1.0 INTRODUCTION

This Annual Groundwater Monitoring Report summarizes the groundwater monitoring activities and results at RFETS for CY 2001, as required in the Rocky Flats Cleanup Agreement (RFCA, 1996) and outlined in the 2001 Integrated Monitoring Plan (IMP) (Kaiser-Hill [K-H], 2000a). Section 1.0 serves as an introduction to the report. Section 2.0 discusses the groundwater quality data collected in CY 2001. Section 3.0 presents baseline (CY 1996) and CY 2001 hydrogeologic data for the RFCA groundwater-monitoring network. Section 4.0 discusses the performance monitoring activities that are in process for the various groundwater remediation projects ongoing at RFETS. Section 5.0 discusses groundwater issues with respect to building D&D activities. Section 6.0 discusses the CY 2001 monitoring results for the Present Landfill. Sections 7.0, 8.0, and 9.0 discuss plume degradation activities, groundwater evaluations, and groundwater characterization activities, respectively. Section 10.0 discusses other groundwater program activities and Section 11.0 provides a data quality assessment of the groundwater data collected during CY 2001. Section 12.0 presents conclusions and future groundwater related activities, and Section 13.0 lists all references found in this report.

1.1 Site Description

The RFETS is located 16 miles northwest of Denver in Jefferson County, Colorado. The Site is a U.S. government-owned and contractor-operated facility that encompasses approximately 6,550 acres (Figure 1-1). Site ownership, however, does not include surface and subsurface minerals or water rights. Site construction was initiated in 1951 and operations were begun in 1952.

Prior to the current closure mission, RFETS was part of the nationwide nuclear weapons research, development, and production complex. The plant produced metal components for nuclear weapons from plutonium, uranium, beryllium, and stainless steel. Other production activities included chemical recovery and purification of recyclable transuranic radionuclides, metal fabrication and assembly, and related quality control functions. The plant conducted research and development programs in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics. Parts manufactured at the Site were shipped offsite for final assembly.

Major plant structures, including all production buildings, are located within the centralized 400-acre Industrial Area (IA) of the Site that is surrounded by a 6,150-acre Buffer Zone. Industrial activity immediately adjoining the Site includes present and/or prior coal and clay mining, petroleum recovery, natural classified-aggregate quarrying, and fabricated-aggregate mining. Other activities include cattle ranching and wind energy research. Several irrigation ditches traverse the Site, transmitting water for downstream agricultural, industrial, and municipal purposes. Three ephemeral streams drain the Site and flow eastward (see Figure 1-2).

1.2 Geology and Hydrogeology

1.2.1 Introduction

The Site is situated approximately two miles east of the Front Range of Colorado (Figure 1-1) on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Spencer, 1961). Haun and Kent (1965) have summarized the geologic history of the Colorado Rocky Mountain region, which includes the Site area. The elevation at the Site is approximately 6,000 feet above mean sea level (MSL). The Industrial Area of the Site is located on an alluvial-covered pediment. The upper surface of the alluvium slopes easterly 1 to 2 degrees. Most of the surrounding area in the Buffer Zone is more prominently dissected with intermittent streams. These small, eastward flowing streams include Rock Creek, Walnut Creek, Woman Creek, and several tributaries and surface water diversion ditches.

1.2.2 Stratigraphy

The stratigraphic sequence that underlies the Site extends from the crystalline Precambrian gneiss, schist, and granitoids at 3,000 feet below MSL to the unconsolidated Quaternary deposits at the surface approximately 6,000 feet above MSL. Based upon aerial photographic interpretation, field geologic mapping, coal and aggregate mine development, petroleum exploration in the vicinity, and numerous borehole investigations, a substantial amount of lithologic information has been gained about the Site. The generalized lithologic section in the Rocky Flats area is shown in Figure 1-3.

The Upper Cretaceous Pierre Shale and Fox Hills Sandstone underlie the Site, with the latter exposed in quarries along the western edge of the Site. The Cretaceous Laramie and Arapahoe Formations are exposed at the surface or underlie the Site. The Quaternary Rocky Flats Alluvium, and to a limited extent Verdos Alluvium, unconformably overlie the Arapahoe and Laramie Formations in the central portion of the Site. More recent valley fill alluvium and hillslope colluvium are also present. The unconsolidated surficial deposits, combined with the weathered portion of subcropping bedrock formations, form the sequence of rocks that have the greatest importance regarding groundwater flow and contaminant transport at the Site.

1.2.2.1 Rocky Flats Alluvium

Scott (1975) identified several Quaternary alluvial pediment covers in the vicinity of the Site. The Rocky Flats Alluvium is an unconsolidated deposit derived from quartzites and granites of the Coal Creek Canyon provenance west of the Site. The deposit thins from west to east with thicknesses ranging from approximately 100 feet to less than one foot. In the central portion of the Site the deposit is approximately 15 to 25 feet thick. The Rocky Flats Alluvium is a heterogeneous deposit dominantly composed of angular to subrounded, poorly sorted, coarse, bouldery-gravel with a clay and sand matrix. Clay, silt, and sand lenses as well as varying amounts of caliche are also present.

Exposures of Rocky Flats Alluvium in the aggregate quarries north and west of the Site exhibit some large scale cross-stratification. Depositional processes include fluvial and debris-flow transport (Shroba and Carrara, 1994) infilling paleotopographic lows and leaving a widespread surface of erosion with extremely low relief.

1.2.2.2 Other Surficial Deposits

In addition to the pediment covering alluvial deposits, younger Quaternary units consisting of colluvium, landslide alluvium, and valley fill alluvium mantle the hillslopes and valley bottoms below the pediment surface. Colluvial deposits are derived from older alluvial deposits and Arapahoe and Laramie Formations. This unit consists of sheetwash, soil creep, and landslide materials with a total thickness of 3 to 16 feet (Shroba and Carrara, 1994). These deposits locally flank the Rocky Flats Alluvium and generally extend to lower parts of the slopes along the principal drainages.

Landslide deposits commonly flank the Rocky Flats Alluvium. They are often bounded by headwall scarps and lobate toes at the downslope margins. Seeps issuing from the base of the Rocky Flats Alluvium contribute to landslide colluvium generation. The landslide units include earth flows, slumps, and debris flows with thicknesses estimated between 10 to 33 feet (Shroba and Carrara, 1994).

Valley-fill alluvial deposits, present in the bottoms of modern stream channels, flood plains, and terraces, are composed of clay, silt, sand, and gravel. They are commonly less than 10 feet thick but can be tens of feet thick. Usually these deposits contain more sand and are well sorted compared to the Rocky Flats Alluvium.

1.2.2.3 Arapahoe Formation

The Arapahoe Formation is composed of claystone and silty claystone with lenticular sandstone in the basal portion of the formation. The Arapahoe Formation is generally less than 25 feet thick in the Site area, occurring as erosional remnants of fine grained sandstone above the Laramie Formation at various locations on Site (EG&G, 1995a). This basal Arapahoe Formation sandstone, often referred to as the No. 1 Sandstone, is of concern as a potential contamination pathway, especially where it subcrops beneath the alluvium.

1.2.2.4 Laramie Formation and Fox Hills Sandstone

The Laramie Formation is approximately 600 to 800 feet thick and is composed of a lower sandstone/claystone/coal interval and an upper, thick claystone interval. Within the upper claystone interval, thin, lenticular sandstone lenses (i.e., Sandstones 2 through 5 in the 1991 Geologic Characterization Report [EG&G, 1991a]) occur. The discontinuous nature of these sandstone lenses coupled with the large claystone layer that encloses them mitigates their potential for transmitting groundwater contamination in both a horizontal and vertical direction.

The Fox Hills Sandstone is primarily fine-grained sandstone with thin siltstone and claystone interbeds and an approximate thickness of between 75 and 125 feet. The Fox Hills Sandstone is exposed in quarries and subcrops

along a narrow, north-south trending pattern in the extreme western part of the Site, upgradient from known sources of contamination.

The permeable lower sandstones and coals of the Laramie, combined with the permeable sandstones of the Fox Hills, constitute a regional aquifer system known as the Laramie-Fox Hills aquifer. This aquifer system is an important water source in the South Platte River Basin (Pearl, 1980), and is the sole water supply for some residents in the Rocky Flats area. This aquifer lies approximately 500 to 600 feet below the Industrial Area and is protected from contamination by the intervening Laramie Formation claystones.

1.2.2.5 Pierre Formation

The Pierre Formation is a 7,500-foot thick, dark gray, silty bentonitic shale that acts as a lower confining layer for the Laramie-Fox Hills aquifer in the Denver Basin. This thick marine shale unit subcrops only in the extreme western part of the Site.

