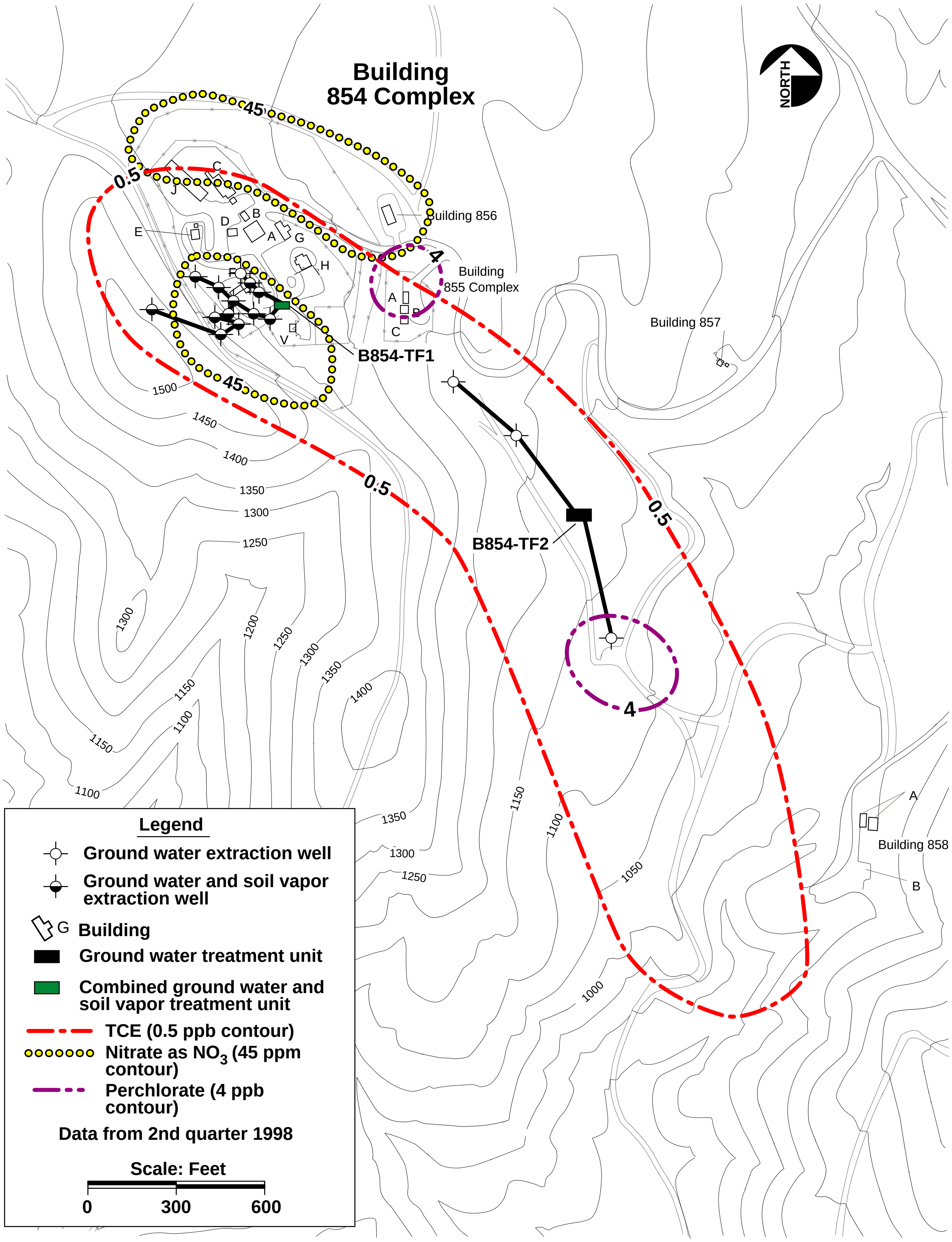


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**Figure 13. Locations of the ground water plumes and the components of the preferred remedial Alternative 2 for the Building 854 area (OU 6).**

