EPA/ROD/R09-97/032
1997

EPA Superfund
Record of Decision:

SCHOFIELD BARRACKS (USARMY)
EPA ID: HI7210090026
OU 02
SCHOFIELD, HI
02/07/1997

<IMG SRC 970320>
<IMG SRC 97032A>

Final Record of Decision
for Operable Unit 2
Schofield Army Barracks
Island of Oahu, Hawaii

Prepared by:

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August 12, 1996

Prepared for:

U.S. Army Environmental Center
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Contract No. DAAA15-91-D-0013

Delivery Order DA03

<IMG SRC 97032B>

Mr. Mark Ripperda
Remedial Project Manager, H-9-4
U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, California 94105-3901

Dear Mr. Ripperda:

The Final Record of Decision for Operable Unit 2 is hereby transmitted to you. The Army has approved this document and requests U.S. Environmental Protection Agency concurrence by signing on sheet 1-5 of said document. Another copy of this document has been sent to the Department of Health, State of Hawaii for their concurrence. Upon concurrence, request that the original signature sheet be transmitted to the Army for reproduction and distribution of the completed document. The original signature sheets will be sent back to your office upon completion of that function.

If you have any questions, please contact Mr. Jon Fukuda, Environmental Division, (808)656-6790, or Mr. James Daniel, U.S. Army Environmental Center, (410) 671-1501.

Sincerely,

<IMG SRC 97032C>

Enclosure

Final Record of Decision
for Operable Unit 2
Schofield Army Barracks
Island of Oahu, Hawaii

Prepared for

U.S. Army Environmental Center
Installation Restoration Division

HLA Project No. 33537 07.04.00
Contract DACA31-94-D0069
Delivery Order No. 0004

August 12, 1996

<IMG SRC 97032D>

Environmental Services Program Support

Final Record of Decision for Operable Unit 2
Schofield Army Barracks, Island of Oahu, Hawaii

August 12, 1996
Contract Number DACA31-94-D0069
Delivery Order No. 0004

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1.0 DECLARATION

This Final Record of Decision (ROD) for Operable Unit (OU) 2 has been prepared by Harding Lawson Associates (HLA) for the U.S. Army Environmental Center (USAEC) under Delivery Order No. 0004 of the Total Environmental Services Program Support (ESPS) Contract DACA31-94-D-0069. This report documents the remedial action plan for OU 2 at Schofield Army Barracks (Schofield Barracks), Island of Oahu, Hawaii.

1.1 Site Name and Location

Schofield Barracks is located in the north-central plateau of the Island of Oahu in the State of Hawaii (Figure 1.1). The Schofield Barracks installation is approximately 22 miles northwest of the City of Honolulu. The closest municipality is Wahiawa, which is immediately north of Schofield Barracks. The installation is divided into two sections, the East Range and the Main Post (Figure 1.2), encompassing a total area of approximately 27.7 square miles. Wheeler Army Airfield (Wheeler) lies between and to the south of the two Schofield Barracks sections.

Operable Unit 2 addresses the contaminated groundwater system beneath Schofield Barracks.

1.2 Statement of Basis and Purpose

This decision document (ROD) presents a response action for OU 2, the contaminated groundwater system beneath Schofield Barracks. This action was selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This ROD explains the basis for selecting the response action for OU 2. Information supporting the selected response action is contained in the Administrative Record for Schofield Barracks.

1.3 Assessment of the Site

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this ROD, may present a current or potential threat to public health, welfare, or the environment.

1.4 Description of the Selected Remedy

The function of OU 2 is to address base-wide groundwater contamination. The selected remedy provides protection of human health and the environment by reducing potential risks associated with domestic use of the contaminated groundwater. The remedy includes the following components:

- Continued treatment for contaminants of concern (COCs) present in extracted groundwater at the Schofield Barracks Supply Wells by air stripping at the wellhead followed by discharge of the treated water to the distribution system

- The Army must consult with EPA and the State of Hawaii prior to abandoning the Schofield Barracks water supply wells, because production-at these wells may help to control plume migration

- Long-term sampling and analysis of water supply wells, agricultural wells, and monitoring wells in the region

- Implementation of the contingency of wellhead treatment on any water supply wells that are impacted by the plume from Schofield Barracks above one-half of the Maximum Contaminant Level (MCL) as established under the Safe Drinking Water Act (SDWA)

- Upgrade the treatment system or pay any incremental costs for treatment caused by contamination from Schofield Barracks at wells that already have a treatment system in place

- Conduct five-year site reviews with the State of Hawaii Department of Health (DOH) and the U.S. Environmental Protection Agency (EPA).

The details of the monitoring plan, evaluation process for implementation of wellhead treatment, and description of conditions at existing water wells may be found in the Final Operation and Maintenance and Long-Term Groundwater Monitoring Plan for Operable Unit 2, Schofield Army Barracks, which is an addendum to this ROD. The EPA and DOH concur with the above selected response actions (remedy).

1.5 Declaration Statement

The selected remedy is protective of human health and the environment, and is cost effective, but does not meet the applicable or relevant and appropriate requirement (ARAR) for restoration of groundwater to MCLs under the SDWA. An ARAR waiver for technical impracticability (TI waiver) is being invoked for this ROD, as described in the Justification for Technical Impracticability Waiver at Schofield Barracks for the Ground Water Record of Decision. The TI waiver justification is part of the Administrative Record for Schofield Barracks.

The selected remedy complies with CERCLA in that this action is a permanent solution to the maximum extent practicable or necessary for OU 2 and satisfies the NCP preference for treatment as a principal element of the remedy. A TI waiver is necessary for this action, however, because contaminants will remain in the groundwater at levels of concern for an undetermined period of time.

Therefore, a groundwater monitoring program will be implemented to assess changing aquifer conditions and to track potential movement of the TCE/carbon tetrachloride plumes. A site review will be conducted once every five years until groundwater remediation goals, which are the SDWA MCLs, are achieved in the groundwater system.

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Major General, U.S.A.
Assistant Chief of Staff for Installation Management
U.S. Army

<IMG SRC 97032E>

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<IMG SRC 97032G>

2.0 DECISION SUMMARY

This section provides an overview of the site-specific factors and analyses that led to final remedy selection. This overview includes a general site description, site history, enforcement and regulatory history, highlights of community participation, scope and role of OU 2, site characteristics, summary of site risks, and documentation of significant changes to these elements. Much of the information presented in this section was derived from previous investigations performed by the U.S. Department of the Army (Army) and its contractors and has been previously presented in more detail in the Preliminary Assessment/Site Investigation (PA/SI) Report (HLA, 1992a), Final Work Plan for Schofield Army Barracks Remedial Investigation/Feasibility Study (RI/FS) (HLA, 1992b), the Final OU 2 Phase I and Phase II Sampling and Analysis Plans (SAPs) (HLA, 1993 and 1995c), the Final OU 2 RI Report (HLA, 1996a), and the Draft Feasibility Study for Operable Unit 2 (HLA, 1996b).

2.1 Schofield Barracks Site Location and Description

Schofield Barracks is located in central Oahu (Figure 1.1) within the physiographic province known as the Schofield Plateau. Ground surface elevations range from approximately 700 feet (National Geodetic Vertical Datum of 1929 [NGVD]) near the central portion of Schofield Barracks to approximately 4,000 feet (NGVD) near the western boundary of the Main Post in the Waianae Mountain Range. The drainage divide of the Schofield Plateau runs roughly east-west through the center of the Main Post. North of this divide, watercourses flow to the north and discharge into Kaiaka Bay at the town of Haleiwa. South of this divide, watercourses flow south and discharge into the West Loch of Pearl Harbor. Narrow gulches dissect the plateau where streams have eroded the land surface.

The relatively flat Schofield Plateau was formed as basaltic lava flowed from the adjacent Koolau and Waianae volcanoes to the east and west, respectively. The upper 100 to 200 feet of the basaltic bedrock within the Schofield Plateau is weathered saprolite. The saprolite consists of soil (primarily fine-grained materials including silt and clay) formed by in situ decomposition of the basaltic bedrock. The saprolite is underlain by relatively unweathered basaltic bedrock consisting of interbedded pahoehoe and a'a lava flows. The lava flows are highly fractured with cinder and clinker zones.

Three types of groundwater systems have been identified in central Oahu: (1) the Schofield High-level Water Body, (2) basal groundwater, and (3) dike-impounded groundwater (Figures 2.1 and 2.2). The Schofield High-level Water Body is located beneath the Schofield Plateau, and subsequently, the site. This water body is bound to the east and west by dike-impounded groundwater and to the north and south by basal groundwater. Lower permeability rocks (possibly volcanic dikes and/or buried ridges) structurally separate these groundwater systems from one another. The Schofield high-level aquifer has a high transmissivity and hydraulic conductivity. The depth to groundwater at the site is approximately 600 feet below ground surface (bgs) (approximately 270 feet above mean sea level [msl]).

The climate at Schofield Barracks, which is south of the Tropic of Cancer at approximately 21 degrees north latitude, is characterized by moderate temperatures that remain relatively constant throughout the year. The average annual rainfall in the vicinity of Schofield Barracks is approximately 1.2 meters (Giambelluca and others, 1986), more than half of which occurs during the rainy season from November through February. Trade winds have an average speed of 12 knots and prevail from the northeast or east approximately 70 percent of the time.

Because of the relatively large amounts of undeveloped land, combined with a relatively large amount of vertical relief, Schofield Barracks is host to diverse and abundant flora and fauna. Undisturbed natural vegetation at Schofield Barracks is found primarily in the steep gulches on the east and west sides. These gulches support birds and other fauna and blocks of forestry plantings and dense shrubbery growth.

2.2 Schofield Barracks Installation Operational History

Schofield Barracks was established in 1908 as a base for the Army's mobile defense of Pearl Harbor and the Island of Oahu. It served as a major support facility during World War II (WWII) temporarily housing more than one million troops. It also served as a support and training facility during the Korean and Vietnam conflicts. Since the Vietnam conflict, it has served primarily as a training facility.

Schofield Barracks is the Army's largest installation outside of the continental United States. It currently serves as the home of the 25th Infantry Division (Light), whose mission is to be prepared to respond to war at a moment's notice. Installation facilities include a medical facility, community and housing support facilities, and transportation and repair facilities.

2.3 Enforcement and Regulatory History

TCE, a commonly used cleaning solvent, was detected in the Schofield Barracks water-supply wells in 1985. The source of the TCE contamination could not be identified. In September 1986, the Army installed air-stripping treatment units to remove TCE from the Schofield Barracks domestic water supply. In 1987, the EPA established an MCL for TCE of 5 micrograms per liter (Ig/l) in drinking water. TCE has not been detected in Schofield Barracks' treated water supply at concentrations greater than this EPA-established limit.

As a result of the detection of TCE in the Schofield Barracks water-supply wells, Schofield Barracks was placed on the National Priorities List (NPL) in August 1990. The NPL was developed by EPA to identify sites that may present a risk to public health or the environment. Investigations conducted following NPL listing also revealed carbon tetrachloride contamination in the groundwater beneath the Former Schofield Barracks Landfill; therefore, carbon tetrachloride contamination of the groundwater will be addressed along with TCE under this ROD.

After Schofield Barracks was placed on the NPL, a Federal Facility Agreement (FFA) was negotiated among EPA, the State of Hawaii, and the Army under CERCLA, Section 120. The FFA was signed by the Army on September 23, 1991, EPA on September 27, 1991, and State of Hawaii on June 5, 1996. The FFA identified Schofield Barracks as being under the jurisdiction, custody, or control of the U.S. Department of Defense (DOD) and subject to the Defense Environmental Restoration Program (DERP).

2.4 Operable Unit 2 Site Selection History

As a part of the FFA, the Army and regulatory agencies agreed to divide the program into subunits called OUs to address potential areas of contamination at Schofield Barracks in an organized manner. This ROD addresses OU 2, which was established to address the contamination present in the groundwater beneath Schofield Barracks.

During 1991, the Army began to investigate potential contaminant sources at Schofield Barracks through implementation of a PA/SI as required by the FFA. The objective of the PA was to identify possible onpost and offpost groundwater contamination sources both at Schofield Barracks and the surrounding study area. The PA consisted of the following three activities designed to collect additional information regarding Schofield Barracks and nearby offpost communities:

- Conduct an onpost records search of 10 onpost sites (including the Former Landfill) identified in the FFA (EPA, State of Hawaii, and Army, 1991).

- Survey and sample existing water-supply wells in the Schofield High-level Water Body.

- Conduct an industrial activity survey of communities in the study area to identify potential offpost TCE sources.