1.2.3 Geologic Structure

The Site is located along the western margin of the Denver Basin, an asymmetric basin with a steeply east-dipping western flank and a gentle west-dipping eastern flank. The interpretation of the subsurface structure is generalized in the east-west geological cross section of the Site area presented in Figure 1-4. A monoclinal fold limb present west of the Site is the most significant surficial structural feature in the Site area. Along the west limb of the fold, an angular unconformity exists between the Upper Cretaceous bedrock and the base of the Quaternary Rocky Flats Alluvium.

No active faults have been identified at the Site. Several high angle bedrock faults have been inferred to exist in the IA based on various stratigraphic and borehole correlation criteria. These faults appear to have only a limited hydrologic significance with regard to vertical groundwater movement and contaminant transport (RMRS, 1996a).

1.2.4 Hydrogeology

This section presents the basic concepts regarding hydrogeologic conditions at the Site that affect groundwater monitoring and protection. Characterization of the hydrogeologic setting is based on the currently accepted conceptual geologic and hydrogeologic models described in the Sitewide Geoscience Characterization Study (EG&G, 1995a; 1995b; 1995c). These conceptual geologic and hydrogeologic models are used to predict the direction and rate of groundwater flow, identify potential pathways for contaminant migration, and determine the extent of contaminant plumes given varying physical, chemical, and biological factors.

1.2.4.1 Definition of the Uppermost Aquifer for the Site

The term *aquifer* as defined by 40 CFR Section 260.10 is a "geologic formation, group of formations, or a part of a formation that is capable of yielding a significant amount of water to a well or spring." An *uppermost aquifer* is also defined as "the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's boundary." Geologic materials with similar hydrologic properties comprise a hydrostratigraphic unit (HSU) (Fetter, 1988). For purposes of this report, the uppermost aquifer or upper hydrostratigraphic unit (UHSU) consists of the unconfined saturated zone, in which unconsolidated and consolidated groundwater-bearing strata are in hydraulic communication. The UHSU consists of the following geologic units: Rocky Flats Alluvium, valley-fill alluvium, colluvium, landslide deposits, weathered Arapahoe and Laramie Formation bedrock, and all sandstones within the Arapahoe and upper Laramie Formations in hydraulic communication with the overlying unconsolidated surficial deposits. The UHSU is considered to be equivalent to the uppermost aquifer at the Site, although in many areas of the site the amount of water available in the UHSU is insufficient to meet the definition of aquifer given above.

Beneath the surficial materials and the consolidated deposits of the UHSU are the geologic units of the lower hydrostratigraphic unit (LHSU). The LHSU consists of the consolidated, unweathered bedrock zone of the Arapahoe and upper Laramie Formations not in hydraulic communication with the overlying UHSU. The Arapahoe and upper Laramie Formations comprising the geologic units of the LHSU consist of lesser amounts of sandstone and greater amounts of adjacent claystones. Because of the low permeability of the claystones, they behave as aquitards restricting hydraulic communication with the UHSU. The lower Laramie Formation and Fox Hills Sandstone comprise a stratigraphically lower and third hydrostratigraphic unit beneath the site. Groundwater within the three-hydrostratigraphic units are hydraulically separated beneath the IA. Because of monoclinal folding and erosional proximity they do converge, however, and potentially mix immediately upgradient of RFETS near the western margin of the Site. Background geochemical characterization of the UHSU and LHSU has revealed that these units have statistically different groundwater chemistry, resulting in the delineation of separate hydrostratigraphic units (EG&G, 1993a).

1.2.4.2 Groundwater Occurrence and Distribution

The Site is located in a regional groundwater recharge area (EG&G, 1991a), however, discharge may occur locally to streams and seeps. Groundwater recharge occurs from the infiltration of incident precipitation and as base flow near the upgradient area of the Site drainage basin that extends west to Coal Creek. Groundwater net recharge also occurs from stream, ditch, and pond seepage, and from leaking utilities such as water supply lines, sanitary sewers, and storm drains. Some of the groundwater that discharges from the UHSU to streams and seeps evaporates as it is being discharged. The Site-wide Water Balance (SWWB) indicated that most of the precipitation component of recharge was lost to evapotranspiration (ET) demands (K-H, 2002c). ET removes groundwater from storage in either the unsaturated zone or the saturated zone.

In the western part of the Site, where the thickness of the Rocky Flats Alluvium may exceed 100 feet, the depth to the water table is 50 to 70 feet below the surface. The depth to water generally becomes shallower from west to east as the alluvial material thins and the underlying claystones are closer to the ground surface. At the head of stream drainages and along valley sides, seeps are common and occur at the base of the Rocky Flats Alluvium where it is in contact with claystones of the Arapahoe/Laramie Formations, and where the Arapahoe Formation sandstone crops out. In summary, the unconsolidated surficial materials are thicker in the western, higher elevations at the Site. Accordingly, the saturated thickness of these materials also thins eastward. The potentiometric surface of groundwater in permeable units of the UHSU has been mapped and is shown sitewide on Plates 3 and 4, and for the IA on Plates 5 and 6. The periods illustrated, spring and fall quarters, represent the times of year when static water levels are generally highest and lowest. Current areas of unsaturated and seasonally unsaturated alluvium and colluvium are indicated in the north/central IA, and east, northeast, and southeast of the IA.

Groundwater in the Arapahoe Formation sandstone units, which subcrop beneath the alluvial material, is not confined when in contact with the surficial materials. In this setting, a hydraulic connection exists between the bedrock sandstone and the alluvial material allowing the bedrock groundwater to exist under unconfined conditions as part of the UHSU. The subcropping Arapahoe Formation No. 1 Sandstone, located in the eastern portion of the IA and in the area between South Walnut Creek and Woman Creek, is part of the UHSU (EG&G, 1991a). The upper discontinuous sandstones of the Laramie Formation also subcrop beneath alluvium and colluvium, but in limited areas in the valleys and along valley slopes. Groundwater in the lenticular sandstone units of the Laramie Formation occurs under confined conditions over scattered areas of the Site.

Groundwater levels in UHSU wells fluctuate in response to seasonal recharge events. Of the wells that are not dry during at least one of the quarterly sampling events, approximately half cannot yield sufficient water volume (approximately 4.5 gallons) necessary for well purging and collection of a full suite of laboratory samples. As a result, sampling crews must return after wells have recovered to obtain additional sample volume.

1.2.4.3 Groundwater Flow

The shallow groundwater flow regime at the Site is illustrated by the configuration of potentiometric contours in Plates 3 and 4. These maps indicate that groundwater flow is largely controlled by the topography of the bedrock surface, which is generally reflected by the topography of the ground surface. Shallow (UHSU) groundwater flow on a regional scale is primarily lateral because of the low permeability of the underlying claystone bedrock (i.e., conductivity contrast between UHSU material and unweathered bedrock) but locally can be controlled by many factors. Groundwater on the ridge tops generally flows toward the east with flow off the ridge tops to the north-northeast and south-southeast. In areas where the ridge tops are bisected by east-northeast trending stream drainages, groundwater flows to the north or south toward the bottom of the valleys. In the valley bottoms, groundwater flows to the east, generally following the course of the stream.

The potential for vertical groundwater flow is limited by the low permeability of bedrock claystones, as indicated by the presence of strong downward vertical hydraulic gradients between the UHSU and underlying bedrock units. This is evidence of poor hydraulic communication. For example, vertical gradients on the order of 0.79 to 1.05 ft/ft have been calculated between colluvium and bedrock sandstones. The vertical groundwater velocity through claystones is estimated to be small, on the order of 10^{-10} to 10^{-7} cm/sec, based on calculations provided in RMRS (1996a). Fracturing, where evident, is most abundant in the weathered bedrock zone and is observed to decrease with depth in unweathered bedrock. Preferential vertical groundwater flow and contaminant transport along fractures or fault zones does not appear to represent a viable pathway for contaminant migration based on an assessment of available data (RMRS, 1996a).

1.2.4.4 Hydraulic Conductivity

The UHSU at the Site has a relatively low to moderate hydraulic conductivity that typically yields small amounts of water to groundwater monitoring wells. The UHSU exhibits a wide range of hydraulic conductivities because of the diverse nature of the individual geologic units that comprise this unit. Summary statistics for UHSU hydraulic conductivities (EG&G, 1995c; Table G-2) indicate a range of 5.0×10^{-2} cm/sec to 3.0×10^{-8} cm/sec. The individual units of the UHSU are listed in order of decreasing "average" geometric mean hydraulic conductivity: valley-fill alluvium (9.197×10^{-4} cm/sec); Arapahoe No. 1 sandstone (7.88×10^{-4} cm/sec); Rocky Flats Alluvium (4.18×10^{-4} cm/sec); colluvium (9.33×10^{-5} cm/sec); weathered Laramie Formation sandstones (3.89×10^{-5} cm/sec); and weathered Laramie Formation claystones (8.82×10^{-7} cm/sec).