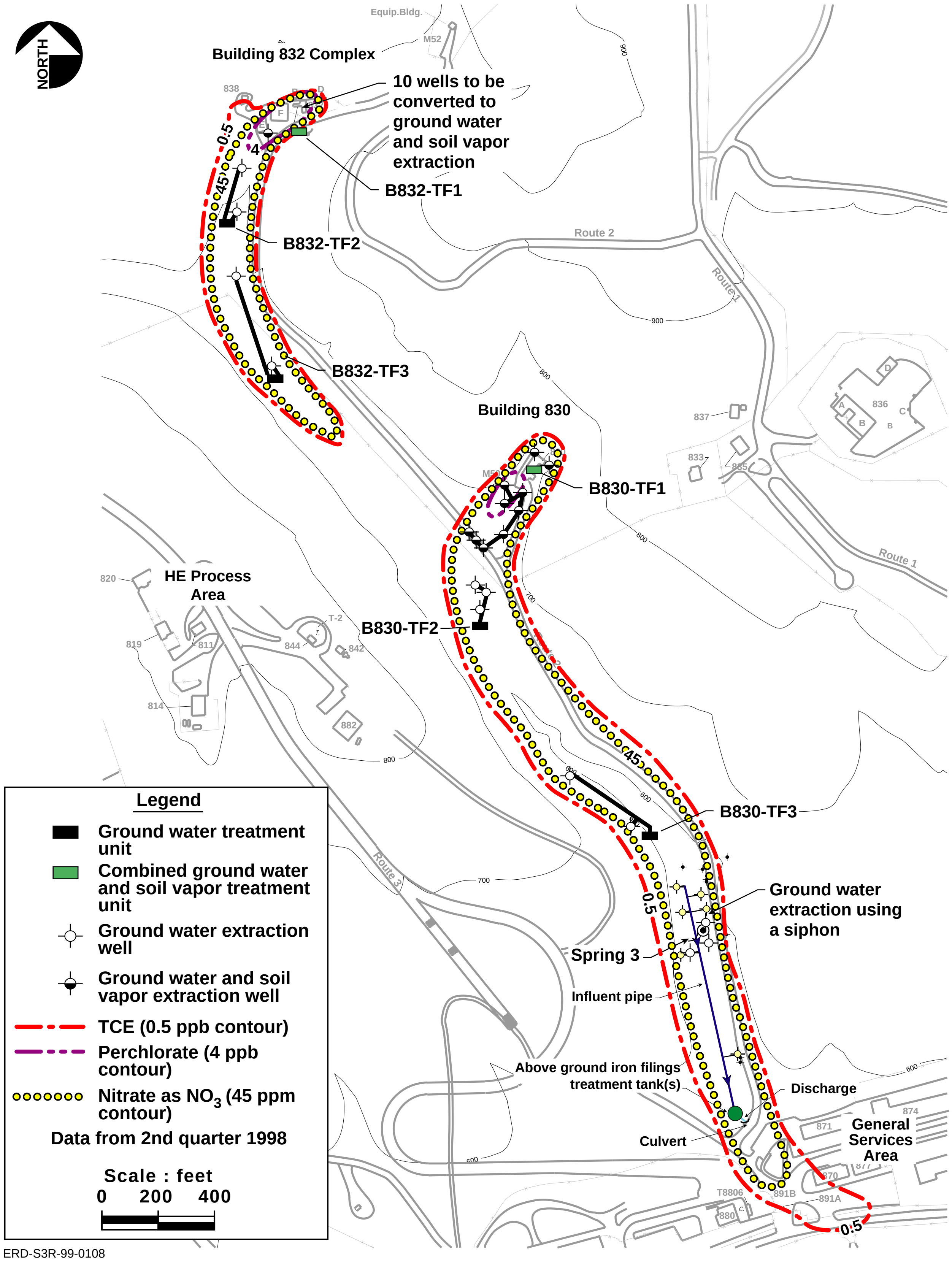


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**Figure 14. Locations of the ground water plumes and the components of the preferred remedial Alternative 2 for the Building 832 Canyon area (OU 7).**