The objective of the SI was to collect field data to assess potential sources of contamination at the Former Laundry, the East Range Disposal Area, and the Former Landfill.

Results of the records search, industrial activity survey, well survey, and sampling were discussed in detail in the PA/SI Report (HLA, 1992a). Given the results of the PA/SI, additional groundwater investigations were recommended.

The investigation of groundwater contamination (OU 2) was conducted under a two-phase program. Phase I focused on collecting data on aquifer characteristics (regional and local) to provide a better understanding of the aquifer behavior. The specific goals of the Phase I RI are presented in the Final SAP for OU 2 Phase I RI (HLA, 1993). The OU 2 Phase II investigation is based on results of the OU 2 Phase I investigation, the OU 1 investigation, the OU 4 Phase I investigation, and the refined site conceptual model. The results of the OU 2 Phase I and II investigations are presented in the Final OU 2 RI Report (HLA, 1996a).

2.5 Operable Unit 2 Site Description

OU 2 consists of the groundwater beneath Schofield Barracks. This groundwater is 550 to 650 feet bgs and is part of the groundwater body known as the Schofield High-level Water Body. It is called a "high-level" water body because the groundwater levels beneath Schofield Barracks are much higher than groundwater levels in the nearby coastal areas because of underground geologic structures which act as dams to groundwater flow. Most of the groundwater beneath Schofield Barracks originates as rainfall in the Koolau and Waianae mountain ranges to the east and west. This rainfall seeps into the ground in the mountain areas and moves through the subsurface eventually reaching Schofield Barracks. A small amount of water also seeps into the ground in the Schofield Barracks area and reaches the underlying groundwater. The groundwater beneath Schofield Barracks eventually flows into the coastal water bodies to the north and south over the groundwater dams.

A source for the TCE in the groundwater beneath Schofield Barracks has not been identified; however, it is likely that the substance migrated from a ground surface location through the soil and bedrock to the underlying groundwater. The former landfill was identified as the source of the carbon tetrachloride in the groundwater underlying that site. The Schofield Barracks water-supply wells are currently extracting contaminated groundwater from the groundwater system (OU 2); however, all contaminated water currently being pumped from the groundwater beneath Schofield Barracks is being treated by an air-stripping treatment system, which removes the contamination to acceptable standards before the water is distributed for human use.

2.6 Highlights of Community Participation

In an effort to involve the public. the Army has undertaken several public and community awareness efforts including issuance of employee bulletins and post newspaper articles for Schofield Barracks employees, media interviews, news releases, and meetings with local officials and neighborhood boards for offpost residents. In addition, the Army has held public meetings, issued fact sheets, and established an Army contact for the public at Schofield Barracks' Public Affairs Office. Copies of work plans, technical reports, fact sheets, and other materials related to the project are available for public review at the following local repositories:

Mililani Public Library
95-450 Makaimoimo Street
Mililani, Hawaii 96789

Wahiawa Public Library
820 California Avenue
Wahiawa, Hawaii 96786

U.S. Army Garrison, Hawaii
Directorate of Public Works
Building 105
Wheeler Army Airfield, Hawaii 96857-5000

State of Hawaii Department of Health
Environmental Quality Control Office
220 South King Street, 4th floor
Honolulu, Hawaii 96813

On May 24, 1996, the Army presented the Proposed Plan for OU 2 at Schofield Barracks to the public for review and comment. The Proposed Plan summarizes information collected during the OU 2 PA/SI and RI and other documents in the Administrative Record for the Schofield Barracks that are available at the above local repositories. In addition, the proposed plan summarizes the alternatives contained in the FS and outlines the preferred alternative. Prior to the public meeting copies of the Proposed Plan were placed in the local repositories and a public notice was placed in the local newspapers advising the public of its availability. Also, copies of the Proposed Plan were mailed directly to residents and public officials on the Community Relations Plan mailing list.

Comments regarding the Proposed Plan were accepted during a 30-day public review and comment period that began on May 24,1996. A public meeting was held on June 12,1996, at 1139A Kilani Avenue, Wahiawa, Hawaii. At that time, the public had the opportunity to discuss the plan with the Army, EPA, and the Hawaii Department of Health (DOH) and express concerns about the plan. In addition, written comments were accepted during the public comment period. Responses to comments received during the public comment period are included in the Responsiveness Summary (Section 3.0), which is part of this ROD. In addition, responses to the comments received during the public comment period were sent directly to the individual commenter. The public comment period, as discussed above, is a continuation of the Army's commitment to community involvement in the Schofield Barracks Installation Restoration Program (IRP) and is required by CERCLA.

This decision document presents the selected remedial action for OU 2 at the Schofield Barracks, Hawaii, chosen in accordance with CERCLA, as amended by SARA, and to the extent practicable, the National Contingency Plan. The decision for OU 2 is based on the Administrative Record.

2.7 Scope and Role of Operable Unit

The scope of OU 2 consists of the groundwater system beneath Schofield Barracks. The objectives of the OU 2 program are to:

- Assess the presence or absence of contamination within the groundwater system
- Assess the extent of contamination if contaminants are present
- Assess the risks to public health and the environment posed by contamination if contaminants are present
- Identify and evaluate remedial alternatives for site cleanup if contaminants are present in levels that could endanger public health and the environment
- Implement a preferred remedial alternative that assures protection of public health and the environment

OU 2 addresses the contamination present in the groundwater beneath Schofield Barracks. Potential sources of contamination to the groundwater system are addressed in OU 1 and OU 4 (the Former Landfill). OU 3 addresses the potential presence of contamination at various other small sites on Schofield Barracks. OU 2 is the only operable unit addressed in this ROD.

OU 2 addresses the principal threat to human health and the environment posed at this site by minimizing human exposure to contaminated groundwater through treatment prior to its entering the drinking water distribution system.

2.8 Site Characterization

This section of the OU 2 ROD provides a summary of the results and data evaluation activities undertaken as a part of the RI/FS for OU 2. Additional details regarding the results and evaluation of data relevant to the groundwater system are presented in the OU 1, 2, and 4 PA/SI report (HLA, 119992a); Final OU 4 Phase II SAP (HLA, 1995a); the Draft OU 2 Feasibility Study Report (HLA, 1996b); the Final OU 2 Remedial Investigation Report (HLA, 1996a); and the Final OU 1 RI Report (HLA, 1995b). A summary of the nature and extent of contamination and contamination fate and transport is provided in Sections 2.8.1 and 2.8.2, respectively.

2.8.1 Nature and Extent of Contamination

Groundwater was the only media investigated for OU 2. The only analytes detected above MCLs in the groundwater system beneath Schofield Barracks and Wheeler were TCE, carbon tetrachloride, antimony, and manganese. Contaminants were detected in two plume areas: (1) beneath the Former Landfill and (2) beneath the Schofield Barracks East Range and Wheeler (East Range/Wheeler). The horizontal extent of carbon tetrachloride, antimony, and manganese contamination, with the exception of one detection of carbon tetrachloride at Well MW-2-3, was limited to the immediate vicinity of the Former Landfill. The inorganic compounds antimony and manganese were detected above MCLs inconsistently. Because of this inconsistency and because these inorganic compounds were not detected above MCLs during the most recent sampling event, the detections of antimony and manganese above MCLs are believed to be anomalous. Therefore, only TCE and carbon tetrachloride were retained as chemicals to be addressed for the OU 2 FS. Figure 2.3 shows a contour map of the horizontal extent of TCE greater than 5 Ig/l in the groundwater system beneath Schofield Barracks. The data points in Figure 2.3 represent average concentrations of TCE in samples collected from the wells. Figure 2.4 presents the detected organic compound analytical results from OU 2 samples for the four sampling rounds. A more detailed explanation of the distribution of VOCs in groundwater beneath Schofield Barracks is summarized in the OU 2 RI report.

The vertical distribution of TCE in the Former Landfill area appears to be relatively uniform with depth from the top of the aquifer (275 feet msl) to approximately 0 feet msl. Data are not available for greater depths in the Former Landfill area. The vertical distribution of TCE in the East Range/Wheeler area appears to increase with depth to about 195 feet msl and then decrease to below MCLs at approximately 5 feet msl.

Existing information indicates that offsite wells have likely not been impacted by TCE or carbon tetrachloride in levels above MCLs from either the Former Landfill area or the East Range/Wheeler area. However, low concentrations (less than 5 Ig/l) of TCE were detected in three offsite wells located near Kunia just southwest of Wheeler.

2.8.2 Contaminant Fate and Transport

As indicated in the previous section, the contaminants designated as COCs for the OU 2 FS are TCE and carbon tetrachloride. This section summarizes the fate and transport processes that affect current and potential migration of these COCs through both the vadose zone and the groundwater system.

Physical and chemical mechanisms that impact the fate and transport of TCE and carbon tetrachloride were evaluated for both the vadose zone and the saturated zone. Results of the vadose zone investigations indicated the following:

- The primary mechanism for contaminant transport in the vadose zone appears to be advective flow of water containing COCs in a dissolved phase (i.e., contaminants move along dissolved in the water).

- The primary direction of COC movement in the vadose zone is vertical, therefore, little lateral spreading of contaminant in the vadose zone likely occurred.

- It was determined that contaminant migration in the vadose zone likely occurred primarily in fractures or other remnant basaltic features in the saprolite zone, and that this migration occurred primarily during high-intensity infiltration events (high-rainfall events which resulted in surface ponding).

- The rate of migration of COCs in the vadose zone may be reduced by adsorption of chemicals onto organic matter within the soil matrix (known as retardation). However, because of the low amount of organic matter in the vadose zone, this mechanism is not considered significant.

- The amount of COC reaching the water table may be reduced by biological degradation of the contaminant in the vadose zone. However, few data are available to evaluate the impact of degradation in the vadose zone, and thus this mechanism was not evaluated in detail.

- Results of field testing and computer modeling indicate that TCE (the most widespread COC) could migrate through the vadose zone to the groundwater in approximately 10 years.

Results of the saturated zone investigations indicated the following:

- On a regional scale (greater than approximately 500 lateral feet), the aquifer material (fractured basalt) appears to be hydraulically connected such that it behaves like porous aquifer material. Therefore, preferred contaminant pathways (such as large single fractures) do not appear to be a significant mechanism of offsite transport.

- As in the vadose zone, the primary mechanism of transport appears to be advective water flow containing COCs in the dissolved phase and the direction of movement is primarily driven by the direction of groundwater flow.

- Retardation and degradation may impact contaminant movement in the saturated zone. However, no data are available to evaluate whether these phenomena have any impact on migration within the saturated zone.

- Results of computer modeling indicate that under the most conservative assumptions (no retardation or degradation), TCE concentration above the MCL could reach downgradient receptors (to the south) in approximately 100 years.

2.9 Summary of Site Risks

A baseline risk assessment was prepared to evaluate the potential human and ecological risks posed by chemicals detected in the groundwater at OU 2. This baseline risk assessment is provided as Section 7.0 in the Final OU 2 RI Report (HLA, 1996a). The data collected during Phase I and II of the RI were used as the source for the analytical data for the human health risk assessment (HRA) and the ecological risk assessment (ERA). Because OU 2 is limited to the groundwater at Schofield Barracks, groundwater is the only medium of concern for this risk assessment. Additionally, the only contaminated water currently being used as a public drinking water supply is extracted from the Schofield water-supply wells. However, this water is being treated by an air-stripping treatment system prior to distribution and use so that the water quality meets the federal SDWA MCLs for public water supplies. Consequently, the risks presented in the HRA reflect untreated groundwater and not actual current exposures.

Two separate areas of concern were evaluated: (1) the Former Landfill area and (2) the East Range/Wheeler area. The Former Landfill area was evaluated using the data from four existing groundwater monitoring wells (Figure 2.3). The East Range area was evaluated using data from groundwater monitoring wells in the eastern portion of Schofield, in the Wheeler area, and the Schofield Barracks water-supply wells.

Chemicals of potential concern (COPCs) were selected for risk assessment by comparing the maximum detected concentration to both the MCLs (primary or secondary) and the EPA Region IX PRG for residential ingestion (EPA, 1995). If the maximum detected concentration exceeded the MCL, the chemical was retained as a COPC. If an MCL was not available, the EPA Region IX PRG was used for comparison. Four chemicals were initially retained as COPCs for the risk assessment: antimony, carbon tetrachloride, manganese, and TCE. However, as discussed in Section 2.8.1, antimony and manganese were detected inconsistently above MCLs and were not detected above MCLs during the most recent sampling event, therefore the detections above MCLs are believed to be anomalous. Therefore, only TCE and carbon tetrachloride were retained as COCs to be addressed in evaluating remedial alternatives.