Hydraulic conductivities for LHSU materials are generally the lowest measured at the Site with geometric mean values for individual lithologic groups ranging from 1.6×10^{-7} to 5.8×10^{-7} cm/sec (EG&G, 1995c; Table G-2).

In summary, the following major geologic and hydrologic parameters influence groundwater flow at the Site (EG&G, 1995a; 1995b):

(1) The surface waters of the upslope drainage basin in part recharge groundwater and the three principal streams draining the Site. The majority of shallow groundwater is intercepted by these drainages.

(2) The semi-arid climate limits the amount of precipitation available for groundwater recharge. The lithology and permeability of the unconsolidated surficial deposits permit meteoric waters to recharge the water table in the cooler times of the year (during low ET) and during extended precipitation events. The water table is contained in these surface deposits and weathered bedrock.

(3) Paleotopography of the bedrock pediment, which is less permeable than the overlying unconsolidated surficial deposits, serves to direct groundwater movement along bedrock "lows."

(4) Paleoweathering of shallow bedrock materials has enhanced the permeability of the upper 10 to 60 feet relative to unweathered bedrock.

(5) The permeability of bedrock units, composed primarily of claystone with lesser amounts of siltstone and sandstone, is generally several orders of magnitude less than that for unconsolidated surficial deposits.

The 600 plus feet of unweathered, upper Laramie Formation claystone bedrock between the shallow groundwater flow system and deep regional Laramie-Fox Hills aquifer provides an effective aquitard that restricts downward vertical groundwater flow and contaminant transport (RMRS, 1996a).

1.3 Environmental History

Processing and fabrication of weapons-related components began at the Site in 1952 and continued through 1989. Fabrication of stainless steel components continued in one building, however, through the early 1990's. During operation, environmental protection measures were established that at the time seemed consistent with prudent environmental management. However, some activities resulted in the environmental contamination of portions of the Site. Efforts to document the extent of Site contamination became a major focus in the 1980s and continue today in accordance with the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the RFCA, a cooperative agreement between U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and Colorado Department of Public Health and Environment (CDPHE). In addition, a historical release report (HRR) (DOE, 1992a) has been developed that documents contamination arising from past practices. The HRR is updated on an annual basis with the knowledge gained from ongoing monitoring and investigative activities. These annual updates are submitted to the EPA and CDPHE as addenda to the original document.

Documented areas of soil contamination have been designated as Individual Hazardous Substance Sites (IHSSs). Many of these IHSSs have been characterized as part of the Remedial Investigation/Feasibility Study (RI/FS) process which was conducted under the Interagency Agreement (IAG, 1991) between DOE, CDPHE and EPA. Some IHSSs have already been remediated and Environmental Restoration, in accordance with a Site environmental remediation priority ranking system, currently schedules others for remediation.

Groundwater investigations at the Site have determined that some IHSSs have released hazardous and radionuclide contaminants to groundwater. The most widespread contamination is that of volatile organic compounds (VOCs). Plate 13 shows the distribution of VOC contamination in the UHSU. Plume definition is inexact, however, because of limitations in well coverage, sampling frequency, variability of hydrostratigraphic conditions, local variations in groundwater velocity, and uncertainty regarding some source area locations. Previously published plume maps for VOCs can be found in previous RFCA Annual Reports (RMRS, 1997e; DOE, 1998b; RMRS, 1999m and 2000d; and SSOC, 2001a), annual RCRA Groundwater reports (EG&G, 1992; 1993c; 1994b; 1995d; and RMRS/K-H, 1996), the Well Evaluation Report (EG&G, 1994a), and in individual Operable Unit RI/RFI reports.

Compared to all other contaminants, groundwater VOC plumes at RFETS have the greatest potential to impact surface water, based on spatial distribution, mobility, and concentration considerations. These plumes have been defined on the basis of concentration values above the RFCA Tier II action level. Tier I and Tier II action levels at RFETS are derived from regulated maximum concentration limits (MCLs). Tier II action levels equal the MCLs; to delineate areas of very high groundwater VOC concentrations, Tier I action levels equal 100 x Tier II action levels.

Plate 13 presents the distribution of some of the most common VOC contaminants in groundwater at RFETS. The most likely sources of VOC contamination were identified using the results of recent field sampling programs and knowledge of Site processes (see RMRS, 1996b). Contaminants besides VOCs are also addressed when their distribution indicates that there is a potential impact to surface water.

Six VOC groundwater contaminant plumes have historically been identified where contaminant concentrations are above Tier I action levels. These groundwater contaminant plumes include the IHSS 119.1 Plume, Mound Plume, 903 Pad/Ryan's Pit Plume, Carbon Tetrachloride Plume, East Trenches Plume, and Industrial Area Plume. In addition, there is a plume with contaminant concentrations above Tier II action levels that has the potential to impact surface water. This VOC plume is associated with the Present Landfill and the Property Utilization and Disposal (PU&D) Yard.

In addition to the VOC plumes, there is a nitrate and uranium plume that emanates from the Solar Ponds. There are also some isolated point sources with constituents that are above Tier II action levels. These are being evaluated on a case by case basis.

1.3.1 Rocky Flats Cleanup Agreement

The RFCA was officially adopted on July 19, 1996 (RFCA, 1996). The RFCA replaces the IAG as the environmental cleanup agreement for RFETS. The RFCA outlines the goals, objectives, and strategies that will lead to the RFETS cleanup and closure mission objectives. The Action Level Framework (ALF) attachment to the RFCA contains specific requirements for environmental monitoring and reporting, and it sets action levels for contaminant concentrations in groundwater (identified in Section 1.3.2) and in other media. The IMP is required under RFCA to further define the monitoring programs for the Site.

To align the groundwater-monitoring program with the new RFETS mission and RFCA requirements, the monitoring network was evaluated in 1996. A data quality objective (DQO) process was used to determine what decisions were necessary for groundwater and the function of each well in the network in supporting those decisions. DOE, CDPHE, EPA, and stakeholders were directly involved in decisions involving the monitoring network. Results of this evaluation are presented in the IMP, which is discussed below.

1.3.2 Integrated Monitoring Plan for Groundwater

The IMP is a summary document that outlines the goals for groundwater monitoring (and other environmental media), and describes the various components of the groundwater monitoring program (K-H, 2000a). Factors influencing groundwater-monitoring requirements include the RFCA ALF for groundwater, the Site history and areas of contamination, the physical and hydrogeologic setting of the Site, the effect of contaminated areas on groundwater, and the nature of the groundwater contaminant plumes. This information is presented in the IMP Background Document (K-H, 2000b), and Appendices A, B, C, and D of the groundwater section of the IMP

Background Document. Appendix E of the groundwater section lists the wells that will be monitored for water quality or groundwater flow.

In the past, two plans were required at RFETS to comply with DOE Order 5400.1 (DOE, 1988; Page III-2), a Groundwater Protection & Management Program Plan and a Groundwater Monitoring Plan. These two plans were historically combined into one document, the Groundwater Protection and Monitoring Program Plan (GPMPP) (EG&G, 1993d), which defines and describes the groundwater protection and monitoring programs at the Site. In addition, an assessment groundwater-monitoring plan was required under RCRA for the interim status units on Site. This plan was called the Groundwater Assessment Plan (GWAP) (DOE, 1993a). Other monitoring plans were developed to address groundwater monitoring requirements as outgrowths of various CERCLA Interim Measure/Interim Remedial Action (IM/IRA) decision documents.

The IMP serves as the Groundwater Monitoring Plan for the Site and it replaces the group of plans named above. It also revises the requirements of the routine groundwater monitoring portion of the IA IM/IRA Decision Document (DOE 1994b) and the French Drain Performance Monitoring Plan (DOE, 1992c). The original IMP was published in May 1997. The IMP and IMP Background Document are updated annually with any changes to the monitoring programs.

Groundwater reporting has been integrated under the IMP. Four quarterly reports are produced annually that document concentration values above RFCA action levels. Also documented are changes in water quality for wells not monitored for comparison to action levels. A RFCA Annual Groundwater Monitoring Report is also required to summarize all actions taken for groundwater compliance within each calendar year.

For confirmed values above action levels and Site background in the designated program monitoring wells, an evaluation of impact to surface water is required. These evaluations are determined on a case by case basis, depending on the data requirements necessary to perform an impact analysis. Section 8.0 of this report discusses the status of the current evaluations that were implemented based on elevated concentrations in groundwater.

The groundwater monitoring network, as defined in the IMP (K-H, 2000a), has eight categories of monitoring wells. Table 1-1 identifies the wells in the current monitoring program. Table 1-2 presents the analytical suites associated with each well in the program and is found at the end of Section 1.0. The decision rules presented in the original IMP have been retained for determining Tier I and II exceedances of groundwater action levels. The well types and decision rules are defined below.