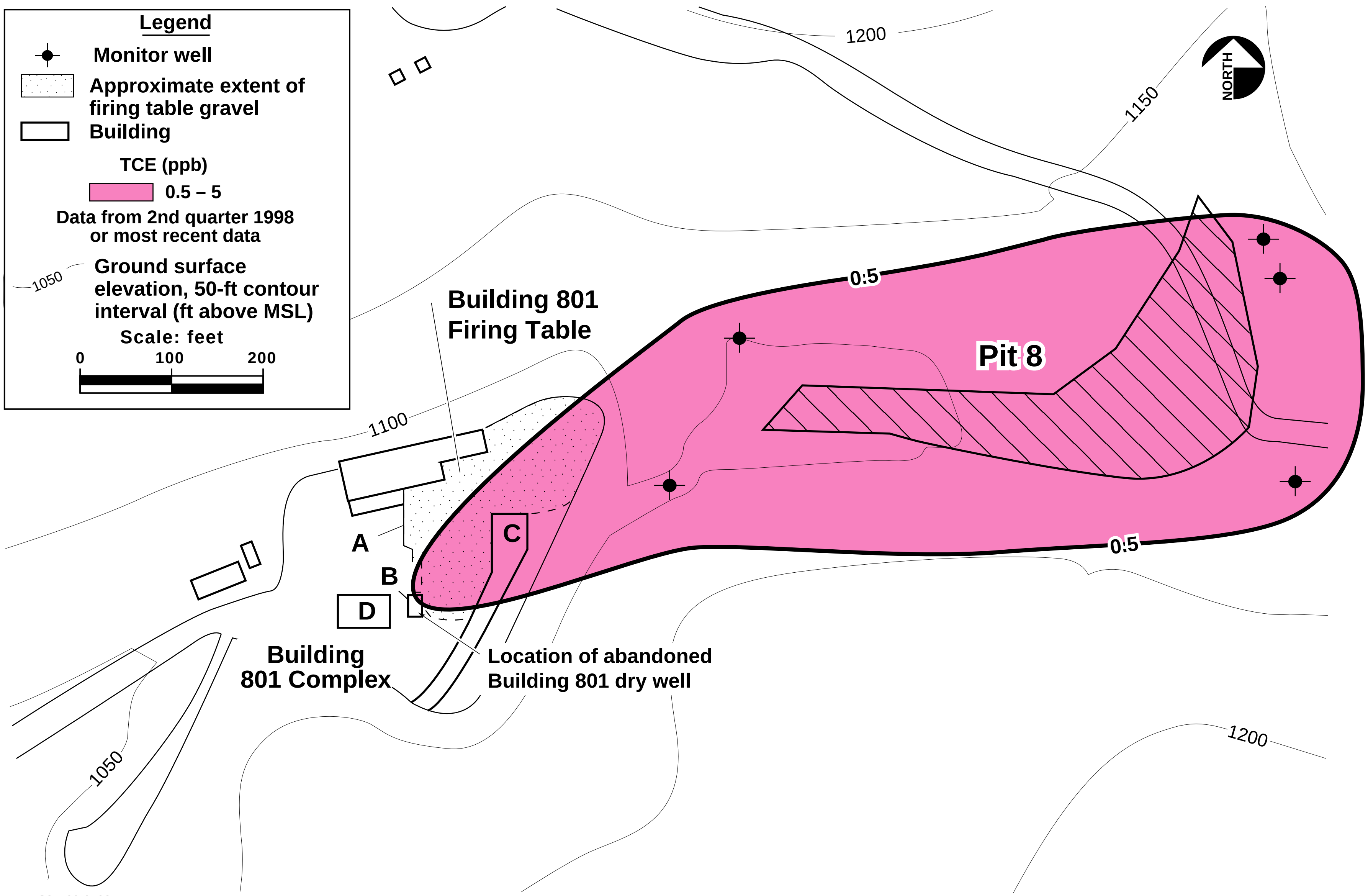


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**Figure 15. Distribution of TCE in ground water and the location of the monitoring network in the Building 801 and Pit 8 Landfill area (OU 8).**

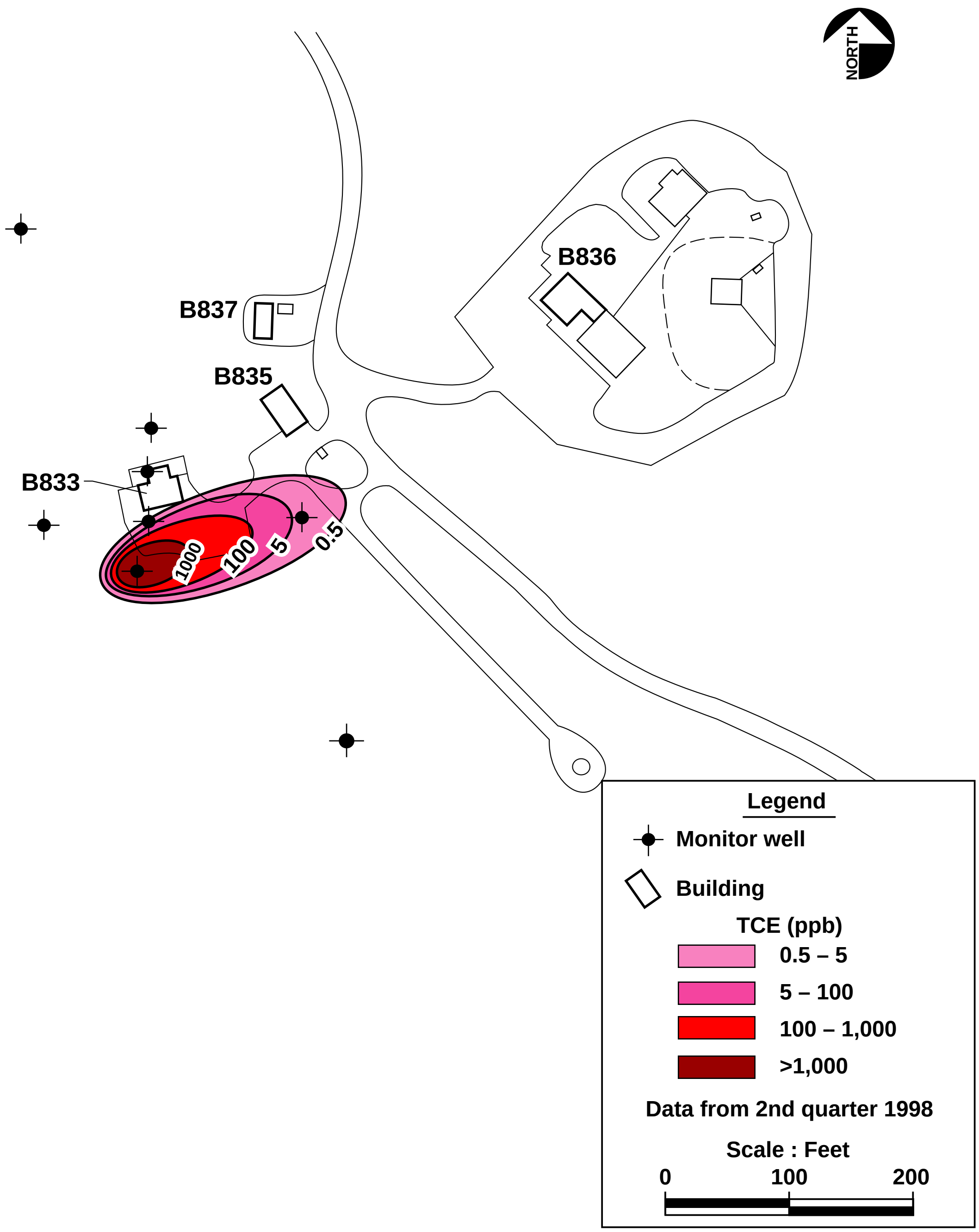


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**Figure 16. Distribution of TCE in ground water and location of the monitoring network in the Building 833 area (OU 8).**