No current human populations with exposure to untreated groundwater were identified. Water withdrawn from the Schofield Barracks water-supply wells is treated to achieve MCLs prior to distribution and use. Therefore, the population of interest in the HRA is a future residential population, both adults and children. Exposure pathways considered in the HRA are those commonly associated with domestic use of water, namely ingestion of water, dermal contact with water, and inhalation of volatile organic compounds (VOCs) during water use. VOCs may volatilize from groundwater and eventually diffuse into the ambient air and subsequently be inhaled by a receptor. However, the low concentrations of VOCs in the groundwater (less than 100 parts per billion [ppb]), the depth to groundwater (approximately 500 to 600 feet), complex hydrogeology, and the inherent uncertainties in estimating these exposures preclude a quantitative evaluation of exposures related to soil gas.

Potential exposures to humans were evaluated for both average case and reasonable maximum exposure (RME) scenarios. Different exposure and chemical intake assumptions were used to represent the average and RME scenarios. Average and RME exposure point concentrations for COPCs in the groundwater were estimated as the arithmetic mean and 95 percent upper confidence limit, respectively, as recommended by EPA. Average and RME exposure point concentrations were developed for (1) the Former Landfill area and (2) the East Range/Wheeler area. Additionally, because Schofield Barracks Water-supply Well No. 4 is most commonly used as the source of water for distribution, the maximum TCE concentration detected in this well was evaluated as a separate source.

Carcinogenic health effects (expressed as risk) and noncarcinogenic health effects (expressed as hazard indices [HI]) were characterized by combining the estimated chemical intakes with the appropriate toxicity factors (i.e., carcinogenic slope factors and noncarcinogenic reference doses). Only chronic toxicity factors were used in the HRA. Oral toxicity factors were used to evaluate dermal exposures. Table 2.1 presents the total carcinogenic and noncarcinogenic risks estimated for the adult and child receptor for both the Former Landfill area and the East Range/Wheeler area.

The RME noncarcinogenic HIs exceed 1.0, which is the EPA benchmark for concern, for both the child and adult resident for the Former Landfill area (maximum HI of 9.3, child receptor). However, the majority of the estimated HI is a result of antimony detected in landfill wells. Antimony was inconsistently detected within a given well and between wells in the Former Landfill area. Because these inconsistencies suggest anomalous data not representative of actual site conditions, and the fact that the potential for exposure to this groundwater is limited, the elevated HIs related to the Former Landfill groundwater are not considered significant.

All of the estimated carcinogenic risks for both areas are either less than or within the EPA acceptable risk range of 1×10^{-6} to 1×10^{-4}. The estimated risk is associated with pretreated water prior to distribution and is not reflective of current exposure conditions because the pretreated water is not used for domestic purposes. Following treatment by air stripping, the water supply taken from any of the Schofield Barracks water-supply wells meets MCLs, the federal water quality standards for public distribution water.

In addition to the quantitative HRA, a qualitative ERA was also developed. Because groundwater from two wells southwest of Schofield Barracks is used to supplement irrigation water for commercial pineapple fields, the potential for adverse effects to pineapple plants exposed to TCE in irrigation water was evaluated. However, adverse effects to pineapple or other plants resulting from low concentrations of TCE in irrigation water are not expected for several reasons: (1) TCE has a low adsorption capacity coefficient indicating ready transport through the soil profile, (2) TCE rapidly evaporates from water and soil to the atmosphere, (3) dilution with other sources of irrigation water will further reduce the TCE concentrations, and (4) crop impairment from exposure to TCE in growth media has not been reported in literature.

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected by this ROD, may present an imminent and substantial endangerment to public health, welfare, and the environment.

2.10 Description of Alternatives

Because of the unique and complex hydrogeological conditions at Schofield Barracks and because a source, or sources, of TCE detected in the Schofield Barracks water-supply wells could not be identified, it became apparent early in the OU 2 RI/FS program that characterizing the groundwater system to the extent necessary to evaluate remedial alternatives for a full range of general response actions would be extremely expensive. Therefore, preliminary FS evaluations were initiated during Phase I of the RI to allow focusing of Phase II RI evaluations and subsequent FS evaluations. Development of general response actions that would satisfy remedial action objectives for the site was undertaken during the Phase I RI. The following general response actions that would satisfy remedial action objectives were identified:

- Restoration of the contaminated groundwater system by pumping, treating, and reinjecting the groundwater

- Containment of the contaminated groundwater plume by boundary pumping, treating, and reinjecting

- Treatment of contaminated groundwater at the wellhead when it is extracted from the groundwater system for domestic use. The water within the aquifer will be restored over time through natural attenuation.

Because of the complex hydrogeology, depth to groundwater, and aquifer characteristics, restoration of the groundwater through a pump and treat remedy was not considered practicable. Therefore, only two general response actions were considered under the OU 2 Feasibility Study:

1. Containment of the contaminated groundwater plume by a boundary pump and treat system, and

2. Reduction of risk via:

    - Continued treatment for COCs present in extracted groundwater at the Schofield Barracks Supply Wells by air stripping at the wellhead followed by discharge of the treated water to the distribution system

    - The Army must consult with EPA and the DOH prior to abandoning the Schofield Barracks water supply wells, because production at these wells may help to control plume migration

    - Long-term sampling and analysis of water supply wells, agricultural wells, and Monitoring wells in the region

    - Implementation of the contingency of wellhead treatment on any water supply wells that are impacted by the plume from Schofield above one-half the MCL as established under the SDWA

    - Upgrading the treatment system or paying any increment costs caused by contamination from Schofield at wells that already have a treatment system in place

    - Conducting five-year site reviews with the State of Hawaii and the U.S. EPA.

A preliminary evaluation was performed for representative alternatives for each of these general response actions. The results of this evaluation (Appendix A of the OU 2 Feasibility study [HLA,1996a] indicated that the pump and treat remedy, even for containment, was impracticable and as such, it was not carried through the detailed analysis comparison. The evaluation concluded that the wellhead treatment option would be protective of human health and the environment. Because this remedy does not restore groundwater within the aquifer, a TI waiver must be invoked, as described in the Justification for Technical Impracticability Waiver at Schofield Barracks for the Ground Water Record of Decision, which is part of the Administrative Record for Schofield Barracks.

The feasibility study for OU 2 initially evaluated and developed five alternatives for the wellhead treatment systems in accordance with CERCLA, the NCP, and relevant EPA and state guidelines, policies, and procedures. Alternative 1 (no action) is developed as an NCP requirement and Alternatives 2 through 5 were developed for wellhead treatment of the extracted contaminated OU 2 groundwater, if necessary.

The feasibility study for OU 2 initially evaluated and developed five alternatives in accordance with CERCLA, the NCP, and relevant EPA and state guidelines, policies, and procedures. The alternatives have been developed as a contingency. Alternative 1 (no action) is developed as an NCP requirement and Alternatives 2 through 5 were developed for wellhead treatment of the extracted contaminated OU 2 groundwater, if necessary. Through the screening of alternatives phase of the FS process, Alternatives 3 (carbon adsorption treatment) and 5 (ultraviolet hydrogen peroxide oxidation treatment) were considered similar in effectiveness and implementability to Alternatives 2 and 4, but had higher costs and were eliminated from further evaluation. The remaining three alternatives evaluated in the OU 2 FS are summarized below. All three remaining alternatives contain the following institutional controls: groundwater monitoring, and five-year site review. Hawaii DOH requires any new wells installed as water-supply wells under SDWA to be sampled for the analytes SDWA-specified, which include TCE and carbon tetrachloride. Additionally, any new wells that are installed within the area covered by the long-term monitoring network will be added to the existing long-term monitoring network presented in Figure 2.4. Should these new wells be or become contaminated with COCs that can be directly attributed to Schofield Barracks, the selected wellhead treatment alternative would be implemented to address this contamination. The purpose of the groundwater monitoring program will be to assess groundwater conditions and to track the movement of the TCE- and carbon tetrachloride-contaminated groundwater plumes to provide an early warning of potential contamination. Five-year site reviews will be conducted to ensure that human health and the environment are protected. The site review will use the groundwater monitoring program data to assess whether additional action is warranted.

The location-, chemical-, and action-specific applicable or relevant and appropriate requirements (ARARs) considered for these three remaining alternatives are summarized in Tables 2.2 through 2.4.

2.10.1 Alternative 1 - No Action/Institutional Controls

Alternative 1 includes the following components:

- No action

- Institutional controls

  - Long-term groundwater monitoring
  - Five-year site reviews

Under Alternative 1 no further action would take place to reduce/control chemicals in OU 2 groundwater. Natural fate processes, including degradation and attenuation, would continue to reduce contaminant concentrations with time in OU 2 groundwater. The No Action alternative is required as part of the NCP to provide a baseline against which to compare the other alternatives.

2.10.2 Alternative 2 - Air Stripping

Alternative 2 includes the following components:

- Treatment of COCs present in groundwater at only those points where it is extracted for domestic use by air stripping at the wellhead prior to discharge to distribution system

- Institutional controls

  - Long-term groundwater monitoring
  - Five-year site reviews

The treatment component is described below and the institutional control components are described in Section 2.10.1.

Air-stripping Treatment and Discharge to Distribution System

Air stripping will be used to reduce the TCE and carbon tetrachloride concentration in groundwater to levels below the PRGs, which are the SDWA MCLs. A process flow diagram for the air-stripping process is presented in Figure 2.5. The first component of the air stripping system is a bag filtration unit for the removal of suspended solids from the extracted groundwater. The air-stripping unit then removes TCE and carbon tetrachloride from the filtered groundwater. Treated water from the air-stripping unit is routed to a distribution system for domestic use.

For cost estimating, treatment system conceptual design, and comparative analysis purposes, Alternative 2 assumes the treatment of groundwater from three current or future impacted groundwater production wells that are used for domestic water-supply purposes that could be impacted by contaminated groundwater from Schofield Barracks. The process win include one bag filter unit per well, one air-stripper unit per well, and a common collection and distribution system for all three wells and treatment units. The installed system will consist of three treatment units, each rated at 1,500 gallons per minute (gpm), which will be connected to the existing three production wells. Operational cost estimates are based on the assumption that the system will operate such that only two wells and two treatment units are extracting and treating groundwater at any given time. Thus, one well and one treatment unit are on standby or in maintenance. This configuration provides for continuous treatment of 3,000 gpm of groundwater.

The three air-stripping units will be constructed on a common concrete pad. The treatment facility will be fenced to prevent public entry and potential exposure to untreated groundwater. The treatment units will be incorporated into the existing production well/distribution system pipeline to provide for discharge into the distribution system.

Suspended solids removed by the bag filtration units will be disposed in a nonhazardous landfill. The State of Hawaii allows 0.1 ton per year (T/yr) of each hazardous constituent to be emitted uncontrolled into the atmosphere (Hawaii Administrative Rules [HAR], Title 11, Chapter 60.1). Based on the maximum influent concentrations of TCE (25 Ig/l) and carbon tetrachloride (8.2 Ig/l) anticipated in groundwater (see Table 2.5) that could potentially impact water-supply wells to the south of Schofield Barracks and the projected flow rate of 1,500 gpm per-well per air stripper, the air-stripper vapor discharge will be below .1 T/yr (Table 2.7) and will not require treatment.

2.10.3 Alternative 4 - Ozone/Hydrogen Peroxide Treatment

Alternative 4 includes the following components:

- Treatment of COCs present in extracted groundwater with ozone/hydrogen peroxide oxidation and discharge to the distribution system

- Institutional controls

  - Long-term groundwater monitoring
  - Five-year site reviews

The treatment component is described below and the institutional control components are described in Section 2.10.

Ozone/Hydrogen Peroxide Oxidation Treatment and Discharge to Distribution System

Ozone/hydrogen peroxide will be used to reduce the TCE and carbon tetrachloride concentrations in the groundwater to levels below the PRGs, which are the SWDA MCLs. A process flow diagram for the ozone/hydrogen peroxide oxidation process is presented in Figure 2.6. The first component of the ozone/hydrogen peroxide oxidation treatment system is a bag filtration unit for the removal of suspended solids from the extracted groundwater. The ozone/hydrogen peroxide oxidation unit then removes TCE and carbon tetrachloride from the filtered groundwater. Treated water from the ozone/hydrogen peroxide oxidation unit is routed to a distribution system for domestic use.