Boundary (B) Monitoring Wells

These wells monitor groundwater leaving the eastern Site boundary. A reportable exceedance occurs if a measured concentration is above both a Tier II action level **and** the background Mean plus 2 Standard Deviations (M2SDs). When there is no historical data, **or** a value is greater than the M2SD of the historical concentration in a well at which there have been historical exceedances of Tier II action levels, the required action is to initiate monthly

sampling for that analyte. Appropriate parties (DOE, CDPHE and EPA) are notified and possible impacts to surface water are evaluated if contaminant levels are above action levels, by the above criteria, for three consecutive months.

D&D (DD) Monitoring Wells

These wells monitor for releases to groundwater from D&D activities. A concentration value is reportable when a measured concentration is above the M2SD of the established historical baseline concentration downgradient of the building(s). The required action is to inform appropriate parties and initiate an evaluation of the situation.

Table 1-1 IMP Wells

Well No	Frequency	Class	Plume/Area	Formation	Purpose
00100	Semiannual	DD	Building 779	AL/BD	D & D Monitoring for Building 779
00197	Semiannual	PE	Old Landfill	AL	Plume Extent well monitoring the Industrial Area Plume
00200	Semiannual	DD	Building 707	AL/BD	D & D Monitoring for Building 707
00297	Semiannual	PD	Solar Ponds	AL	Plume Definition well monitoring the southern migration of the Solar Ponds Plume
00300	Semiannual	DD	Building 707	AL/BD	D & D Monitoring for Building 707
00397	Semiannual	PE	PU&D	AL	Plume Extent well monitoring the PU&D Yard Plume
00400	Semiannual	DD	Building 776/777	AL/BD	D & D Monitoring for Building 776/777 Complex
00491	Semiannual	PD	903 Pad	BD/UHSU	Plume Definition well monitoring the 903 Pad VOC Plume
00500	Semiannual	DD	Building 776/777	AL/BD	D & D Monitoring for Building 776/777 Complex
00597	Semiannual	PD	PU&D/Landfill	AL	Plume Definition well monitoring the Landfill/PU&D yard Plume
00600	Semiannual	DD	Building 776/777	AL/BD	D & D Monitoring for Building 776/777 Complex
00700	Semiannual	DD	Building 776/777	AL/BD	D & D Monitoring for Building 776/777 Complex
00797	Semiannual	PM	881 Hillside	AL	Performance Monitoring for 881 Footing Drain Sump
00897	Semiannual	PM	Mound	BD/UHSU	Performance Monitoring on the Mound Source remediation
00997	Semiannual	D	NA	AL	Drainage well below Pond B-4 in South Walnut Creek Drainage
01097	Semiannual	PA	PU&D/Landfill	AL	Plume Degradation well monitoring upgradient of the Landfill/PU&D Yard Plume
01497	Semiannual	PA	PU&D	AL	Plume Degradation well monitoring the PU&D Yard Plume
01697	Semiannual	PE	PU&D	AL	Plume Extent well monitoring the PU&D Yard Plume
02291	Semiannual	PM	Mound	BD/UHSU	Performance Monitoring on the Mound Source remediation
02397	Semiannual		Building 779	AL	D&D monitoring upgradient of Building 779
02497	Semiannual	DD	Building 779	AL	D&D monitoring downgradient of Building 779
02500	Semiannual	DD	Building 779	AL/BD	D&D monitoring downgradient of Building 779
0386	Semiannual	B	Boundary	BD/UHSU	Boundary Well – in small drainage north of the east access gate

Well No	Frequency	Class	Plume/Area	Formation	Purpose
03991	Semiannual	PD	East Trenches	AL	Plume Definition well monitoring the East Trenches Plume
04091	Semiannual	PE	East Trenches	AL	Plume Extent well monitoring the northward migration of the East Trenches Plume
04591	Semiannual	PE	East Trenches	AL	Plume Extent well monitoring the southward migration of the East Trenches Plume
0487	Semiannual	PD	881 Hillside	AL	Plume Definition well for the 881 Hillside Plume
04991	Semiannual	PE	East Trenches	AL	Plume Extent well monitoring the eastward migration of the East Trenches Plume
05091	Semiannual	PE	East Trenches	AL	Plume Extent well monitoring the eastward migration of the East Trenches Plume
05391	Semiannual	PD	East Trenches	AL	Plume Definition well monitoring eastward concentration of VOCs from the East Trenches Plume
05691	Semiannual	PM	East Trenches	AL	Performance Monitoring well monitoring effects of remediation downgradient of Trench T-4
06091	Semiannual	PE	East Trenches	AL/BD	Plume Extent well monitoring the northeast migration of the East Trenches Plume
06491	Semiannual	B	Boundary	BD/UHSU	Boundary Well – in small drainage east of RFETS at Indiana St.
07391	Semiannual	PM/PA	903 Pad/Ryan's Pit	AL/BD	Performance Monitoring/Plume Degradation well monitoring effects of remediation of Ryan's Pit
08091	Semiannual	PE	Mound/E. Trench	AL	Plume Extent well monitoring the southern migration of Mound and East Trenches Plumes
1187	Semiannual	PA	903 Pad/Ryan's Pit	BD/UHSU	Plume Degradation well monitoring the southern migration of the 903 Pad/Ryan's Pit Plume
1386	Quarterly	PE/PM	Drainage/ Solar Ponds	AL	Performance Monitoring – SEP Treatment System, Plume Extent Monitoring for Solar Ponds Plume
1786	Quarterly	PE/PM	Solar Ponds	AL	Performance Monitoring – SEP Treatment System, Plume Extent Monitoring for Solar Ponds Plume
1986	Semiannual	PE	Industrial Area	AL	Plume Extent well monitoring the northern migration of the IA Plume
2186	Semiannual	PE	Industrial Area	BD/UHSU	Plume Extent well monitoring the northern migration of the IA Plume
3386	Semiannual	PE	Solar Ponds	AL	Plume Extent well monitoring the southern migration of the SEP Nitrate and VOC Plumes
3586	Semiannual	PE/PM	Mound	AL	Plume Extent well tracking migration of Solar Ponds nitrate Plume
3687	Semiannual	PM	East Trenches	BD/UHSU	Performance Monitoring well monitoring effects of remediation downgradient of Trench T-4
4087	Quarterly	RCRA	Landfill	AL	RCRA/Plume Extent well monitoring downgradient of Present Landfill
4787	Semiannual	PE	881 Hillside	AL	Plume Extent south of the 881 Hillside Plume
4887	Semiannual	PE	881 Hillside	AL	Plume Extent south of the 881 Hillside Plume
5187	Semiannual	DD	Building 881	AL	D & D Monitoring for Building 881
5387	Semiannual	PE	881 Hillside	AL	Plume Extent south of the 881Hillside Plume
5587	Semiannual	D	NA	AL	Drainage well monitoring the Woman Cr. Drainage south of the 881 Hillside Plume

Well No	Frequency	Class	Plume/Area	Formation	Purpose
5887	Quarterly	RCRA	PU&D/Landfill	AL	RCRA upgradient/ Plume Extent well monitoring the PU&D Yard Plume and Present Landfill
6186	Semiannual	PE	Industrial Area	AL	Plume Extent well monitoring eastward migration of IA Plume
6286	Semiannual	PD	903 Pad	BD/USHU	Plume Definition well monitoring pathway to Woman Cr. In the 903 Pad/Ryan's Pit Plume
6386	Semiannual	PD	903 Pad	AL	Plume Definition well monitoring pathway to Woman Cr. In the 903 Pad/Ryan's Pit Plume
6486	Semiannual	D	NA	AL	Drainage well monitoring the Woman Creek drainage downgradient of the 881 Hillside Plume
6586	Semiannual	D	NA	AL	Drainage well monitoring the N side of Woman Creek below 903Pad/Ryans Pit Plume
7086	Semiannual	PE	IA/Old Landfill	AL	Plume Extent well monitoring IA Plume and Old Landfill Plume pathway in Woman Cr.
10098	Semiannual	DD	Building 123	AL	D & D Monitoring for Building 123
10194	Semiannual	PE	East Trenches	AL	Plume Extent well monitoring the southern migration of the East Trenches Plume
10198	Semiannual	DD	Building 123	AL	D & D Monitoring for Building 123
10294	Semiannual	B	Boundary	AL	Boundary Well – in drainage below Pond D-2 in the southeast corner of the Site
10298	Semiannual	DD	Building 123	AL	D & D Monitoring for Building 123
10394	Semiannual	B	Boundary	AL	Boundary Well – in the Woman Cr. Drainage at the Indiana Street Boundary
10398	Semiannual	DD	Building 123	AL	D & D Monitoring for Building 123
10498	Semiannual	DD	Building 123	AL	D & D Monitoring for Building 123
10592	Semiannual	PM	881 Hillside	AL	Performance Monitoring for the French Drain
10598	Semiannual	DD	Building 123	AL	D & D Monitoring for Building 123
10692	Semiannual	PM	881 Hillside	AL	Performance Monitoring for the French Drain
10792	Semiannual	PM	881 Hillside	AL	Performance Monitoring for the French Drain
10992	Semiannual	PM	881 Hillside	AL	Performance Monitoring for the French Drain
10994	Semiannual	PE	IA/Old Landfill	AL	Plume Extent IA VOA Plume/Old Landfill Plume near Woman Creek
11092	Semiannual	PM	881 Hillside	AL	Performance Monitoring for the French Drain
11791	Semiannual	PA	903 Pad/Ryan's Pit	AL/BD	Plume Degradation well monitoring the southern migration of the 903 Pad/Ryan's Pit Plume
11891	Semiannual	PM	East Trenches	BD/UHSU	Performance Monitoring well monitoring effects of remediation downgradient of Trench T-3
12191	Semiannual	PM	East Trenches	BD/UHSU	Performance Monitoring at edge of T3 soil excavation
12691	Semiannual	PM	East Trenches	BD/UHSU	Performance Monitoring well monitoring effects of remediation downgradient of Trench T-4
15599	Semiannual	PM	Mound	AL	Performance Monitoring for the Mound groundwater treatment system
15699	Semiannual	PM	Mound	AL	Performance Monitoring for the Mound groundwater treatment system
15799	Semiannual	PM	Mound	AL	Performance Monitoring for the Mound groundwater treatment system
18199	Semiannual	PA/DD	IHSS 118.1/B771	AL	Plume Degradation well monitoring the IHSS 118.1 plume and D&D monitoring for Building 771 Complex