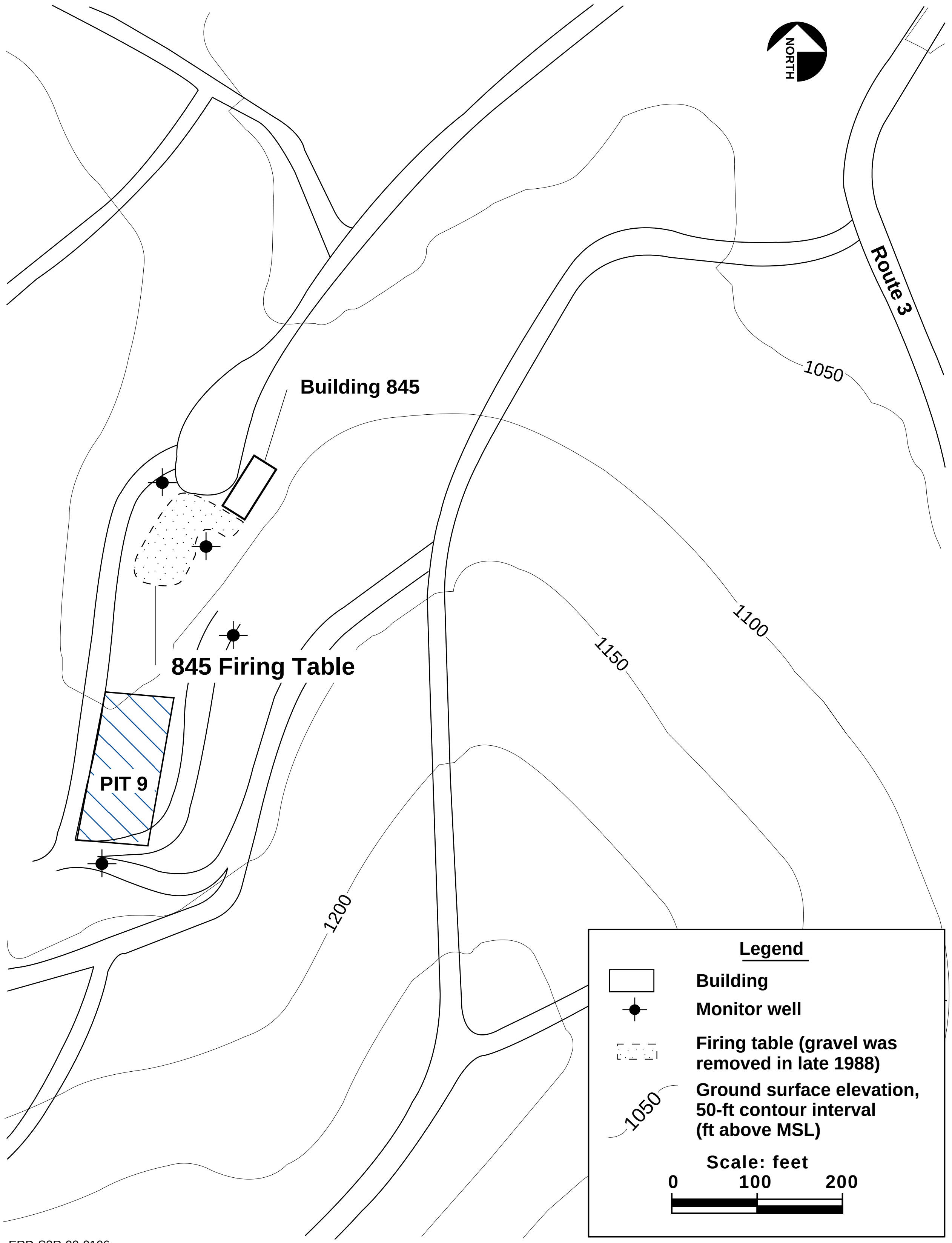


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**Figure 17. Location of the Building 845 firing table and Pit 9 Landfill (OU 8).**