For cost estimating, treatment system conceptual design, and comparative analysis purposes, Alternative 4 assumes the treatment of groundwater from three current or future groundwater production wells that are used for domestic water-supply purposes that could be impacted by contaminated groundwater from Schofield Barracks. The process will include one bag filter unit per well, one ozone/hydrogen peroxide oxidation unit per well, and a common collection and distribution system for all three wells and treatment units. The installed system will consist of three treatment units, each rated at 1,500 gpm, which will be connected to the existing three production wells. Operational cost estimates are based on the assumption that the system will operate such that only two wells and two treatment units are extracting and treating groundwater at any given time. Thus, one well and one treatment unit are on standby or in maintenance.

This configuration provides for continuous treatment of 3,000 gpm of groundwater.

The three ozone/hydrogen peroxide oxidation units will be constructed on a common concrete pad. The treatment facility will be fenced to prevent public entry and potential exposure to untreated groundwater. The treatment units will be incorporated into the existing production well/distribution system pipeline to provide for discharge into the distribution system.

Suspended solids removed by the bag filtration units will be disposed of in a nonhazardous landfill. Offgas generated by the ozone/hydrogen peroxide oxidation units will be treated with a catalytic oxidizer to destroy excess ozone prior to release to the atmosphere.

2.11 Summary of Comparative Analysis of Alternatives

This section provides a comparison of the alternatives described in Section 2.10 with respect to the following nine NCP criteria: (1) overall protection of human health and the environment, (2) compliance with ARARs; (3) long-term effectiveness and permanence; (4) reduction in toxicity, mobility, and volume; (5) short-term effectiveness; (6) implementability; (7) cost; (8) state acceptance; and (9) community acceptance. As previously discussed, each of the alternatives incorporates commonalties including groundwater monitoring and five-year site reviews. Accordingly, these components of the alternatives were not evaluated in the comparative analysis. Table 2.6 provides a summary of the comparative analysis of alternatives.

2.11.1 Overall Protection of Human Health and the Environment

Alternative 1 does not provide any additional protection of human health and the environment. Alternatives 2 and 4 consist of groundwater treatment at the wellhead prior to distribution for domestic use. Alternatives 2 and 4 both offer an increase in protection of human health and the environment. Alternatives 2 and 4 remove COCs from the groundwater and provide approximately equal protection of human health and the environment.

2.11.2 Compliance with ARARs

Alternative 1, no action, does not achieve chemical-specific ARARs. There are no location-specific or action-specific ARARs for this alternative.

Alternatives 2 and 4 will meet the action-specific ARARs listed in Table 2.4. Neither Alternative 2 nor 4 involves generation of fugitive dust emissions except during construction for which appropriate preventative measures will be taken and neither alternative will exceed the State of Hawaii air discharge standards for emissions of volatile organic compounds (VOCs) from point sources.

Both Alternatives 2 and 4 will meet the MCLs required to discharge the treated groundwater into the water distribution systems. The proposed wellhead treatment systems will be co-located with existing and future supply wells and will meet the potential location-specific ARARs listed in Table 2.2.

None of the wellhead treatment options meets the chemical-specific ARARs for restoration of the groundwater to MCLs. As discussed in Section 2.10, the RI Report, and the FS Report, the unique and complex hydrogeologic conditions at Schofield Barracks (i.e., 550 to 650 feet thick vadose zone and highly transmissive fractured basaltic bedrock aquifer) required a unique approach to address groundwater contamination. A TI waiver to the MCL is therefore justified based on the following discussion. More detailed discussions are contained in the RI Report (HLA, 1996b), the OU 2 FS Report (HLA, 1996a), the Justification for Technical Impracticability Waiver at Schofield Barracks for the Ground Water Record of Decision, and the minutes of the February 24, 1994 In-progress Review (IRP).

2.11.2.1 High Groundwater Volume

The high transmissivity of the Schofield High Level Water Body and the associated high volume of water flowing through the system would require tremendous extraction and treatment capacities to address a plume of any substantial size. The Schofield supply wells, pumping at 4 to 5 million gallons per day, have done nothing to reduce the concentrations of TCE in the aquifer since the stripping towers were installed in 1986. The average concentration of TCE in the supply wells has remained steady at approximately 25 to 30 Ig/l over that time period. Modeling estimates presented at the February 24, 1994, IPR projected extraction/reinjection rates of from 17 million to 56 million gallons per day would be required to restore the aquifer over a period of 15 to 30 years (depending on the plume size and location). An extraction/reinjection rate of approximately 216 million gallons per day was estimated to be required to restore the groundwater based on application of the OU 2 RI groundwater model using current information on the plume boundaries. In addition to the technical difficulties associated with installing and operating such a vast network of extraction/injection well systems in a complex bedrock aquifer such as the Schofield High Level Water Body, the power required to run such a network is not currently available within the Oahu power grid. A new power plant with associated engineering and operating difficulties would be required to implement such a remedy.

2.11.2.2 Potential Impacts to Basal Aquifers

In addition, the sustainable yield of the Schofield High-Level Water Body has been estimated by the Honolulu Board of Water Supply at 104 million gallons per day. Of this, approximately 76 million gallons per day is required as recharge to the Honolulu-Pearl Harbor Basal Aquifer to avoid salt water intrusion. Currently 10.7 million gallons per day are pumped by Schofield plateau wells, leaving approximately 17.7 million gallons per day of increased usage. This would limit the extraction capacity of a groundwater treatment system network and would make the groundwater resource unavailable for productive use or would require installation of a reinjection well network. As discussed above, the projected extraction rate required to restore the Schofield High Level Water Body is estimated at approximately 40 million gallons per day which would exceed the extraction limits and would thus require reinjection.

2.11.2.3 Protectiveness of Wellhead Treatment

The limitation on groundwater extraction likewise puts an upper bound on the future number of production wells potentially requiring treatment, which, in turn, further supports the Army's selection of wellhead treatment of impacted wells rather than active pump and treat of the aquifer. Wellhead treatment will provide adequate protection of human health and the environment in a cost-effective manner and will meet the intent of the Safe Drinking Water Act MCLs by ensuring that the water-supply systems are providing safe drinking water to Oahu residents.

2.11.3 Long-term Effectiveness and Permanence

Alternative 1 does not provide any additional risk reduction over the long term. Alternatives 2 and 4 provide an increase in long-term effectiveness and permanence by treating extracted OU 2 groundwater prior to distribution for domestic use. The treatment technology to be employed by both Alternatives 2 and 4 are proven technologies with a long track record of effectiveness and reliability. Monitoring of the groundwater supplies as required under the Safe Drinking Water Act, further ensures that TCE and carbon tetrachloride levels in the treated water supply will be maintained below the MCL. The technology employed in Alternative 4 breaks down TCE and carbon tetrachloride into nonhazardous products eliminating concerns about residual contamination. Although Alternative 2 simply removes the TCE and carbon tetrachloride from the water through volatilization, modeling projections indicate that the emissions from the air stripping towers will be low and are well below EPA's acceptable risk ranges (see discussion in Section 2.13, Protection of Human Health and the Environment).

2.11.4 Reduction In Toxicity, Mobility, and Volume

Alternative 1 does not provide a reduction in toxicity, mobility, or volume except through natural attenuation of COCs in the OU 2 groundwater system. Alternative 4 provides an increased reduction in toxicity, mobility, and volume by destroying the COCs in the ozone/hydrogen peroxide oxidation unit. Alternative 2 also provides an increased reduction in toxicity, mobility, and volume of COCs although the COCs are transferred to the atmosphere as VOCs rather than destroyed.

2.11.5 Short-term Effectiveness

The short-term conditions at the site would remain unchanged under Alternative 1 because no action is implemented. Alternatives 2 and 4 will have minimal short-term impacts to the community and workers associated with construction of a concrete slab and installation of the treatment system equipment. Alternatives 2 and 4 will likely create some minimal short-term ecological and environmental effects due to construction activities from dust generation, vegetation clearing, and general construction noise.

2.11.6 Implementability

The only technical aspect of Alternative 1 is the implementation of the groundwater monitoring program to re-evaluate the site in five years. Groundwater monitoring is also a component of Alternatives 2 and 4 to support decisions on implementing remedial action at impacted wells. The Army, Hawaii Department of Health and EPA, as well as the Honolulu Board of Water Supply and the public, will be involved in the review of monitoring data to analyze trends and to determine when wellhead treatment is required.

Alternatives 2 and 4 are considered to be technically implementable. Both treatment systems involve components that are readily available from several vendors.

2.11.7 Cost

The net present worth of Alternative 1, Alternative 2, and Alternative 4 are $1,350,000, $3,900,000, and $5,910,000, respectively. A breakdown of capital cost, operation and maintenance (O&M) cost, and net present worth for each alternative is presented in Table 2.8.

2.11.8 State Acceptance

As indicated by DOH approval of the Final OU 2 FS and Proposed Plan, Alternative 2 is more acceptable to the State than Alternatives 1, 3, 4, and 5.

2.11.9 Community Acceptance

Community acceptance is documented in Section 3.0 (Responsiveness Summary).

2.12 Selected Remedy

Based on consideration of the requirements of CERCLA, the detailed analysis of alternatives, and public comment, the Army, EPA, and DOH have determined that a remedy with the following components is the preferred remedy for Schofield Barracks OU 2:

- Continued treatment for COCs present in extracted groundwater at the Schofield Barracks Supply Wells by air stripping at the wellhead followed by discharge of the treated water to the distribution system

- The Army must consult with EPA and DOH prior to abandoning the Schofield Barracks water supply wells, because production at these wells may help to control plume migration

- Long-term sampling and analysis of water supply wells, agricultural wells and monitoring wells in the region

- Implementation of the contingency of wellhead treatment on any water supply wells that are impacted by the plume from Schofield Barracks above one-half the MCL as established under the SDWA

- Upgrade the treatment system or pay any incremental costs caused by contamination from Schofield Barracks at wells that already have a treatment system in place

- Conduct five-year site reviews with the State of Hawaii and the U.S. EPA.

The details of the monitoring plan, evaluation process for implementation of wellhead treatment, and description of conditions at existing water wells may be found in the Final Operation and Maintenance and Long-Term Groundwater Monitoring, Plan for Operable Unit 2, Schofield Army Barracks, which is an addendum to this ROD.

Alternative 2 (air stripping) is the preferred alternative for the wellhead treatment systems. The comparative analysis indicates that Alternative 2 is preferred to Alternative 4 (ozone/hydrogen peroxide/oxidation) with respect to cost. However, Alternative 2 is considered equal to Alternative 4 with respect to protection of human health and the environment, compliance with ARARs, long-term effectiveness and permanence, short-term effectiveness, and implementability.

The major costs associated with Alternative 2 are presented in Table 2.9.

For comparative analysis purposes a treatment system conceptual design was assumed for treatment of groundwater from three current or future impacted groundwater production wells that are used for domestic water-supply purposes that could be impacted by contaminated groundwater from Schofield Barracks. The conceptual air stripper treatment system design consists of three treatment units, each rated at 1,500 gpm, connected to three existing domestic water-supply production wells. However, there are potentially seven existing water production well systems with a varying number of production wells at varying flow rates that could be impacted by Schofield Barracks groundwater. Three of the seven existing production well systems are currently treating the extracted groundwater to remove pesticides using carbon adsorption. If TCE-contaminated water from Schofield Barracks impacts any of the existing three water-supply carbon adsorption systems, the carbon usage rates may increase over their normal carbon usage rates at these systems. The impact to carbon usage at these three systems was modeled to estimate the possible carbon usage increase. The results of the modeling are summarized in Appendix B. The modeling results indicate that the carbon usage rate will likely increase as the concentrations of TCE increase. Therefore, the Army will be responsible for sharing some carbon usage costs until the air stripper system is installed.

2.13 Statutory Determinations

Under its legal authorities, EPA's primary responsibility at Federal Facility NPL sites is to oversee remedial actions that achieve adequate protection of human health and the environment. In addition, Section 121 of CERCLA establishes several other statutory requirements and preferences. These specify that, when complete, the selected remedial action for this site must comply with applicable or relevant and appropriate environmental standards established under federal and state environmental laws unless a statutory waiver is justified. The selected remedy also must be cost effective and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Finally, the statute includes a preference for remedies that employ treatment which permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as their principal element. The following sections discuss how the selected remedy meets these statutory requirements.