Well No	Frequency	Class	Plume/Area	Formation	Purpose
18399	Semiannual	PA	IHSS 118.1	AL	Plume Degradation well monitoring the IHSS 118.1 plume
18499	Semiannual	PA	IHSS 118.1	AL	Plume Degradation well monitoring the IHSS 118.1 plume
18799	Semiannual	PA	IHSS 118.1	AL	Plume Degradation well monitoring the IHSS 118.1 plume
20998	Semiannual	DD	Building 771	AL	D & D Monitoring for Building 771 Complex
21098	Semiannual	PE	IHSS 118.1	AL	Plume Extent well monitoring the IHSS 118.1 plume
22596	Semiannual	PE	Industrial Area	AL	Plume Extent well monitoring the northern migration of the IA Plume
22696	Semiannual	PE	Industrial Area	AL	Plume Extent well monitoring the westward migration of the IHSS 118.1 Plume
22796	Semiannual	PE	Industrial Area	AL	Plume Extent well monitoring the northern migration of the IHSS 118.1 Plume
22896	Semiannual	PD	Industrial Area	AL	Plume Definition well monitoring the northward extent of the Tier I part of IA VOA Plume
22996	Semiannual	DD	Building 886	AL	D & D Monitoring for Building 886
23096	Semiannual	PE	903 Pad	AL	Plume Extent well monitoring the southern migration of the Ryan's Pit – OU2 VOA Plume
23296	Semiannual	PE/PM	East Trenches	AL	Plume Extent/Performance Monitoring well monitoring the East Trenches Treatment System
30100	Semiannual	PE	PU&D	AL	Plume Extent well monitoring the PU&D Yard Plume
30900	Semiannual	PA	PU&D	AL	Plume Degradation well monitoring the PU&D Yard Plume
37101	Semiannual	DD	Building 371/374	AL/BD	D & D Monitoring for Building 371/374 Complex
37201	Semiannual	DD	Building 371/374	AL/BD	D & D Monitoring for Building 371/374 Complex
37301	Semiannual	DD	Building 371/374	AL/BD	D & D Monitoring for Building 371/374 Complex
37402	Semiannual	DD	Building 371/374	AL/BD	D & D Monitoring for Building 371/374 Complex
37501	Semiannual	DD	Building 371/374	AL/BD	D & D Monitoring for Building 371/374 Complex
37601	Semiannual	DD	Building 371/374	AL/BD	D & D Monitoring for Building 371/374 Complex
37701	Semiannual	DD	Building 371/374	AL/BD	D & D Monitoring for Building 371/374 Complex
37791	Semiannual	DD	Building 881	AL	D & D Monitoring for Building 881
38591	Semiannual	D	NA	AL	Drainage well in Woman Creek drainage below 881 Hillside
39691	Semiannual	DD	Building 881	AL/BD	D & D Monitoring for Building 881
40099	Semiannual	DD	Building 444	AL/BD	D & D Monitoring for Building 444 Complex
40199	Semiannual	DD	Building 444	AL/BD	D & D Monitoring for Building 444 Complex
40299	Semiannual	DD	Building 444	AL/BD	D & D Monitoring for Building 444 Complex
40399	Semiannual	DD	Building 444	AL/BD	D & D Monitoring for Building 444 Complex
40499	Semiannual	DD	Building 444	AL/BD	D & D Monitoring for Building 444 Complex
40599	Semiannual	DD	Building 771	AL/BD	D & D Monitoring for Building 771 Complex
40699	Semiannual	DD	Building 771	AL/BD	D & D Monitoring for Building 771 Complex
40799	Semiannual	DD	Building 771	AL/BD	D & D Monitoring for Building 771 Complex
40899	Semiannual	DD	Building 771	AL/BD	D & D Monitoring for Building 771 Complex
40999	Semiannual	DD	Building 886/865	AL/BD	D & D Monitoring for Buildings 886 and 865
41099	Semiannual	DD	Building 886	AL/BD	D & D Monitoring for Building 886
41199	Semiannual	DD	Building 886	AL/BD	D & D Monitoring for Building 886
41299	Semiannual	DD	Building 444	AL/BD	D & D Monitoring for Building 444 Complex
41499	Semiannual	DD	Building 771	AL/BD	D & D Monitoring for Building 771 Complex

Well No	Frequency	Class	Plume/Area	Formation	Purpose
41591	Semiannual	B	Boundary	AL	Boundary Well – in small drainage near east access gate
41599	Semiannual	DD	Building 771	AL/BD	D & D Monitoring for Building 771 Complex
41691	Semiannual	B	Boundary	AL	Boundary Well – in the Walnut Cr. Drainage at the Indiana Street Boundary
43392	Semiannual	PE	Industrial Area	AL	Plume Extent well monitoring southward migration of IA Plume
52894	Quarterly	RCRA	Landfill	AL	RCRA/Plume Extent well monitoring downgradient of Present Landfill
52994	Quarterly	RCRA	Landfill	AL	RCRA/Plume Extent well monitoring downgradient of Present Landfill
55901	Semiannual	DD	Building 559	AL/BD	D & D Monitoring for Building 559
56001	Semiannual	DD	Building 559	AL/BD	D & D Monitoring for Building 559
56101	Semiannual	DD	Building 559	AL/BD	D & D Monitoring for Building 559
56201	Semiannual	DD	Building 559	AL/BD	D & D Monitoring for Building 559
56301	Semiannual	DD	Building 559	AL/BD	D & D Monitoring for Building 559
60299	Semiannual	DD	Building 776/777	AL/BD	D & D Monitoring for Building 776/777 Complex
60499	Semiannual	DD	Building 707	AL/BD	D & D Monitoring for Building 707
60599	Semiannual	DD	Building 707	AL/BD	D & D Monitoring for Building 707
60699	Semiannual	DD	Building 707	AL/BD	D & D Monitoring for Building 707
61099	Semiannual	DD	Building 883	AL/BD	D & D Monitoring for Building 883
61199	Semiannual	DD	Building 883	AL/BD	D & D Monitoring for Building 883
61499	Semiannual	DD	Building 707	AL/BD	D & D Monitoring for Building 707
70099	Quarterly	PM	Solar Ponds	AL/BD	Performance Monitoring of groundwater treatment system below Solar Pond
70193	Quarterly	RCRA	PU&D/Landfill	BD/UHSU	RCRA upgradient/Plume Extent well monitoring the Present Landfill
70299	Quarterly	PM	Solar Ponds	AL/BD	Performance Monitoring of groundwater treatment system below Solar Ponds
70393	Quarterly	RCRA	PU&D/Landfill	AL	RCRA upgradient /Plume Definition well monitoring the edge of the PU&D Yard Plume
70493	Quarterly	RCRA	PU&D	BD/UHSU	RCRA upgradient/Plume Definition well monitoring the edge of the PU&D Yard Plume
70693	Semiannual	PA	PU&D/Landfill	AL	Plume Degradation well monitoring the Landfill/PU&D Yard Plume
75992	Semiannual	PE	Mound/East Trench	AL	Plume Extent well monitoring So. Walnut Cr. Drainage below Mound Site Plume
76992	Semiannual	PE	PU&D/Landfill	AL	Plume Extent well monitoring the eastward migration of the PU&D Yard/Landfill Plume
77392	Semiannual	PD	Landfill	AL	Plume Definition well monitoring the eastward migration of the PU&D Yard Plume
83101	Semiannual	DD	Building 883/881	AL/BD	D & D Monitoring for Buildings 883 and 881
83201	Semiannual	DD	Building 883	AL/BD	D & D Monitoring for Building 883
86501	Semiannual	DD	Building 865	AL/BD	D & D Monitoring for Building 865
86601	Semiannual	DD	Building 865	AL/BD	D & D Monitoring for Building 865
86701	Semiannual	DD	Building 865	AL/BD	D & D Monitoring for Building 865
88101	Semiannual	DD	Building 881	AL/BD	D & D Monitoring for Building 881
90099	Semiannual	PA	903 Pad/Ryan's Pit	AL/BD	Plume Degradation well monitoring the southern migration of the 903 Pad/Ryan's Pit Plume
90199	Semiannual	PE	903 Pad/Ryan's Pit	AL/BD	Plume Extent well monitoring the southern migration of the 903 Pad/Ryan's Pit Plume