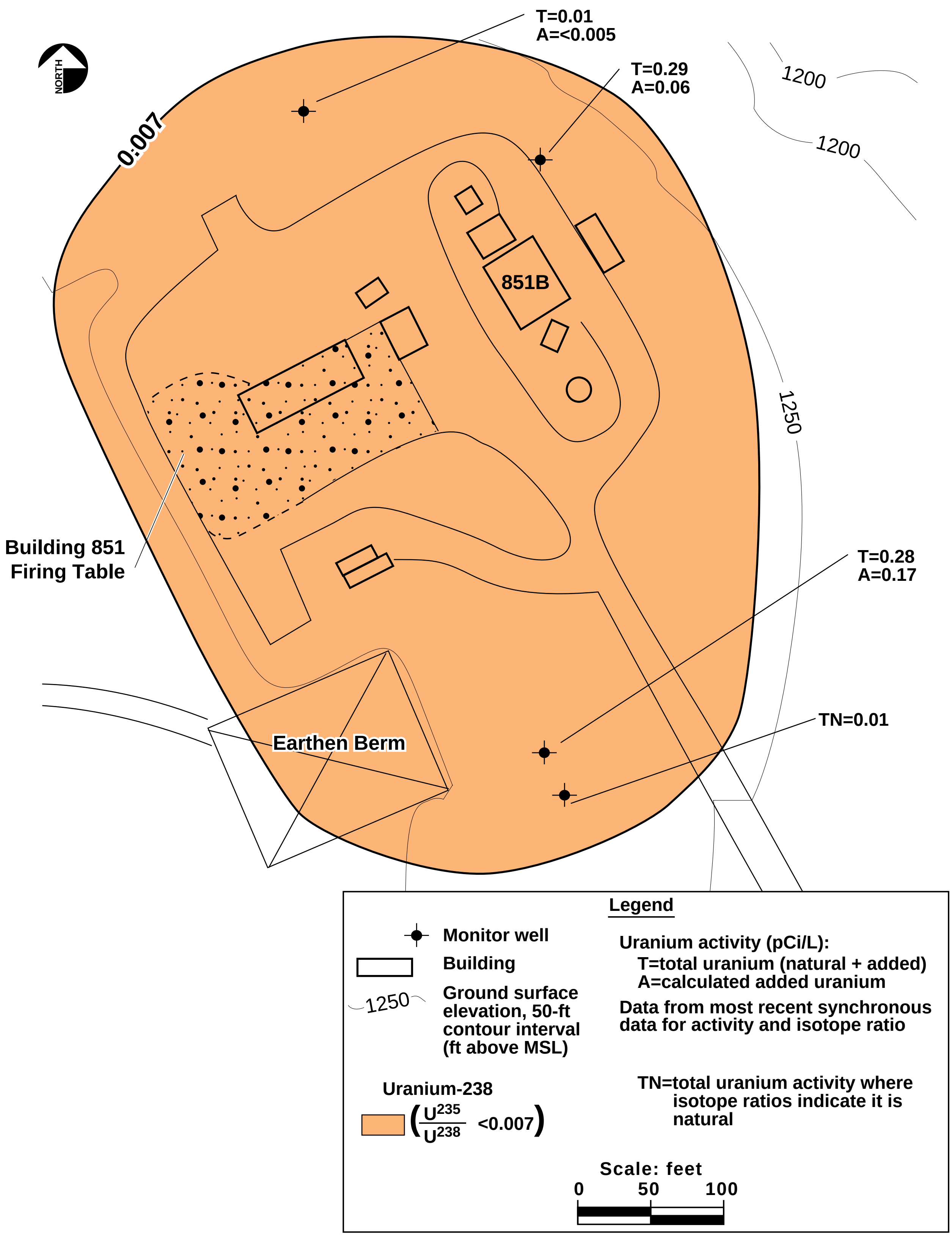


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**Figure 18. Distribution of uranium-238 in ground water and location of the monitoring network in the Building 851 Firing Table area (OU 8). Range of total uranium at the Building 851 Firing Table is from 0.01 pCi/L to 0.29 pCi/L, which is within the 0-9.5 pCi/L background range for total uranium.**

# Tables

**Table 1. Cleanup alternatives for LLNL Site 300.**

| | Building 834 | | | Pit 6 Landfill | | | HE Process Area | | Building 850 Firing Table | | | | Pit 2 Landfill | | | Building 854 | | Building 832 Canyon | | Building 801, Pit 8 Landfill | | | Building 833 | | | B845 Firing Table, Pit 9 Landfill | | | Building 851 Firing Table | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alternative** → | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| **Monitoring** | | √ | √ | | √ | √ | | √ | | √ | √ | √ | | √ | √ | | √ | | √ | | √ | √ | | √ | √ | | √ | √ | | √ | √ |
| **Risk and hazard management** | | √ | √ | | √ | √ | | √ | | √ | √ | √ | | | | | √ | | √ | | | | | √ | √ | | | | | | |
| **Monitored natural attenuation** | | | | | √ | | | | | √ | √ | √ | | | | | | | | | | | | | | | | | | | |
| **Ground water extraction** | | √ | √ | | | √ | | √ | | | | √ | | | | | √ | | √ | | | | | | √ | | | | | | √ |
| **Soil vapor extraction** | | √ | √ | | | | | | | | | | | | | | √ | | √ | | | | | | √ | | | | | | |
| **Enhanced *in situ* bioremediation** | | | √ | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ***In situ* reactive barriers** | | | | | | | | | | | | √ | | | | | | | | | | | | | | | | | | | |
| **Excavation of soil and bedrock beneath firing tables** | | | | | | | | | | | √ | √ | | | | | | | | | | | | | | | | | | | |
| **Removal of surface soil and sand pile adjacent to firing tables** | | | | | | | | | | √ | √ | √ | | | | | | | | | | | | | | | | | | | |
| **Landfill waste characterization with contingent monitoring, capping, and/or excavation** | | | | | | | | | | | | | | | √ | | | | | | | √ | | | | | | √ | | | |
| **Estimated 30-year cost** | $0 | $12.1M | $14.5 | $0 | $2.4M | $6.0M | $0 | $27.6M | $0 | $4.0M | $8.3M | $16.1M | $0 | $0.5M | $22.2M | $0 | $9.1M | $0 | $26.8M | $0 | $0.5M | $21.6M | $0 | $0.8M | $4.3M | $0 | $0.5M | $7.1M | $0 | $0.5M | $4.2M |