Protection of Human Health and the Environment

Overall protection of human health and the environment will be provided by the selected remedy prior to distribution of the OU 2 groundwater. Based on the baseline risk assessment (HLA, 1996a), no current populations with exposure to contaminated OU 2 groundwater were identified onsite or offsite. Additionally, groundwater modeling was performed to evaluate contaminant migration both with and without the impacts of retardation and degradation. The modeling results using no degradation and retardation indicate that the OU 2 plume may migrate offsite to the south, flowing across the southern groundwater dam at concentrations above 5 Ig/l within 5 years but will not likely impact current downgradient water-supply wells for approximately 100 years. Modeling results using high retardation and degradation indicate no impact to downgradient water-supply wells. Alternative 2 was developed to address the contaminated OU 2 plume if it does migrate offsite, the COC concentrations exceed the MCLs, and the OU 2 groundwater is extracted in new or existing potable water-supply wells. Contaminated OU 2 groundwater will be treated by an air stripper at the wellhead to remove COCs to concentrations below the MCLs prior to distribution for domestic use. Because air stripping does not destroy TCE or carbon tetrachloride prior to vapor discharge to the atmosphere, an air dispersion model and a theoretical risk assessment were performed to evaluate potential health risks posed by the air stripper vapor discharge. To perform a theoretical risk assessment for the constituents, the EPA single-source dispersion model SCREEN3 (EPA, 1995) was first used to calculate airborne concentrations of TCE and carbon tetrachloride within 3,281 feet (1,000 meters) of the air strippers. Using model results and EPA guidance, the highest annual average air concentration for TCE was predicted to be 0.079 micrograms per cubic meter (I/m 3). The equivalent concentration for carbon tetrachloride was predicted to be 0.026 Ig/m 3. The model results indicated that the maximum concentration would occur at a distance of 2,162 feet (659 meters) from the air strippers.

Using the SCREEN3 model results, a theoretical risk assessment was performed for the air stripper airborne concentrations of TCE and carbon tetrachloride. The cumulative risks associated with the predicted concentrations of the constituents are well below EPA's acceptable cancer risk range of 10 -4 to 10 -6. In addition, the noncancer hazard indices are well below EPA's acceptable level of 1.0. The calculated cumulative cancer risk for the two constituents was 2.2 x 10 -7 and the calculated cumulative hazard index was 0.012. Based on the dispersion model and risk assessment results, no significant health risks are expected for the constituents calculated to be released from the conceptual design air strippers. Additionally, institutional controls as discussed in Section 2.10 will be implemented to reduce the chance of inadvertent exposure.

Natural attenuation will be the primary mechanism for contaminant concentration reduction in the aquifer (Schofield High-level Water Body) eventually eliminating the need for treatment. Periodic groundwater monitoring and five-year site reviews will provide data to indicate when contaminant levels in groundwater have attained MCLs.

Compliance with ARARs

The location-, chemical-, and action-specific ARARs are listed below:

- Location-specific ARARs:
  - 16 United States Code (USC) 661 et seq., 662 and 663, requiring actions to be taken to prevent, mitigate, or compensate for project-related damages or losses to fish and wildlife resources.
  - Clean Water Act (CWA) 404, 33 CFR 320-330, and 40 Code of Federal Regulations (CFR) 230, prohibiting discharges that cause or contribute to significant degradation of the water of ecosystems.
  - HC 183D-61 et seq., prohibiting interference with wild birds or their nests.
  - CWA 404, prohibiting the discharge of fill material into aquatic ecosystems that would jeopardize endangered, threatened, or rare species.
  - HC 194D-4, 16 USC 1531 et seq., 50 CFR 402 prohibiting actions that jeopardize endangered or threatened species or critical habitat of such species as designated in 50 CFR 17, 50 CFR 226, or 50 CFR 227.
- Chemical-specific ARARs:
  - 40 CFR, Part 141, (b) and (g), defining SDWA MCLs
  - 40 CFR, Part 141, (f), defining SDWA maximum contaminant level goals (MCLGs).
- Action-specific ARARs:
  - Hawaii Administrative Rule (HAR) 11-60.1-33(a)(l)-(7) and (b), prohibiting the discharge of visible fugitive dust emissions beyond the property lot line on which the dust originates and requiring precautions to prevent fugitive dust emissions.
  - HAR 11-60.1-68, requiring monitoring of VOC emissions if emissions are greater than 1 ton per year for each hazardous air pollutant.
  - 40 CFR, Part 141, (b) and (g), defining MCLs.

While the selected alternative will treat groundwater at the wellhead to concentrations below the MCLs, a waiver for the chemical-specific ARAR, as applied to the contaminated aquifer, is required based on the technical impracticability of groundwater restoration to below the MCL concentrations. A detailed justification for the TI waiver is provided in Section 2.11.2 of this ROD.

Other Criteria, Advisories, or Guidance To Be Considered for Remedial Action

In implementing the selected remedy, EPA and the State of Hawaii have agreed to consider a number of procedures that are not legally binding (known as to be considered [TBCs]). These include the following:

- 40 CFR 6.302(g) and (h), requiring actions to be taken to prevent, mitigate, or habitat compensate for project-related damages or losses to fish, wildlife resources, or critical habitat.

- EPA Office of Water Lifetime Health Advisories for 70-kg Adult, May 1995, defining maximum recommended concentration of a given chemical in drinking water.

  - EPA Office of Water Health Advisory, May 1995, defining the concentration of a given chemical in drinking water that will result in one excess cancer death in one million people.

  - 40 CFR 300.430(a)(1)(iii)(D), requiring institutional controls to prevent or limit exposure to hazardous substances, pollutants, or contaminants.

Cost Effectiveness

The selected remedy is cost effective, providing overall effectiveness proportional to its costs. The net present worth of the selected remedy is $3,990,000. While Alternative 1 offers the lowest estimated cost, it does not provide long-term effectiveness. Considering Alternatives 2 and 4 provides comparable long-term effectiveness, but the estimated cost of Alternative 2 is less than Alternative 4, Alternative 2 provides the best combination of cost and long-term effectiveness.

Utilization of Permanent Solutions and Alternative Technologies to the Maximum Extent Practicable

The U.S. Army, in coordination with EPA and the State of Hawaii, determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner for OU 2. The selected remedy provides the best balance of tradeoffs in terms of long-term effectiveness and permanence; reduction in toxicity, mobility, or volume; short-term effectiveness; implementability; and cost.

Although Alternative 4 is comparatively effective in the long term, Alternative 4 has a greater estimated cost. The selected remedy addresses the principal threat posed by the contaminated OU 2 groundwater efficiently and cost effectively.

Preference for Treatment as a Principal Element

The statutory preference for remedies that employ treatment as a principal element is satisfied by the selected remedy. The principal threat of the site is the potential for domestic use of contaminated groundwater with COC concentrations above PRGs. The selected remedy adequately addresses this threat by treating the OU 2 groundwater at the wellhead to remove COCs to concentrations below the PRGs prior to distribution for domestic use.

Table 2.1: Summary of Noncarcinogenic and Carcinogenic Risks for OU 2

Receptor/Pathway	Noncarcinogenic Hazard Index Average	Noncarcinogenic Hazard Index RME	Carcinogenic Risk Average	Carcinogenic Risk RME
East Range Area - Adult				
Groundwater Ingestion	6.39E-02	3.96E-01	2.33E-07	4.67E-06
Groundwater VOC Inhalation	1.32E-02	3.12E-02	2.37E-07	2.41E-06
Groundwater Dermal	9.91E-03	2.23E-02	8.42E-08	6.31E-07
Total	8.70E-02	4.50E-01	5.55E-07	7.72E-06
Maximum TCE* - Adult				
Groundwater Ingestion	1.56E-01	6.23E-01	1.32E-06	1.76E-05
Groundwater VOC Inhalation	NA	NA	1.44E-06	9.62E-06
Groundwater Dermal	7.43E-02	1.04E-01	6.31E-07	2.94E-06
Total	2.30E-01	7.27E-01	3.40E-06	3.02E-05
Former Landfill - Adult				
Groundwater Ingestion	4.31E-01	2.75E+00	5.02E-07	1.30E-05
Groundwater VOC Inhalation	7.45E-02	2.84E-01	4.50E-07	5.87E-06
Groundwater Dermal	1.04E-02	2.91E-02	8.63E-08	8.15E-07
Total	5.16E-01	3.07E+00	1.04E-06	1.97E-05
East Range Area - Child				
Groundwater Ingestion	1.70E-01	1.20E+00	2.08E-07	2.84E-06
Groundwater VOC Inhalation	3.52E-02	9.48E-01	2.11E-07	1.46E-06
Groundwater Dermal	2.61E-02	5.88E-02	7.40E-08	3.32E-07
Total	2.32E-01	1.35E+00	4.92E-07	4.63E-06
Maximum TCE* - Child				
Groundwater Ingestion	4.16E-01	1.89E+00	1.18E-06	1.07E-05
Groundwater VOC Inhalation	NA	NA	1.28E-06	5.83E-06
Groundwater Dermal	1.96E-01	2.74E-01	5.54E-07	1.55E-06
Total	6.11E-01	2.16E+00	3.01E-06	1.81E-05
Former Landfill - Child				
Groundwater Ingestion	1.15E+00	8.35E+00	4.46E-07	7.91E-06
Groundwater VOC Inhalation	1.99E-01	8.62E-01	4.00E-07	3.56E-06
Groundwater Dermal	2.75E-02	7.68E-02	7.58E-08	4.30E-07
Total	1.38E+00	9.29E+00	9.22E-07	1.19E-05

NA Not applicable
OU Operable unit
RME Reasonable maximum exposure
TCE Trichloroethene
VOC Volatile organic compound

* Based on maximum depth-specific sampling result from the Schofield Barracks water-supply wells.

Table 2.2: Location-specific Applicable or Relevant and Appropriate Requirements for Schofield Barracks OU 2

Location Characteristic(s)	Prerequisite(s)	Requirement(s)	Citation(s)
Wilderness areas, wildlife resources, wildlife refuges, or scenic rivers			
* Within area affecting or river- and - presence of fish or wildlife resources	* Presence of fish or wildlife resources; action by federal agency that results in the control or structural modification of a natural stream or body of water * Offsite response action	* The effects of water-related projects on fish and wildlife resources must be considered. * Action must be taken to prevent, mitigate, or compensate for project-related damages or losses to fish and wildlife resources. * Offsite actions that alter a resource require consultation with the FWS. NMFS. and/or the appropriate state agency. * Consultation with the responsible agency is also strongly recommended for onsite actions.	* Fish and Wildlife Coordination Act (16 USC 661 of seq.).ºº 662 and 663 - applicable * 40 CFR º6.302(g)(applies to federal agencies only) - TBC
* Location encompassing aquatic ecosystem with dependent fish, wildlife, other aquatic life, or habitat	* Action(s) involving the discharge of dredge or fill material into aquatic ecosystem	* Degradation or destruction of aquatic ecosystems must be avoided to the extent possible. Discharges that cause or contribute to significant degradation of the water of such ecosystems are prohibited.	* Clean Water Act º404 - applicable * 40 CFR º230 - applicable * 33 CFR º320-330 - applicable
* Presence of wild birds or their nests		* The Intentional, knowing, or reckless taking, catching, injuring, killing, destroying, or keeping in captivity or possession or wild birds is prohibited. * Damaging or destroying the nests of wild birds is prohibited.	* HC º183D-61 et seq. - applicable
Endangered, threatened, or rare species			
* Presence of endangered or threatened species or critical habitat (see above citation) of same within an aquatic ecosystem as defined in 40 CFR º230.3(c)	* Action involving discharge of dredge or fill material into aquatic ecosystem	* Dredge or fill material shall not be discharged into an aquatic ecosystem if it would jeopardize such species or would likely result in the destruction or adverse modification of a critical habitat of the species.	* Clean Water Act º404 - applicable * 40 CFR º230.10(b)-applicable
* Presence of federal or state endangered or threatened species		* The taking of any threatened or endangered species within the state is prohibited.	* HCº 195D-4 - applicable

Table 2.2 (continued)

Location Characteristic(s)	Prerequisite(s)	Requirement(s)	Citation(s)
* Presence of endangered or threatened species - or - critical habitat of such species as designated in 50 CFR º17. 50 CFR º220, or 50 CFR º227	* Action that is likely to jeopardize species or destroy or adversely modify critical habitat	* Actions that jeopardize species/habitat must be avoided or appropriate mitigation measures taken. * Offsite actions that affect species/habitat require consultation with DOI, FWS, NMFS, and/or state agencies as appropriate, to ensure that proposed actions do not jeopardize the continued existence of the species or adversely modify or destroy critical habitat. * Consultation with the responsible agency is also strongly recommended for onsite actions.	* Endangered Species Act of 1973 (16 USC 1531 et seq.) - applicable * 50 CFR º402 - applicable * 40 CFR º6.302(h) - TBC * Fish and Wildlife Coordination Act (16 USC 661 et seq.) - applicable