Well No	Frequency	Class	Plume/Area	Formation	Purpose
90299	Semiannual	PE	903 Pad/Ryan's Pit	AL/BD	Plume Extent well monitoring the southern migration of the 903 Pad/Ryan's Pit Plume
90399	Semiannual	PA	903 Pad/Ryan's Pit	AL/BD	Plume Degradation well monitoring the southern migration of the 903 Pad/Ryan's Pit Plume
95099	Semiannual	PM	East Trenches	AL	Performance Monitoring of groundwater treatment system below East Trenches
95199	Semiannual	PM	East Trenches	AL	Performance Monitoring of groundwater treatment system below East Trenches
95299	Semiannual	PM	East Trenches	AL/BD	Performance Monitoring of groundwater treatment system below East Trenches
99101	Semiannual	DD	Building 991	AL/BD	D & D Monitoring for Building 991
99201	Semiannual	DD	Building 991	AL/BD	D & D Monitoring for Building 991
99301	Semiannual	DD	Building 991	AL/BD	D & D Monitoring for Building 991
99401	Semiannual	DD	Building 991	BD/UHSU	D & D Monitoring for Building 991
B206989	Quarterly	RCRA	Landfill	BD/UHSU	RCRA/Plume Extent well monitoring downgradient of Present Landfill
B208289	Semiannual	PE	Solar Ponds	BD/UHSU	Plume Extent well monitoring the northeast migration of the SEP Nitrate Plume
B208789	Semiannual	PE	Solar Ponds	AL	Plume Extent well monitoring the northeast migration of the SEP Nitrate Plume
P114389	Semiannual	PE	Industrial Area	AL	Plume Extent well to monitor extent of Industrial Area plume pathway to Walnut Creek
P209289	Semiannual	PD	IHSS 118.1	AL	Plume Definition well for IHSS 118.1
P209389	Semiannual	PD	IHSS 118.1	BD	Plume Definition well for IHSS 118.1
P209489	Semiannual	PD	Solar Ponds	BD/UHSU	Plume Definition well for IHSS 118.1
P218089	Semiannual	DD	Building 707	AL	D & D Monitoring for Building 707
P218389	Semiannual	PE	Solar Ponds	AL	Plume Extent well monitoring the northern migration of the SEP Nitrate Plume
P219089	Semiannual	DD	Building 771	AL/BD	D & D Monitoring for Building 771 Complex
P219189	Semiannual	PD	IHSS 118.1	AL	Plume Definition well for IHSS 118.1
P219489	Semiannual	PE	Solar Ponds	AL	Plume Extent well monitoring the northern migration of the SEP Nitrate Plume
P313589	Semiannual	PE	Industrial Area	AL	Plume Extent to monitor the eastward migration of IA Plume near Building 881
P314289	Semiannual	PE	Industrial Area	AL	Plume Extent to monitor the southern migration of IA Plume near Building 850
P317989	Semiannual	DD	Building 886/865	AL	D & D Monitoring for Buildings 886 and 865
P416689	Semiannual	PE	Industrial Area	AL	Plume Extent to monitor southern migration of IA Plume south of Building 440
P416789	Semiannual	PD	Industrial Area	AL	Plume Definition of IA Plume south of 400 area along pathway to Woman Creek
P416889	Semiannual	PD	Industrial Area	AL	Plume Definition of IA Plume south of Building 664 along pathway to Woman Creek
P419689	Semiannual	DD	Building 444	AL/BD	D & D Monitoring for Building 444 Complex
891COL WEL	Quarterly	PM	881 Hillside	AL	Performance Monitoring of groundwater in collection well on 881 Hillside
ETP ef	Semiannual	PM	East Trenches	NA	Performance Monitoring of groundwater treatment system below East Trenches
ETP in	Semiannual	PM	East Trenches	NA	Performance Monitoring of groundwater treatment system below East Trenches

Well No	Frequency	Class	Plume/Area	Formation	Purpose
R1-0	Semiannual	PM	Mound	NA	Performance Monitoring of groundwater treatment system below Mound
R2-E	Semiannual	PM	Mound	NA	Performance Monitoring of groundwater treatment system below Mound
371-Basement	Semiannual	DD	Building 371/374	NA	D & D Monitoring for Building 371/374 Complex at foundation drain outfall
371-Sub-Basement	Semiannual	DD	Building 371/374	NA	D & D Monitoring for Building 371/374 Complex at foundation drain outfall
FD-559/561	Semiannual	DD	Building 559	NA	D & D Monitoring for Building 559 at foundation drain access point
FD-707-4	Semiannual	DD	Building 707	NA	D&D Monitoring for Building 707 at foundation drain access point
771FDOut #2	Semiannual	DD	Building 771	NA	D&D Monitoring for Building 771 at foundation drain outfall
BS-865-2	Semiannual	DD	Building 865	NA	D & D Monitoring for Building 865 at foundation drain access point
SW099	Quarterly	PM	Landfill	PM	Performance Monitoring of groundwater intercept system below Present Landfill
SW100	Quarterly	PM	Landfill	PM	Performance Monitoring of groundwater intercept system below Present Landfill
SW13494	Quarterly	DD	Building 881	NA	D&D Monitoring for Building 881

Plume Definition (PD) Monitoring Wells

These wells are located within known contaminant plumes and produce samples with contaminant concentrations which are above Tier II action levels, but are below the Tier I action levels established in the ALF. A value is reportable when a measured concentration is above all of the following: a Tier I action level, the background M2SD, **and** the M2SD of the historical concentration in the well. The required action is to reclassify the well as a Tier I reportable well and evaluate possible impacts to groundwater.

Plume Extent (PE) Monitoring Wells

These wells are located at the edges of known groundwater contaminant plumes, along pathways to surface water, and monitor for an increase in concentrations that may result in future impacts to surface water. A value is reportable if a measured concentration is above a Tier II action level **and** the background M2SD. When there is no historical data, **or** a value is greater than the M2SD of the historical concentration in a well at which there have been historical values above Tier II action levels, the required action is to initiate monthly sampling. Appropriate parties are notified and possible impacts to surface water are evaluated if contaminant levels are above action levels, by the above criteria, for three consecutive months.

Drainage (D) Monitoring Wells

These wells are located in stream drainages, downgradient of contaminant plumes. They have the same reporting requirements as PE wells under the IMP. That is, a value is reportable when a measured concentration is above the Tier II action level and the background M2SD. When there are no historical data, **or** a value is greater than the

M2SD of the historical concentration in a well at which there have been historical values above Tier II action levels, the required action is to initiate monthly sampling. Appropriate parties are notified and possible impacts to surface water are evaluated if values are above action levels, by the above criteria, for three consecutive months.

Performance Monitoring (PM) Wells

These wells monitor the effect of a remediation or source removal action, as required in the ALF. If an increasing trend in the concentration of a contaminant is noted, then the appropriate parties are notified and an evaluation of the situation is initiated.

RCRA Monitoring Wells

These wells monitor upgradient and downgradient groundwater contaminant concentrations at RCRA units. If the mean concentration of a contaminant in a downgradient well is greater than the mean concentration in upgradient wells and concentrations at the well show an upward trend with time, a report will be made to appropriate agencies and an investigation will be initiated to investigate possible causes.

Plume Degradation (PA) Monitoring Wells

These wells monitor the downgradient portions of groundwater plumes or plume sources to establish whether natural processes are degrading (also called attenuating) the nature and extent of the plume prior to affected groundwater entering the surface water environment. In areas where monitoring can document a plume degradation process, other remediation activities may not be necessary. These wells differ from plume extent wells in that the analyte suite may include parameters that focus on measuring the degradation process. Also, evaluations of data from these wells would not only include concentration of contaminants but also the breakdown products from these contaminants. If significant plume degradation can be substantiated, then a non-remedial decision may be promulgated for the plume.