**Note**: **Shaded columns are DOE's preferred alternatives.**

**Table 2. Proposed remedial components and treatment technologies for ground water contaminants at LLNL Site 300.**

| Ground water contaminant | Operable unit | Proposed remedial components | Proposed treatment technology |
|---|---|---|---|
| VOCs | Building 834 | Extraction | Air stripping, GAC polish |
| | Pit 6 Landfill | MNA | Not applicable |
| | HE Process Area: | | |
| | —Building 815 | Extraction | GAC |
| | —Burn Pits | Extraction | GAC |
| | Building 854 | Extraction | GAC |
| | Building 832 Cyn: | | |
| | —Building 830 | Extraction | GAC |
| | —Building 832 | Extraction | GAC |
| | —B830 down-gradient | Ground water siphon | *Ex situ* iron filings |
| | Building 801/Pit 8 | Monitoring | Not applicable |
| | Building 833 | Monitoring | Not applicable |
| | Building 851 | Monitoring | Not applicable |
| Tritium | Pit 6 Landfill | MNA | Not applicable |
| | Building 850 | MNA | Not applicable |
| | Building 854 | Monitoring | Not applicable |
| Uranium-238 | Building 850 | Monitoring | Not applicable |
| | Building 854 | Monitoring | Not applicable |
| | Building 851 | Monitoring | Not applicable |
| Perchlorate | Pit 6 Landfill | Monitoring | Not applicable |
| | HE Process Area: | | |
| | —HE Lagoons | Extraction | GAC, biotreatment[1], IX polish |
| | —Burn Pits | Extraction | GAC, biotreatment[1], IX polish |
| | Building 854 | Extraction | GAC, biotreatment[1], IX polish |
| | Building 832 Cyn: | | |
| | —Building 830 | Extraction | GAC, biotreatment[1], IX polish |
| | —Building 832 | Extraction | GAC, biotreatment[1], IX polish |
| Nitrate | Building 834 | Extraction | Biotreatment[2] |
| | Pit 6 Landfill | Monitoring | Not applicable |
| | HE Process Area: | | |
| | —HE Lagoons | Extraction | Biotreatment[2] |
| | —Burn Pits | Extraction | Biotreatment[2] |
| | Building 850 | Monitoring | Not applicable |
| | Building 854 | Extraction | Biotreatment[2] |
| | Building 832 Cyn: | | |
| | —Building 830 | Extraction | Biotreatment[2] |
| | —Building 832 | Extraction | Biotreatment[2] |
| | Building 801/Pit 8 | Monitoring | Not applicable |

**Table 2. (Continued.)**

| Ground water contaminant | Operable unit | Proposed remedial components | Proposed treatment technology |
|---|---|---|---|
| High Explosive Compounds | HE Process Area | Extraction | GAC |
| | Building 845/Pit 9 | Monitoring | Not applicable |
| TBOS/TKEBS | Building 834 | Extraction | Oil-water separation, GAC polish |

**Notes:**

[1]Biotreatment for perchlorate may include bioreactors or CMBS.

[2]Biotreatment for nitrate may include phytoremediation, CMBS, bioreactors, or other biotechnology.

**Abbreviations:**

| | |
|---|---|
| MNA | Monitored Natural Attenuation |
| GAC | Granular Activated Carbon (aqueous-phase) |
| CMBS | Cascading Modular Biotreatment System |
| IX | Ion exchange |

**Table 3. Remedial Alternatives for Building 834.**

| Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|
| **No further action for all contaminants and media of concern.**<br><br>**<u>Total Estimated Cost:</u>**<br>**$0** | **<u>Module B:</u>**<br>**Ground water monitoring**<br><br>**<u>Module C:</u>**<br>**Exposure control through risk and hazard management.**<br><br>**<u>Module D:</u>**<br>**Ground water and soil vapor extraction and treatment of VOCs, silicon-based lubricants, and nitrate (ongoing since 1995).**<br><br>**<u>Total Estimated Cost:</u>**<br>**$12,095,000** | **<u>Module B:</u>**<br>**Ground water monitoring.**<br><br>**<u>Module C:</u>**<br>**Exposure control through risk and hazard management.**<br><br>**<u>Module D:</u>**<br>**Ground water and soil vapor extraction and treatment of VOCs, silicon-based lubricants, and nitrate (ongoing since 1995).**<br><br>**<u>Module E:</u>**<br>**Enhanced *in situ* bioremediation of VOCs.**<br><br>**<u>Total Estimated Cost:</u>**<br>**$14,504,000** |