Source: United States Army Environmental Control

CFR	Code of Federal Regulations
DOI	Department of Interior
FWS	U.S. Fish And Wildlife Service
HC	Hawaii Citation
NMFS	National Marine Fisheries Service
TBC	To be considered
USC	United States Code

Table 2.3: Chemical-specific Applicable or Relevant and Appropriate Requirements and "To-Be-Considered" Guidance for Cleanup of Groundwater at Schofield Barracks OU 2 a

	Relevant and Appropriate Requirements b			TBC Guidance c
Chemical	SDWA MCLs d (mg/l)	Hawaii MCLs e (mg/l)	SDWA MCLGs f (mg/l)	Health Advisories g (mg/l)
Acetone	5			
Benzene	5	5	0	1 h
bis(2-Ethylhexyl)phthalate	6		0	3 h
2-Butanone (methyl ethyl ketone)				* i
Carbon disulfide				
Carbon tetrachloride	5	5	0	0.3 h
Chloromethane				
1,1-Dichloroethane				
1,2-Dichloroethane	5	5	0	0.4 h
cis-1,2-Dichloroethene	70	70	0	
trans-1,2-Dichloroethene	100	100	0	
Ethylbenzene	700	700	700	700
2-Hexanone				
4-Methyl-1-pentanone				
4-Methyl-2-pentanone				
Methylene chloride	5		0	5 h
Nitrobenzene				
Phenol				4,000
Pyrene				
1,1,2,2-Tetrachloroethane				
Tetrachloroethene	5	5	0	0.7 h
Toluene	1,000	1,000	1,000	1,000
Trichloroethene	5	5	0	3 h
Vinyl chloride	2	2	0	
Xylenes, total	10,000	10,000	10,000	10,000

Source: United States Army Environmental Center

ARARs Applicable or relevant and appropriate requirements
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
CFR Code of Federal Regulations
EPA U.S. Environmental Protection Agency
HA Health advisory
MCL Maximum contaminant level
MCLG Maximum contaminant level goal
mg/l Milligrams per liter
SDWA Safe Drinking Water Act
TBC To be considered
USAEC U.S. Army Environmental Center

Table 2.3 (continued)

a. This table provides ARARs or TBC guidance for all chemicals detected in the groundwater at Schofield Barracks, as reported in Figure 3.5 of the Draft Final Sampling and Analysis Plan for Operable Unit 4 Phase II Remedial Investigation and Feasibility Study Field Program, August 19, 1994. The bolded and italicized values indicate the ARAR or TBC for each chemical. The MCLs/MCLGs in this table are relevant and appropriate requirements for cleanup of extracted groundwater. The MCLs would be applicable "at the tap." These decisions are based on the determination that the underground water system at Schofield Army Barracks is a public water system designated as a Community Water System by the Hawaii Department of Health, Division of Drinking Water (Personal communication with A. Zane, Engineer, Division of Drinking Water, July 25, 1995). A Community Water System is "a public water system which serves at least 15 connections used by year-round residents or regularly serves at least 25 year-round residents." (40 CFR º 141.2 Definitions [1994] and Hawaii Administrative Rules 20 º 11-20-2 Definitions [1994]).

b. Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site." (40 CFR º 300.5 Definitions. [1994]). "Maximum contaminant level goals (MCLGs), established under the Safe Drinking Water Act, that are set at levels above zero, shall be attained by remedial actions for ground waters that are current or potential sources of drinking water, where the MCLGs are relevant and appropriate under the circumstances of release." (40 CFR º 300.430[e][2](i)[B] [1994]).

c. This "category consists of advisories, criteria, or guidance that were developed by the EPA, other federal agencies, or states that may be useful in developing CERCLA remedies." (40 CFR º 300.400(g)[3] [1994]). TBCs are nonpromulgated advisories and are not legally binding. They "do not have the status of potential ARARs." (CERCLA Compliance with Other Laws Manual Draft Guidance, USEPA OSWER Directive 9234.1-01,1988.)

d. 40 CFR Part 141 Subpart B and Subpart G (1994).

e. State of Hawaii Maximum Contamination Levels. Rules Relating to Potable Water Systems Title 11 Chapter 20 ºº 11-20-2, -3, and -4, as amended, originally effective August 8, 1977, as Chapter 49 of the Public Health Regulations, Department of Health.

f. 40 CFR Part 141 Subpart F (1994).

g. USEPA Office of Water Lifetime Health Advisories (HAs) for a 70-kg Adult, May 1995.

h. USEPA Office of Water Health Advisory representing a 1 x 10 -6 cancer risk, the concentration in drinking water that will result in one excess cancer death in one million people (May 1995).

i. Under review. Drinking Water Regulations and Health Advisories, USEPA Office of Water, May 1995.

Table 2.4: Action-specific Applicable or Relevant and Appropriate Requirements for OU 2 at Schofield Army Barracks, Hawaii

Actions	Requirements	Prerequisites	Federal Citation	Hawaii Citation
Alternative 1 No Action				
Institutional controls	Institutional controls such as water use and deed restrictions to supplement engineering controls as appropriate for short-and long-term management to prevent or limit exposure to hazardous substances, pollutant, or contaminants,	Presence of hazardous substances, pollutants, or contaminants,	40CFR º 300.430(a)(1)(iii)(D) to be considered.	
Alternative 2 Air Stripping .				
Fugitive dust emissions	Visible fugitive dust emissions must not be discharged beyond the property lot line on which the fugitive dust originates. Reasonable Precautions must be used to prevent fugitive dust emissions.	Fugitive emissions from excavation of contaminated soil and construction of pads.		º11-60.1-33(a)(1) through (7) and (b) applicable
Air emissions from the air stripper	Administrative and substantive requirements of permit if exemption listed at º11-60.1-62(d)(1) cannot be met. Requirements include the installation of devices for the measurement or analysis of source emissions or ambient concentrations of air pollutants; monitoring; and requirements concerning the use, maintenance, and installation of monitoring equipment.	Exemption under º11-60.1-62(d)(1) cannot be met.	º11-60.1-68 applicable	
Discharge of treated groundwater	Comply with MCLs. See Section 3 of the OU 2 FS Report for a discussion of MCLs.	Discharge of treated groundwater into water distribution system.		
Alternative 4 Peroxide/Ozone Oxidation				
Fugitive dust emissions	See Alternative 2			
Discharge of treated groundwater	See Alternative 2			

CFR Code of Federal Regulations
MCL Maximum contaminant level
RCRA Resource Conservation and Recovery Act

Table 2.5: Preliminary Estimated Influent Chemicals of Concern Concentrations and Proposed Treatment Standards for Schofield Army Barracks OU 2

Chemicals of Concern	Estimated Range of Groundwater Influent Concentrations (Ig/l)	Federal MCls a (Ig/l)
Carbon tetrachloride	<1 -b to 8.2 -b	5
Trichloroethene	<1 -b to 25 -c	5

< Less than
MCLs Maximum contaminant levels
OU Operable Unit
Ig/l Microgram per liter

a. State of Hawaii MCLs are equivalent to the federal MCLs for these compounds.
b. Based on OU 2 RI sampling results.
c. Based on influent concentration data to the Schofield Barracks water supply well air stripper treatment system the air stripper influent concentrations (sampled February 28, 1995). (State of Hawaii Department of Health personal communication)

Table 2.6: Summary of Comparative Analysis of Alternatives

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Groundwater Extraction, Air Stripping	Alternative 4 Groundwater Extraction, Ozone/Hydrogen Peroxide Oxidation
Effectiveness			
Overall protection of human health and the environment	Inadequate; uncertainty regarding time frame when OU 2 groundwater plume would migrate offsite and what the TCE concentration would be. Natural attenuation will be the primary mechanism for reducing contaminant concentration in the aquifer.	Protective; immediately upon treatment and prior to distribution of the OU 2 groundwater for domestic use. Natural attenuation will be the primary mechanism for contaminant concentration reduction in the aquifer.	Protective; immediately upon treatment and prior to distribution of the OU 2 groundwater. Natural attenuation will be the primary mechanism for contaminant concentration reduction in the aquifer.
Compliance with ARARs and other guidance	No action does not achieve chemical-specific ARARs, however, through natural attenuation chemical-specific ARARs are expected to be achieved; there are no action-specific ARARs and no location-specific ARARs.	Air stripping can meet chemical-specific ARARs immediately through treatment at the wellhead, and with time through natural attenuation. However, because the alternative will not actively restore the aquifer to below MCL concentrations, a TI waiver has been invoked for this ARAR. Action-specific and location-specific ARARs are expected to be met by this alternative.	Ozone/hydrogen peroxide oxidation can meet chemical-specific ARARs Immediately through treatment at the wellhead, and with time through natural attenuation. However, because the alternative will not actively restore the aquifer to below MCL concentrations, a TI waiver has been invoked for this ARAR. Action-specific and location-specific ARARs are expected to be met by this alternative.
Long-term effectiveness	Through deed restriction this alternative will reduce residual risk associated with the groundwater within the OU 2 plume onsite. Future hypothetical risk and exposure pathways would continue to pose a threat to human health and the environment. Natural attenuation will eventually contribute to the attainment of MCLs and the elimination of residual risk and threat to human health and the environment.	Treatment at the wellhead combined with natural attenuation will eventually contribute to the attainment of MCLs and the elimination of residual risk and threat to human health and the environment.	Treatment at the wellhead combined with natural attenuation will eventually contribute to the attainment of MCLs and the elimination of residual risk and threat to human health and the environment.

Table 2.6 (continued)

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Groundwater Extraction, Air Stripping	Alternative 4 Groundwater Extraction, Ozone/Hydrogen Peroxide Oxidation
Reduction of toxicity, mobility, and volume	No reduction in mobility, toxicity, or volume from treatment. However, reduction in toxicity, mobility, and volume through natural attenuation and degradation.	Extracted groundwater will have a reduction in toxicity and volume providing protection to human health and the environment. However, reduction in mobility, toxicity, and volume will not occur to a large extent in the contaminated groundwater system, except through natural attenuation.	Contaminants in extracted groundwater will be reduced in toxicity and volume providing protection to human health and the environment. However, reduction in mobility, toxicity, and volume will not occur in the contaminated groundwater system, except through natural attenuation.
Short-term effectiveness	Unchanged; Army controls access to the site and groundwater removal and use.	Impacts to the community and workers will be minimal during construction of the concrete pad and set tip of the treatment equipment. Possible short-term ecological and environmental effects due to construction activities from dust generation, vegetation clearing, and construction noise.	Impacts to the community and workers will be minimal during construction of the concrete pad and set up of the treatment equipment. Possible short-term ecological and environmental effects due to construction activities from dust generation, vegetation clearing, and construction noise.
Implementability	Technically feasible to implement groundwater monitoring program.	Technically feasible to implement. Conventional equipment used in this alternative. Effectiveness monitored through process monitoring and groundwater monitoring.	Technically feasible to implement. Conventional equipment used in this alternative. Effectiveness monitored through process monitoring and groundwater monitoring.
Cost	Total Estimated Capital Cost = $0 Total Estimated Annual Operation and Maintenance Cost = $87,500 Total Estimated Present Worth = $1,350,000	Operating Flow Rate = 3,000 gpm Total Estimated Capital Cost = $650,000 Total Estimated Annual Operation and Maintenance Cost = $217,000 Total Estimated Present Worth = $3,990,000	Operating Flow Rate = 3,000 gpm Total Estimated Capital Cost = $1,500,000 Total Estimated Annual Operation and Maintenance Cost = $287,000 Total Estimated Present Worth = $5,910.000

ARAR Applicable or relevant and appropriate requirement
gpm Gallons per minute
OU Operable unit
PRG Preliminary remediation goal
TCE Trichloroethene

Table 2.7: Calculations for Estimated Maximum Trichloroethene Vapor Discharge from Alternative 2 (Air Stripping Treatment)

Assumptions:

- Maximum influent groundwater flow rate into the air stripper is 1,500 gallons per minute (gpm)

- The trichloroethene (TCE) concentration of 25 micrograms per liter (Ig/l) is based on influent concentration data to the Schofield Barracks water supply well air stripper treatment system.

Trichloroethene (TCE)

$$\frac{1\ \text{gram}}{1{,}000\ \text{milligrams}} \quad \frac{1\ \text{pound}}{453.6\ \text{grams}} \quad \frac{3.785\ \text{liters}}{\text{gallon}} \quad \frac{60\ \text{minutes}}{1{,}000\ \text{milligrams}} \quad \frac{1{,}500\ \text{gallons}}{\text{minute}} \quad \frac{.025\ \text{milligrams}}{\text{liter}} \quad \frac{24\ \text{hour}}{\text{day}} \quad \frac{365\ \text{day}}{\text{year}}$$

= 164 pounds per year of TCE.