1.3.3 Changes to the Groundwater Monitoring Program

Additions to the Groundwater Monitoring Network

Wells have been added to the Site monitoring network based on the results or in support of groundwater evaluations, remediation activities, and closure activities. Plate 1 shows the locations of all existing monitoring wells at RFETS.

The Building D&D monitoring program was expanded with the addition of monitoring wells around Buildings 371/374, 883, 865, 881, 991 and 559. With this addition, all major buildings with the potential to impact groundwater quality have monitoring networks in place.

The largest programmatic improvement for groundwater has been in the evaluation of the Industrial Area VOC Plume. Evaluation of the Industrial Area Plume involved the installation of 14 wells in the interior of the plume to

identify the sources for the groundwater contamination such that multiple plumes may be identified. The results of this evaluation are reflected in plume maps for the IA VOCs (Section 8.2) and in the Composite VOC Plume map (Plate 13; Section 8.3) for the Site.

An evaluation was performed during the spring and summer of 2002 to determine if the Composite VOC Plume map should be constructed differently than had been done previously. Concerns revolved around presentation of data that represented a combination of new data and historic data. The decision was made to present the new plume configuration and a representative plume configuration from 1997. These changes will be reflected in the 2001 Composite VOC Plume map (Plate 13). See Section 8.3 of this 2001 Annual Report for a detailed discussion of the Composite VOC Plume map.

Given the large amount of new data with respect to the nature and extent of groundwater contamination at RFETS, a review of the groundwater-monitoring network will begin in FY02. The evaluation will be part of the Well Abandonment and Replacement Project, which will start in FY02. This project will help focus the abandonment of wells no longer necessary at RFETS for monitoring purposes. It is anticipated that changes will be proposed to the monitoring program based on this evaluation.

Removals from the Groundwater Monitoring Network

Wells are proposed for removal from the Site monitoring network either to facilitate improvements to the network, because of well damage, or because of closure activities. Well 02197 was removed from the program because of poor water production.

Table 1-2 Analyte Suites

Well Number	Frequency	Plume/Area	Drivers	VOC Suite	Metals Suite	Tritium	PU/AM	SR 89/90	Uranium	Nitrate	Fluoride	Sulfate	Cyanide	Cesium - 137	Chloride	Sulfide	TOC	Methane	Ethene	Water Quality Suite	Np-237	TPH	PCB
100	Semiannual	Bldg. 779		X	X		X		X	X													
197	Semiannual	Old Landfill	RFCA	X	X	X		X	X	X	X	X											
200	Semiannual	Bldg. 707		X	X		X		X												X		
297	Semiannual	Solar Ponds	RFCA, RCRA	X	X	X	X	X	X	X	X	X											
300	Semiannual	Bldg. 707		X	X		X		X												X		
397	Semiannual	PU&D	RFCA	X	X	X			X	X	X	X											
400	Semiannual	Bldg. 776/777		X	X	X	X		X	X													
491	Semiannual	903 Pad		X	X		X		X	X		X											
500	Semiannual	Bldg. 776/777		X	X	X	X		X	X													
597	Semiannual	PU&D/Landfill	RFCA	X	X	X			X	X	X	X											
600	Semiannual	Bldg. 776/777		X	X	X	X		X	X													
700	Semiannual	Bldg. 776/777		X	X	X	X		X	X													
797	Semiannual	881 Hillside	RFCA	X	X				X	X		X											
897	Semiannual	Mound		X	X		X		X	X													
997	Semiannual	Drainage	RFCA	X	X		X	X	X														
1097	Semiannual	PU&D		X						X		X			X	X	X		X				
1497	Semiannual	PU&D		X						X		X			X	X	X		X				
1697	Semiannual	PU&D	RFCA	X	X	X			X	X	X	X											
2097	Semiannual	PU&D		X						X		X			X	X	X		X				
2291	Semiannual	Mound		X	X		X		X	X													
2397	Semiannual	Bldg. 779		X	X		X		X	X													
2497	Semiannual	Bldg. 779	RFCA	X	X		X		X	X													
2500	Semiannual	Bldg. 779		X	X		X		X	X													
386	Semiannual	Boundary	RFCA, AIP	X	X	X	X		X	X	X	X											
3991	Semiannual	East Trenches	RFCA	X	X		X		X	X													
4091	Semiannual	East Trenches	RFCA	X	X		X		X	X													
4591	Semiannual	East Trenches	RFCA	X	X		X		X	X													
487	Semiannual	881 Hillside	RFCA	X	X				X	X		X											

Well Number	Frequency	Plume/Area	Drivers	VOC Suite	Metals Suite	Tritium	PU/AM	SR 89/90	Uranium	Nitrate	Fluoride	Sulfate	Cyanide	Cesium-137	Chloride	Sulfide	TOC	Methane	Ethene	Water Quality Suite	Np-237	TPH	PCB
4991	Semiannual	East Trenches	RFCA	X	X		X		X	X													
5091	Semiannual	East Trenches	RFCA	X	X		X		X	X													
5391	Semiannual	East Trenches		X	X		X		X	X													
5691	Semiannual	East Trenches		X	X		X		X	X													
6091	Semiannual	East Trenches	RFCA	X	X		X		X	X													
6491	Semiannual	Boundary	RFCA, AIP	X	X	X	X		X	X	X	X											
7391	Semiannual	903 Pad/Ryan's Pit		X	X		X		X	X		X			X	X	X	X	X				
8091	Semiannual	Mound/E. Trench	RFCA	X	X		X	X	X	X													
1187	Semiannual	903 Pad/Ryan's Pit		X						X		X			X	X	X	X	X				
1386	Quarterly**	Drainage/Solar Ponds	RFCA, RCRA	X	X	X	X	X	X+X (D&T)	X	X	X											
1786	Quarterly**	Solar Ponds	RFCA, RCRA	X	X	X	X	X	X+X (D&T)	X	X	X											
1986	Semiannual	Ind. Area	RFCA	X	X		X		X	X													
2186	Semiannual	Ind. Area	RFCA	X	X		X		X	X													
3386	Semiannual	Solar Ponds	RFCA, RCRA	X	X	X	X	X	X	X	X	X											
3586	Semiannual	Mound		X	X		X		X	X													
3687	Semiannual	East Trenches		X	X		X		X	X													
4087	Quarterly	Landfill	RFCA, RCRA	X	X	X			X	X	X	X											
4787	Semiannual	881 Hillside	RFCA	X	X				X	X		X											
4887	Semiannual	881 Hillside	RFCA	X	X				X	X		X											
5187	Semiannual	Bldg. 881		X	X		X		X	X													X*
5387	Semiannual	881 Hillside	RFCA	X	X				X	X		X											
5587	Semiannual	Drainage	RFCA	X	X			X	X	X		X											
5887	Quarterly	PU&D	RFCA, RCRA	X	X	X			X	X	X	X											
6186	Semiannual	Ind. Area	RFCA, IM/IRA for IA	X	X		X		X	X													
6286	Semiannual	903 Pad	RFCA	X	X		X		X	X		X											
6386	Semiannual	903 Pad	RFCA	X	X		X		X	X		X											
6486	Semiannual	Drainage	RFCA	X	X			X	X	X		X											
6586	Semiannual	Drainage	RFCA	X	X		X		X	X													
7086	Semiannual	IA/Old Landfill	RFCA	X	X			X	X	X		X											
10098	Semiannual	Bldg. 123		X	X		X		X	X			X	X									