**Table 4. Remedial Alternatives for the Pit 6 Landfill.**

| Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|
| **No further action for all contaminants and media of concern.**<br><br>**Total Estimated Cost:**<br>**$0** | **Module B:**<br>**Ground water and surface water monitoring. (Monitoring only for nitrate and perchlorate.)**<br><br>**Module C:**<br>**Exposure control through risk and hazard management.**<br><br>**Module D:**<br>**Monitored natural attenuation of VOCs and tritium in ground water.**<br><br>**Total Estimated Cost:**<br>**$2,377,000** | **Module B:**<br>**Ground water and surface water monitoring. (Monitoring only for nitrate.)**<br><br>**Module C:**<br>**Exposure control through risk and hazard management.**<br><br>**Module D:**<br>**Monitored natural attenuation of tritium in ground water.**<br><br>**Module E:**<br>**Ground water extraction and treatment of VOCs and perchlorate.**<br><br>**Total Estimated Cost:**<br>**$5,939,000** |

**Table 5. Remedial Alternatives for the HE Process Area.**

| Alternative 1 | Alternative 2 |
|---|---|
| **No further action for all contaminants and media of concern.**<br><br>**Total Estimated Costs:**<br>**$0** | **Module A:**<br>**No further action for (1) VOCs in subsurface soil/rock at the HE rinsewater lagoon release sites, and (2) VOCs and HMX/RDX in subsurface soil/rock at the HE burn pit release site.**<br><br>**Module B:**<br>**Ground water and surface water monitoring.**<br><br>**Module C:**<br>**Exposure control through risk and hazard management.**<br><br>**Module D:**<br>**Contaminant migration control by ground water extraction and treatment of VOCs and nitrate at the leading edge of the Building 815 TCE plume.**<br><br>**Module E:**<br>**Ground water extraction and treatment of VOCs, HE compounds, nitrate, and perchlorate released from Building 815 and HE rinsewater lagoons.**<br><br>**Module F:**<br>**Ground water extraction and treatment of VOCs, nitrate, and perchlorate released from the HE Burn Pit.**<br><br>**Total Estimated Cost:**<br>**$27,621,000** |

**Table 6. Remedial Alternatives for Building 850.**

| Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 |
|---|---|---|---|
| **No further action for all contaminants and media of concern.**<br><br>**Total Estimated Cost:**<br>**$0** | **Module B:**<br>**Ground water monitoring.**<br><br>**Module C:**<br>**Exposure control through risk and hazard management.**<br><br>**Module D:**<br>**Monitored natural attenuation of tritium in ground water and surface water.**<br><br>**Module G:**<br>**Removal of contaminated sand pile at Building 850 and removal of contaminated soil adjacent to Building 850 firing table (partial module G).**<br><br>**Total Estimated Cost:**<br>**$4,029,000** | **Module B:**<br>**Ground water monitoring.**<br><br>**Module C:**<br>**Exposure control through risk and hazard management.**<br><br>**Module D:**<br>**Monitored natural attenuation of tritium in ground water and surface water.**<br><br>**Module G:**<br>**Excavation of contaminated soil and bedrock under Building 850 firing table, removal of contaminated sand pile at Building 850, and removal of contaminated soil adjacent to Building 850 firing table.**<br><br>**Total Estimated Cost:**<br>**$8,246,000** | **Module B:**<br>**Ground water monitoring.**<br><br>**Module C:**<br>**Exposure control through risk and hazard management.**<br><br>**Module D:**<br>**Monitored natural attenuation of tritium in ground water and surface water.**<br><br>**Module E:**<br>**Ground water extraction and treatment of uranium-238 and nitrate.**<br><br>**Module F:**<br>**Control migration of uranium-238 in ground water using an *in situ* reactive permeable barrier.**<br><br>**Module G:**<br>**Excavation of contaminated soil and bedrock under Building 850 firing table, removal of contaminated sand pile at Building 850, and removal of contaminated soil adjacent to Building 850 firing table.**<br><br>**Total Estimated Cost:**<br>**$16,097,000** |

**Table 7. Remedial Alternatives for the Pit 2 Landfill.**

| Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|
| **No further action for all contaminants and media of concern.**<br><br>**Total Estimated Cost:**<br>**$0** | **Module B:**<br>**Ground water and surface water monitoring.**<br><br>**Total Estimated Cost:**<br>**$515,000** | **Module B:**<br>**Ground water and surface water monitoring.**<br><br>**Module C:**<br>**Waste characterization with contingent monitoring, capping and/or excavation of the Pit 2 Landfill.**<br><br>**Total Estimated Cost Range:**<br>**Between $767,000 and $22,250,000, depending on the amount of waste excavated.** |

**Table 8. Remedial Alternatives for Building 854.**

| Alternative 1 | Alternative 2 |
|---|---|
| **No further action for all contaminants and media of concern.**<br><br>**<u>Total Estimated Cost</u>:**<br>**$0** | **<u>Module A</u>:**<br>**No further action for metals, HMX, PCBs, and tritium in surface soil.**<br><br>**<u>Module B</u>:**<br>**Ground water monitoring.**<br><br>**<u>Module C</u>:**<br>**Exposure control through risk and hazard management.**<br><br>**<u>Module D</u>:**<br>**Ground water and soil vapor extraction and treatment of TCE, perchlorate, and nitrate. (Presumptive remedy).**<br><br>**<u>Total Estimated Cost</u>:**<br>**$9,150,000** |