Table 2.8: Summary of Estimated Costs for Remedial Action Alternatives at Schofield Army Barracks for OU 2

Alternative	Estimated Capital Cost ($)	Estimated Annual O&M Cost ($)	Estimated Net Present Worth* ($)
Alternative 1: No Action	0	87,500	1,350,000
Alternative 2: Air Stripping	650,000	217,000	3,990,000
Alternative 4: Ozone/Hydrogen Peroxide Oxidation	1,500,000	287,000	5,910,000

O&M Operation and maintenance

* Based on 5 percent rate of return and 30-year life.

Table 2.9: Estimated Cost Summary of Selected Remedy - Air Stripping

Capital Cost	
Direct Capital Cost	
Extraction system	$19,000
Mobilization and demobilization/site work	41,000
Groundwater treatment system	322,000
Subtotal - Estimated Direct Capital Cost	$382,000
Indirect Capital Cost	
Contingency (@ 25 percent)	$96,000
Engineering (@ 10 percent)	38,000
Contractor markup (@ 10 percent)	38,000
Construction management (@ 25 percent)	96,000
Total - Estimated Capital Cost	S650,000
Annual Operation and Maintenance (O&M) Cost	
Labor and maintenance	$21,000
Electricity	83,000
Five-year site review and groundwater monitoring	70,000
Subtotal - Estimated O&M Cost	$174,000
Contingency (@ 25 percent)	43,000
Total Estimated Annual O&M Cost	S217,000

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3.0 RESPONSIVENESS SUMMARY

3.1 Overview

This section provides a summary of the public comments and concerns regarding the Proposed Plan at Schofield Barracks, Island of Oahu, Hawaii. At the time of the public review period, the Army had selected Alternative 2, as the preferred alternative for the OU 2 groundwater. On the basis of the written and verbal comments received, the Army's Proposed Plan was generally accepted by the public.

3.2 Background on Community Involvement

The Army has implemented a progressive public relations and involvement program for environmental activities at Schofield Barracks. A Technical Review Committee, comprised of representatives from the Army, the EPA, the State of Hawaii DOH, and members of the general public, has been established and meets periodically to involve the public in decisions made regarding investigation results, proposed work, and potential remedial actions. The Army distributed over 100 copies of a fact sheet to interested parties and to the information repositories (Section 2.6). These fact sheets described the installation restoration program at Schofield Barracks, including a discussion of how the public could get more information and get involved in the program. A synopsis of community relations activities conducted by the Army is presented in Appendix A.

The Army held a public comment period on the alternatives presented in the OU 2 FS and Proposed Plan from May 24 through June 24, 1996. Over 100 copies of the Proposed Plan were mailed to the public for review and comment and were placed in the repositories discussed in Section 2.6. The Proposed Plan also invited readers to a public meeting to discuss the preferred alternative. This public meeting was held to discuss the selected preferred alternative. The meeting was held on June 12, 1996, from 7:00 to 8:00 p.m. in the Hale Koa, at Wahiawa District Park, 1139A Kilani Avenue, Wahiawa, Hawaii.

Comments were received from the public regarding the Proposed Plan public during the comment period and those comments are addressed below.

3.3 Summary of Comments Received During Public Comment Period and Department of the Army Responses

The comments received during the public comment period and accompanying Army responses are provided in Appendix B.

4.0 ACRONYMS

ARAR	Applicable or relevant and appropriate requirement
Army	U.S. Department of the Army
bgs	Below ground surface
BWS	Board of Water Supply
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminants of concern
COPC	Chemicals of potential concern
CWA	Clean Water Act
DERP	Defense Environmental Restoration Program
DOD	U.S. Department of Defense
DOH	Department of Health
DOI	Department of Interior
EPA	U.S. Environmental Protection Agency
ERA	Ecological risk assessment
ESPS	Environmental Services Program Support
FWS	U.S. Fish and Wildlife Service
FFA	Federal Facility Agreement
gpm	Gallons per minute
HAR	Hawaii Administrative Rules
HC	Hawaii Citation
HI	Hazard index
HLA	Harding Lawson Associates
HRA	Health risk assessment
IPR	In-Progress Review
IRP	Installation Restoration Program
lb/day	Pounds per day
MCL	Maximum Contaminant Level
MCLG	Maximum contaminant level goal
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NGVD	National Geodetic Vertical Datum of 1929
NMFS	National Marine Fisheries Service
NPL	National Priorities List
O&M	Operation and maintenance
OU	Operable unit
PA/SI	Preliminary Assessment/Site Investigation
ppb	Parts per billion
PRG	Preliminary remediation goal
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable maximum exposure
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act of 1986
Schofield Barracks	Schofield Army Barracks
SDWA	Safe Drinking Water Act
TBC	To be considered
TCE	Trichloroethene
USAEC	U.S. Army Environmental Center
USC	United States Code
UV	Ultraviolet
VOC	Volatile organic compound
WES	Waterways Experiment Station
Wheeler	Wheeler Army Airfield
WWII	World War II
Ig/m 3	Micrograms per cubic meter
Ig/l	Micrograms per liter

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Appendix A

SYNOPSIS OF COMMUNITY RELATIONS ACTIVITIES

May 1985 - Schofield Barracks issued a press release regarding the detection of Trichloroethylene (TCE) in the Schofield Barracks Supply wells and the temporary switch to city and county water supplies.

August 1990 - Schofield Barracks issued a press release regarding the placement of the installation on the National Priorities List (NPL).

October 1990 - Schofield Barracks Public Affairs Office and Environmental Office addressed the Wahiawa Neighborhood Board regarding Army plans to conduct investigations on Schofield Barracks to identify sources of TCE.

January 1992 - Schofield Barracks and U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) submitted press releases requesting public involvement in locating the source(s) of TCE contamination in and around Schofield Barracks.

January 1992 - Schofield Barracks and USATHAMA conducted interviews with twenty local residents to assist in the development of a Community Relations Plan for the Schofield Barracks Installation Restoration Program (IRP).

June 1992 - The Army finalized the Community Relations Plan for Schofield Barracks and placed copies in the newly established information repositories located in the Mililani Public Library, the Wahiawa Public Library, The Hawaii Department of Health, and the Directorate of Public Works in Building 300 of Wheeler Army Airfield.

February 25, 1993 - Schofield Barracks and the Army Environmental Center (AEC) conducted a public meeting at the Hale Koa at Wahiawa District Park in Wahiawa to provide the public with an update on the IRP and the results of the first phase of the investigations.

February 1993 - In conjunction with the public meeting, the Army published and distributed a fact sheet that provided an update on the IRP and initial investigative results.

September 13 and 14, 1994 - Schofield Barracks and the AEC conducted public availability sessions at the Hale Koa at Wahiawa District Park (September 13) and at the Schofield Barracks Post Library (September 14) to provide an update on the IRP.

September 13 and 14, 1994 - In conjunction with the public availability sessions, the Army solicited interest in the formation of a Restoration Advisory Board (RAB) comprised of local citizen representatives, Army representatives, and regulatory agency representatives that would oversee the conduct of the Army's IRP at Schofield Barracks.

September 12 through 14, 1994 - The Army presented a poster display that summarized installation restoration efforts and plans for Schofield Barracks at the 1st Hawaii National Technologies Conference sponsored by the Hawaii Department of Health

September 1994 - In conjunction with the public availability session, the Army published and distributed a fact sheet that provided an update on the IRP and initial investigative results.

May 24 through June 24, 1996 - Schofield Barracks conducted a public review period for the Proposed Plan for Operable Unit 2.

June 12, 1996 - Schofield Barracks and the AEC conducted a public meeting to present the Operable Unit 2 Proposed Plan and solicit public comments.

Appendix B

COMMENTS RECEIVED DURING PUBLIC COMMENT PERIOD AND ARMY RESPONSES

Directorate of Public Works AUG 09 1996

Mr. Henry Curtis
Executive Director
Life of the Land
1111 Bishop Street
Suite 503
Honolulu, Hawaii 96813

Dear Mr. Curtis:

Thank you for your input on the Army's Proposed Plan for addressing groundwater contamination at Schofield Barracks.

In response to your comment regarding the detection levels used in monitoring water supply wells under the Schofield Barracks installation restoration program, the Army, in the past has used an analytical method that will accurately detect trichloroethylene (TCE) down to 1.0 micrograms per liter (ug/1) or parts per billion (ppb). This provides an adequate safety factor between the detection limits and the Safe Drinking Water Act Maximum Contaminant Level of 5 ug/l. In addition, the Army recently agreed to a request by the Hawaii Department of Health to use a drinking water analytical method that will detect TCE down to 0.3 ug/l for all future sampling to be conducted under the proposed wellhead treatment remedial action.

We would like to assure you that the approach in the Operable Unit 2 Proposed Plan for addressing the groundwater contamination is fully protective of human health and the environment. The Army is committed to ensuring that the water supply wells potentially impacted by the TCE originating from Schofield Barracks are monitored and that actions are taken if TCE is found in those supply wells.

Your participation in the OU 2 Proposed Plan Public meeting was appreciated. Your continued interest in the cleanup efforts at Schofield Barracks is encouraged, and if you have any further questions, please contact Mr. Jon Fukuda, Environmental Department, Directorate of Public Works, 656-6790.

Sincerely,

ORIGINAL SIGNED BY;

Dennis J. Fontana
Colonel, U.S. Army
Director of Public Works

LIFE OF THE LAND

HAWAII'S OWN ENVIRONMENTAL ACTION GROUP
EDUCATION, RESEARCH, LOBBYING & LITIGATION
PROTECTING HAWAII’S FRAGILE ENVIRONMENT

June 21, 1996

Comments RE: Operable Unit 2: Groundwater

The facts are simple. TCE exists in the groundwater. The Army/EPA has spent $8M looking for the source, unfortunately unsuccessfully. The Army has removed an equivalent of 1 drum (55 gallons) of TCE per year from groundwater filtration for the past 10 years.

The City & County of Honolulus Board of Water Supply (BWS) maintains five separate water systems for Oahu. They are:

- Waialua--Haleiwa--Sunset;
- Waianae--Ewa--Downtown--East Honolulu--Windward
- Wahiawa;
- Mililani;
- Kunia.

The fiction is that everything is okay. The BWS has monitored wells for pesticide and toxic contamination for many years. Persistent critics outside of the government, and sources within the BWS have stated that the BWS tests leave a lot to be desired. If contamination is found ill a well, either the detection level for a test will be lowered (if 3 ppb was detected, the next testing will only be able to measure 5 ppb), or the well will no longer be tested.

There is a disease cluster in Village Park. Many believe that the contamination is in the ground water or the soil. The Hawaii Department of Health has testified before the State Legislature that they would investigate --- if the had the $ --- but since they don't --- other priorities come first.

The EPA came out to Oahu last fall to obtain information about the proposed Kunia Superfund site. The EPA asked Life of the Land for input. The EPA wanted to limit the Kunia Superfund to Kunia. The EPA did not want the Proposed Kunia Superfund Site to overlap with the Schofield Superfund Site. Too many complications!

The Galbraith property has been proposed as the site for the joint Wahiawa/Schofield Wastewater Treatment Plant and Wetlands Facility. This would require separating the Schofield Superfund Site into sections, and then de-listing the Galbraith section.

These examples lead the environmental community to question the message we are receiving.

In this case, the community, through participation in the RAB process, can feel assured that everything is under control. The community would also feel comfortable knowing that if conditions change, they would know about the changes up-front. The military could also profit greatly from this continued interaction with the community.

Life of the Land is interesting in serving on such a Board.

<IMG SRC 97032N>

Henry Q Curtis
Executive Director

1111 Bishop St, Suite 503 * Honolulu, HI 96813 * 533-3454 * fax 533-0993

<IMG SRC 97032O>

June 18, 1996

Commander
USAG-HI
Directorate of Public Works
Attn: Mr. John Fukuda
Schofield Barracks HI 96857-5000

Dear Mr. Fukuda,

The O'ahu Group of the Sierra Club is concerned that the proposed plan to address groundwater contamination at Schofield does not appear to call for the long-term cleanup of site contamination and restoration of the groundwater system. While it may be cost-effective in the short-term to treat water before consumption, it is imperative that the sources of contamination be identified and cleaned up.

Sincerely,

<IMG SRC 97032P>

Directorate of Public Works

Mr. Phillip D. Bogetto
0'ahu Group Chair
Hawaii Chapter
Sierra Club
P.O. Box 2577
Honolulu, Hawaii 96803

Dear Mr. Bogetto:

Thank you for your input on the Army's Proposed Plan for addressing groundwater contamination at Schofield Barracks.

The Army shares your opinion that the best approach for protecting and restoring groundwater is to identify and cleanup sources of contamination. The Army's highest priority under the installation restoration program was the identification and investigation of potential sources of the solvent trichloroethylene (TCE) which resulted in contamination of the groundwater underlying the installation. A thorough investigation was conducted under Operable Unit 1 (TCE sources) to determine the source, or sources, of TCE contamination. The investigation included extensive historical records search, interviews with past employees, an extensive review of historical aerial photographs and site walks to identify potential source areas. This was followed by a remedial investigation of those sites which included soil gas surveys to detect the smallest presence of TCE and other contaminants. Unfortunately, that search failed to identify a source of contamination. As discussed at the Operable Unit 1 public meeting on July 18, 1995, the Army has followed up on all information regarding possible TCE sources and will continue to do so, however, at this time we have investigated all suspected sites.

We would like to assure you that the approach proposed under the Operable Unit 2 Proposed Plan is fully protective of human health and the environment. The Army is committed to ensuring that the water supply wells potentially impacted by the TCE originating from Schofield Barracks are monitored and that actions are taken if TCE is found in the supply wells.

Your continued interest in the cleanup efforts at Schofield Barracks is encouraged, and if you have any questions, please contact Mr. Jon Fukuda, Environmental Department, Directorate of Public Works, 656-6790.

Sincerely,

<IMG SRC 97032Q>

<IMG SRC 97032R>

HOUSE OF REPRESENTATIVES
STATE OF HAWAII
STATE CAPITOL
HONOLULU, HAWAII 96813

Marcus R. Oshiro
State Representative

District 40
Wahiawa Whitmore Village

June 20, 1996

Commander
U.S. Army Garrison - Hawaii
Directorate of Public Works
ATTN: APVG-GWV (Mr. Jon Fukuda)
Schofield Barracks, Hawaii 96857-5000

Dear Commander:

RE: OU2 Public Comments

Please accept the following as my written comments to the proposed clean up plans for Operable Unit 2 (OU2). My concerns regarding the proposed alternative are as follows:

1. Source of carbon tetrachloride and TCE has not been identified

   I have concerns regarding the integrity of the Risk Assessment; How can one measure the risk of danger to health and environmental when there is no knowledge of the extent of contamination? Do you have any best estimates of the quantity of contamination? Can this be deduced from past records, oral investigations of past personnel? More resources should be directed to ascertaining the extent of and quantity of contamination.

2. Protection of Public Water Supply.

   I have grave concerns over the current monitoring process, especially given the close proximity of Board of Water Supply wells and water sources of the contaminated groundwater beneath Schofield. If the contaminated body of groundwater should move from it present site, would it not expose the public water supply to contamination also?

   I would like clarification on the safeguards currently established. Likewise, clarification of the safeguards being taken to insure that the larger groundwater body is not contaminated.

I wish to obtain a copy of the map of the test sites and the corresponding levels of contaminants found in each (This was the visual aid used at the Public Meeting).

I thank you for the opportunity to comment. If you have any questions or if I can be of any further assistance, please feel free to contact me at 586-8505.

Very truly yours,

<IMG SRC 97032S>

MO:gt

<IMG SRC 97032T>

DEPARTMENT OF THE ARMY
HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII
SCHOFIELD BARRACKS, HAWAII 96857-5000

REPLY TO
ATTENTION OF

August 30, 1996

Directorate of Public Works

Honorable Marcus R. Oshiro
State Representative
District 40
State of Hawaii
State Capitol
Honolulu, Hawaii 96813

Dear Mr. Oshiro:

I would like to thank you for the interest you have shown in the Army's clean-up program at Schofield Barracks and for your comments on the Operable Unit 2 (Groundwater) Proposed Plan provided in your letter of June 20, 1996. The following information is provided in response to your comments:

Comment 1: Source of carbon tetrachloride and TCE has not been identified.

Response: The Army shares your concern that the source of the TCE plume from the East Range Area has not been specifically identified. The Army's highest priority under the installation restoration program was the identification and investigation of potential sources of the solvent trichloroethylene (TCE), which resulted in contamination of the groundwater underlying the installation. The best approach for protecting and restoring groundwater is to identify and clean up sources of contamination. A thorough investigation was conducted under Operable Unit 1 (TCE Sources) to determine the source or sources of TCE contamination. The investigation included extensive historical record searches, interviews with over 120 people, an extensive review of historical aerial photographs (120 photographs dating back to the 1940's), and site walks to identify potential source areas. This was followed by a remedial investigation of those sites, which included soil gas surveys to detect the smallest presence of TCE in the soils, soil sampling to depths of 150 feet, stream and sediment sampling, geophysical surveys to locate past disposal trenches, and various other techniques to determine the presence of TCE and other contaminants. Unfortunately, that search failed to identify a source of contamination. As discussed at the Operable Unit 1 public meeting on July 18, 1995, the Army has followed up on all information regarding possible TCE sources. However, at this time, we have investigated all suspected sites.

The risk assessment conducted for groundwater contamination at Schofield Barracks was performed using the highest concentration of TCE recorded in the groundwater at the East Range. These levels are much higher than those currently found in the Schofield Supply wells, and are much higher than could potentially migrate to other municipal water supply wells downgradient of Schofield Barracks. Natural processes of dilution, absorption and degradation will continue to reduce TCE concentrations as the groundwater moves away from the Schofield area.

Even using the highest concentrations, the groundwater risk assessment showed no unacceptable risk from consumption of the untreated groundwater. Regardless of the risk, the Army is obligated under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to address groundwater contamination based on the exceedance of Safe Drinking Water Act Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act for TCE and carbon tetrachloride. The proposed plan for Operable Unit 2 addresses the contamination through long-term monitoring of the supply wells, and the installation of treatment systems at Community water sources if concentrations approach the MCL.

Comment 2: Protection of Public Water Supply.

Response: We would like to assure you that the approach proposed under the Operable Unit 2 Proposed Plan for addressing groundwater contamination is fully protective of human health and the environment. The Army is committed to ensuring that the water supply wells, impacted by the TCE originating from Schofield Barracks, are monitored and that actions are taken if TCE is found in those supply wells. The Army's trigger level for taking action is one-half the MCL to allow time for procurement and installation of any required wellhead treatment systems. Based on data from the remedial investigation and from eleven years of monitoring the Schofield Barracks supply wells, the concentrations have remained relatively constant. The quarterly monitoring program will provide timely data to provide a continuing assessment of plume migration rates and directions so early action can be taken if needed.

As you requested, a map showing the locations of the wells tested during the remedial investigation and which will be included in the long term monitoring program is enclosed.

Again, your interest and participation in the OU 2 Proposed Plan public meeting are appreciated. Your continued interest in the cleanup efforts at Schofield Barracks is encouraged, and if you have any further questions, please contact Mr. Jon Fukuda, Environmental Department, Directorate of Public Works, 656-6790.

Sincerely,

<IMG SRC 97032U>

Enclosure

<IMG SRC 97032V>

Appendix C

ANALYSIS OF THE IMPACT OF TRICHLOROETHENE (TCE) ON CARBON USAGE IN THE HONOLULU BOARD OF WATER SUPPLY TREATMENT SYSTEMS

HLA contacted both Carbonaire and Calgon and asked each of the companies to model the possible effects of TCE on the groundwater that is currently being treated at the Board of Water Supply's Mililani I and Mililani II systems. Table 1 was provided to both companies. Both companies were asked to model the effects of a range of TCE concentrations (0.5 micrograms per liter(Ig/1), 1.0 Ig/l, 2.0 Ig/l, 3.0 Ig/l, 5.0 Ig/l, 10.0 Ig/l, 15.0 Ig/l and 25 Ig/l) on carbon usage if the treatment system influent contained the highest contaminant concentrations listed for each chemical on Table 1 (3.0 Ig/l of 1,2,3-trichloropropane (TCP), 0.9 Ig/l 1,2-Dichloropropane (DCP) and 1,2-Dibromo-3-chloropropane (DBCP)) and the TCE concentrations in the effluent were not to exceed 2.5 Ig/l.

Carbonaire could not model a multicomponent system where the least adsorbable compound (i.e., TCE) was not the driver (compound driving the usage rate). However, Carbonaire estimated that TCE would only have a minor affect on the adsorption of TCP. Calgon was able to model a multi-component system using a proprietary program developed for Calgon. The program is based on Polyani Adsorption Theory and incorporates the modification of the theory proposed by Hansen and Fackler. The theory and equations were derived from the first principals of thermodynamics. The effects of competive adsorption between the identified species are considered when determining the total capacity of the GAC and the composition of the adsorbate mixture that fills the carbon.

The principals and assumptions incorporated into the model were given by Calgon as follows:

- All adsorbates gave equal access to all sites. This limits the model because molecular sieving can exclude certain molecules because of size or shape.

- The possibility of chemisorption is not considered. Chemisorption generally occurs when carbon acts as a catalyst causing a chemical reaction to occur when certain chemicals come into contact with carbon. The compound that reacts with the carbon may then react with the contaminant of concern that you are trying to remove from your water and change the contaminant of concern in such a way that it will no longer adsorb to the carbon.

- The adsorbates compete for adsorption sites on a volume basis, so a large molecule displaces an equal volume of small molecules.

- The molecule having adsorption with the greatest thermodynamic driving force will displace or prevent adsorption of other molecules at a specific site.

The modeling results from Calgon are presented in Table 2 to for Mililani I and Mililani III systems. The modeling results indicate that the carbon usage rate will go up as the concentrations of TCE increase from 0.5 Ig/l to 5.0 Ig/l indicating that the U.S. Army would be responsible for sharing some carbon usage costs at concentrations ranging between the detection limit and 2.5 Ig/l. However, additional cost for carbon usage would not be high enough to warrant installation of the air stripper prior to TCE concentrations reaching 2.5 Ig/l.

Table 1: Honolulu Board of Water Supply Chemical Laboratory Report

Subject: Trihelomethanes/Volatile Organic Chemicals Test Results (in Ig/l)

Compound	Sample Source Mililani Wells 1 GAC Cont. #11	Mililani Wells 1 Pump #3	Mililani Wells 1 Pump. #4	Detection Limit (Ig/l)	EPA MCL (Ig/l)
1,2-Dichloropropane (DCP)	0.9	0.7	0.8	0.1	3
1,2,3-Trichloropropane (TCP)	0.2	3.0	2.2	0.1	0.8*
1,2-Dibromo 3-Chrloropropane (DBCP)	<0.01	0.10	0.14	0.01	0.04*
1,2-Dibromethane (EDB)	<0.01	<0.01	<0.01	0.01	0.04*
Date Sampled:	10/18/95	10/17/95	10/17/95		
Date Received:	10/20/95	10/20/95	10/20/95		
Date Analyzed:	10/25,26/95	10/25/95	10/25/95		
Lab ID No.:	951020028	951020021	951020022		

* State DOH MCL

Table 2: Estimated Increase in Carbon Usage at Mililani I and Mililani II Systems

TCE Influent (Ig/l)	TCE Effluent (Ig/l)	Estimated Annual Carbon Usage a (lbs/yr)	Percent Increase of Annual Carbon b Usage Rate	Carbon Replacement and Disposal Cost a ($/lb)	Annual Increase in Carbon Replacement and Disposal Cost
Mililani I					
0.5	0.5	240,000	<1	$1.70	Approx. $4,100.00
1	1	240,000	4	$1.70	$16,320.00
2	2	240,000	8	$1.70	$32,960.00
3	2.5	240,000	12	$1.70	$48,960.00
5	2.5	240,000	23	$1.70	$93,840.00
10	2.5	240,000	46	$1.70	$187,680.00
15	2.5	240,000	62	$1.70	$252,960.00
25	2.5	240,000	96	$l.70	$391,680.00
Mililani II					
0.5	0.5	80,000	<1	$1.70	Approx. $1,400.00
1	1	80,000	4	$1.70	$5,440.00
2	2	80,000	8	$1.70	$10,880.00
3	2.5	80,000	12	$1.70	$16,320.00
5	2.5	80,000	23	$1.70	$31,280.00
10	2.5	80.000	46	$1.70	$62,560.00
15	2.5	80,000	62	$1.70	$84,320.00
25	2.5	80,000	96	$1.70	$130,560.00

a. Estimated annual carbon usage rates and carbon replacement and disposal cost were provided by Honolulu Board of Water Supply.

b. Percent increase of annual carbon usage rate if TCE impacts BWS carbon treatment system was provided by Calgon using their proprietary multicomponent computer model.