**Table 9. Remedial Alternatives for Building 832 Canyon.**

| Alternative 1 | Alternative 2 |
|---|---|
| **No further action for all contaminants and media of concern.**<br><br>**<u>Total Estimated Cost</u>:**<br>**$0** | **<u>Module A</u>:**<br>**No further action for (1) HMX in surface soil and nitrate in subsurface soil/rock at Building 830 and (2) HMX in subsurface soil/rock at Building 832.**<br><br>**<u>Module B</u>:**<br>**Ground water and surface water monitoring.**<br><br>**<u>Module C</u>:**<br>**Exposure control through risk and hazard management.**<br><br>**<u>Module D</u>:**<br>**Ground water and soil vapor extraction and treatment of VOCs, perchlorate, and nitrate at Building 832. (Presumptive remedy).**<br><br>**<u>Module E</u>:**<br>**Ground water and soil vapor extraction and treatment of VOCs, perchlorate, and nitrate at Building 830. (Presumptive remedy).**<br><br>**<u>Module F</u>:**<br>**Downgradient ground water extraction using siphon with *ex situ* treatment of VOCs by iron filings.**<br><br>**<u>Total Estimated Cost</u>:**<br>**$26,766,000** |

**Table 10. Remedial Alternatives for the Building 801 Dry Well and Pit 8 Landfill.**

| Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|
| **No further action for all contaminants and media of concern.**<br><br>**<u>Total Estimated Cost:</u>**<br>**$0** | **<u>Module A:</u>**<br>**No further action for VOCs in subsurface soil for the Building 801 dry well.**<br><br>**<u>Module B:</u>**<br>**Ground water monitoring.**<br><br>**<u>Total Estimated Cost:</u>**<br>**$535,000** | **<u>Module A:</u>**<br>**No further action for VOCs in subsurface soil for the Building 801 dry well.**<br><br>**<u>Module B:</u>**<br>**Ground water monitoring.**<br><br>**<u>Module C:</u>**<br>**Waste characterization with contingent monitoring, capping and/or excavation of the Pit 8 Landfill.**<br><br>**<u>Total Estimated Cost Range:</u>**<br>**Between $742,000 and $21,612,000, depending on the amount of waste excavated.** |

**Table 11. Remedial Alternatives for Building 833.**

| Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|
| **No further action for all contaminants and media of concern.**<br><br>**<u>Total Estimated Cost:</u>**<br>**$0** | **<u>Module B:</u>**<br>**Ground water monitoring.**<br><br>**<u>Module C:</u>**<br>**Exposure control through risk and hazard management.**<br><br>**<u>Total Estimated Cost:</u>**<br>**$820,000** | **<u>Module B:</u>**<br>**Ground water monitoring.**<br><br>**<u>Module C:</u>**<br>**Exposure control through risk and hazard management.**<br><br>**<u>Module D:</u>**<br>**Ground water and soil vapor extraction and treatment of VOCs at Building 833.**<br><br>**<u>Total Estimated Cost:</u>**<br>**$4,256,000** |

**Table 12. Remedial Alternatives for the Building 845 Firing Table and Pit 9 Landfill.**

| Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|
| **No further action for all contaminants and media of concern.**<br><br>**<u>Total Estimated Cost:</u>**<br>**$0** | **<u>Module A</u>**<br>**No further action for HMX and uranium-238 in subsurface soil/rock.**<br><br>**<u>Module B</u>:**<br>**Ground water and surface water monitoring.**<br><br>**<u>Total Estimated Cost:</u>**<br>**$488,000** | **<u>Module A</u>**<br>**No further action for HMX and uranium-238 in subsurface soil/rock.**<br><br>**<u>Module B</u>:**<br>**Ground water and surface water monitoring.**<br><br>**<u>Module C</u>:**<br>**Waste characterization with contingent monitoring, capping, and/or excavation of the Pit 9 Landfill.**<br><br>**<u>Total Estimated Cost Range</u>:**<br>**Between $693,000 and $7,065,000, depending on the amount of waste excavated.** |

**Table 13. Remedial Alternatives for the Building 851 Firing Table.**

| Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|
| **No further action for all contaminants and media of concern.**<br><br>**<u>Total Estimated Cost:</u>** | **<u>Module A:</u>**<br>**No further action for VOCs and uranium-238 in subsurface soil/rock and for RDX, metals and uranium-238 in surface soil.**<br><br>**<u>Module B:</u>**<br>**Ground water and surface water monitoring**<br><br>**<u>Total Estimated Cost:</u>**<br>**$530,000** | **<u>Module A:</u>**<br>**No further action for VOCs and uranium-238 in subsurface soil/rock and for RDX, metals and uranium-238 in surface soil.**<br><br>**<u>Module B:</u>**<br>**Ground water and surface water monitoring.**<br><br>**<u>Module C:</u>**<br>**Ground water extraction and treatment of uranium.**<br><br>**<u>Total Estimated Cost:</u>**<br>**$4,198,000** |