				VOC	Metals			SR						Cesium -						Water Quality			
Well Number	Frequency	Plume/Area	Drivers	Suite	Suite	Tritium	PU/AM	89/90	Uranium	Nitrate	Fluoride	Sulfate	Cyanide	137	Chloride	Sulfide	TOC	Methane	Ethene	Suite	Np-237	TPH	PCB
10194	Semiannual	East Trenches	RFCA	X	X		X		X	X													
10198	Semiannual	Bldg. 123		X	X		X		X	X			X	X									
10294	Semiannual	Boundary	RFCA, AIP	X	X	X	X		X	X	X	X											
10298	Semiannual	Bldg. 123		X	X		X		X	X			X	X									
10394	Semiannual	Boundary	RFCA, AIP	X	X	X	X	X	X	X	X	X											
10398	Semiannual	Bldg. 123		X	X		X		X	X			X	X									
10498	Semiannual	Bldg. 123		X	X		X		X	X			X	X									
10592	Semiannual	881 Hillside	RFCA, IM/IRA -FD	X	X				X	X		X											
10598	Semiannual	Bldg. 123		X	X		X		X	X			X	X									
10692	Semiannual	881 Hillside	RFCA, IM/IRA -FD	X	X				X	X		X											
10792	Semiannual	881 Hillside	RFCA, IM/IRA -FD	X	X				X	X		X											
10992	Semiannual	881 Hillside	RFCA, IM/IRA -FD	X	X				X	X		X											
10994	Semiannual	IA/Old Landfill	RFCA	X	X			X	X	X		X											
11092	Semiannual	881 Hillside	RFCA, IM/IRA -FD	X	X				X	X		X											
11791	Semiannual	903 Pad/Ryan's Pit		X						X		X			X	X	X	X	X				
11891	Semiannual	East Trenches		X	X		X		X	X													
12191	Semiannual	East Trenches	East Trenches	X	X		X		X	X													
12691	Semiannual	East Trenches		X	X		X		X	X													
15599	Semiannual	Mound		X			X		X														
15699	Semiannual	Mound		X			X		X														
15799	Semiannual	Mound		X			X		X														
18199	Semiannual	IHSS 118.1/Bldg 771		X	X	X	X		X	X		X			X	X	X	X			X		
18399	Semiannual	IHSS 118.1		X						X		X			X	X	X	X					
18499	Semiannual	IHSS 118.1		X						X		X			X	X	X	X					
18799	Semiannual	IHSS 118.1		X						X		X			X	X	X	X					
20998	Semiannual	Bldg. 771		X	X	X	X		X	X											X		
21098	Semiannual	IHSS 118.1		X						X		X			X	X	X	X					
22596	Semiannual	Ind. Area	RFCA, IM/IRA for IA	X	X		X		X	X													
22696	Semiannual	Ind. Area	RFCA, IM/IRA for IA	X	X		X		X	X													
22796	Semiannual	Ind. Area	RFCA, IM/IRA for IA	X	X		X		X	X													

Well Number	Frequency	Plume/Area	Drivers	VOC Suite	Metals Suite	Tritium	PU/AM	SR 89/90	Uranium	Nitrate	Fluoride	Sulfate	Cyanide	Cesium-137	Chloride	Sulfide	TOC	Methane	Ethene	Water Quality Suite	Np-237	TPH	PCB
22896	Semiannual	Ind. Area	RFCA, IM/IRA for IA	X	X		X		X	X													
22996	Semiannual	Bldg. 886	RFCA, IM/IRA for IA	X	X		X		X	X													
23096	Semiannual	903 Pad	RFCA	X	X		X		X	X		X											
23296	Semiannual	East Trenches	RFCA	X	X		X		X	X													
30100	Semiannual	PU&D		X	X	X			X	X	X	X											
30900	Semiannual	PU&D		X						X		X			X	X	X		X				
37101	Semiannual	Bldg. 371/374		X	X		X		X	X												X*	
37201	Semiannual	Bldg. 371/374		X	X		X		X	X												X*	
37301	Semiannual	Bldg. 371/374		X	X		X		X	X												X*	
37402	Semiannual	Bldg. 371/374		X	X		X		X	X												X*	
37501	Semiannual	Bldg. 371/374		X	X		X		X	X												X*	
37601	Semiannual	Bldg. 371/374		X	X		X		X	X												X*	
37701	Semiannual	Bldg. 371/374		X	X		X		X	X												X*	
37791	Semiannual	Bldg. 881		X	X		X		X	X													X*
38591	Semiannual	Drainage	RFCA	X	X			X	X	X		X											
39691	Semiannual	Bldg. 881		X	X		X		X	X													X*
40099	Semiannual	Bldg. 444		X	X	X			X	X			X										
40199	Semiannual	Bldg. 444		X	X	X			X	X			X										
40299	Semiannual	Bldg. 444		X	X	X			X	X			X										
40399	Semiannual	Bldg. 444		X	X	X			X	X			X										
40499	Semiannual	Bldg. 444		X	X	X			X	X			X										
40599	Semiannual	Bldg. 771		X	X	X	X		X	X											X		
40699	Semiannual	Bldg. 771		X	X	X	X		X	X											X		
40799	Semiannual	Bldg. 771		X	X	X	X		X	X											X		
40899	Semiannual	Bldg. 771		X	X	X	X		X	X											X		
40999	Semiannual	Bldg. 865/886		X	X		X		X	X													
41099	Semiannual	Bldg. 886		X	X		X		X	X													
41199	Semiannual	Bldg. 886		X	X		X		X	X													
41299	Semiannual	Bldg. 444		X	X	X			X	X			X										
41499	Semiannual	Bldg. 771		X	X	X	X		X	X											X		

Well Number	Frequency	Plume/Area	Drivers	VOC Suite	Metals Suite	Tritium	PU/AM	SR 89/90	Uranium	Nitrate	Fluoride	Sulfate	Cyanide	Cesium - 137	Chloride	Sulfide	TOC	Methane	Ethene	Water Quality Suite	Np-237	TPH	PCB
41591	Semiannual	Boundary	RFCA, AIP	X	X	X	X		X	X	X	X											
41599	Semiannual	Bldg. 771		X	X	X	X		X	X											X		
41691	Semiannual	Boundary	RFCA, AIP	X	X	X	X	X	X	X	X	X											
43392	Semiannual	Ind. Area	RFCA	X	X		X		X	X													
52894	Quarterly	Landfill	RFCA, RCRA	X	X	X			X	X	X	X											
52994	Quarterly	Landfill	RFCA, RCRA	X	X	X			X	X	X	X											
55901	Semiannual	Bldg. 559		X	X		X		X	X													X*
56001	Semiannual	Bldg. 559		X	X		X		X	X													X*
56101	Semiannual	Bldg. 559		X	X		X		X	X													X*
56201	Semiannual	Bldg. 559		X	X		X		X	X													X*
56301	Semiannual	Bldg. 559		X	X		X		X	X													X*
60299	Semiannual	Bldg. 776/777		X	X	X	X		X	X													
60499	Semiannual	Bldg. 707		X	X		X		X												X		
60599	Semiannual	Bldg. 707		X	X		X		X												X		
60699	Semiannual	Bldg. 707		X	X		X		X												X		
61099	Semiannual	Bldg. 883		X	X				X	X												X*	X*
61199	Semiannual	Bldg. 883		X	X				X	X												X*	X*
61499	Semiannual	Bldg. 707		X	X		X		X												X		
70099	Quarterly	Solar Ponds							X (T)	X													
70193	Quarterly	PU&D	RFCA, RCRA	X	X	X			X	X	X	X											
70299	Quarterly	Solar Ponds							X (T)	X													
70393	Quarterly	PU&D	RFCA, RCRA	X	X	X			X	X	X	X											
70493	Quarterly	PU&D	RFCA, RCRA	X	X	X			X	X	X	X											
70693	Semiannual	PU&D/Landfill		X						X		X			X	X	X		X				
75992	Semiannual	Mound/E. Trench	RFCA	X	X		X	X	X	X													
76992	Semiannual	PU&D/Landfill	RFCA, RCRA	X	X	X			X	X	X	X											
77392	Semiannual	Landfill	RFCA	X	X	X			X	X	X	X											
83101	Semiannual	Bldg. 883/881		X	X		X		X	X												X*	X*
83201	Semiannual	Bldg. 883		X	X				X	X												X*	X*
86501	Semiannual	Bldg. 865		X	X				X	X													

Well Number	Frequency	Plume/Area	Drivers	VOC Suite	Metals Suite	Tritium	PU/AM	SR 89/90	Uranium	Nitrate	Fluoride	Sulfate	Cyanide	Cesium - 137	Chloride	Sulfide	TOC	Methane	Ethene	Water Quality Suite	Np-237	TPH	PCB
86601	Semiannual	Bldg. 865		X	X				X	X													
86701	Semiannual	Bldg. 865		X	X				X	X													
88101	Semiannual	Bldg. 881		X	X		X		X	X													X*
90099	Semiannual	903 Pad/Ryan's Pit		X						X		X			X	X	X	X	X				
90199	Semiannual	903 Pad/Ryan's Pit		X	X		X		X	X		X											
90299	Semiannual	903 Pad/Ryan's Pit		X	X		X		X	X		X											
90399	Semiannual	903 Pad/Ryan's Pit		X	X		X		X	X		X			X	X	X	X	X				
95099	Semiannual	East Trenches	RFCA	X																			
95199	Semiannual	East Trenches	RFCA	X																			
95299	Semiannual	East Trenches	RFCA	X																			
99101	Semiannual	Bldg. 991		X	X		X		X	X												X*	
99201	Semiannual	Bldg. 991		X	X		X		X	X												X*	
99301	Semiannual	Bldg. 991		X	X		X		X	X												X*	
99401	Semiannual	Bldg. 991		X	X		X		X	X												X*	
B206989	Quarterly	Landfill	RFCA, RCRA	X	X	X			X	X	X	X											
B208289	Semiannual	Solar Ponds	RFCA, RCRA	X	X	X	X	X	X	X	X	X											
B208789	Semiannual	Solar Ponds	RFCA, RCRA	X	X	X	X	X	X	X	X	X											
P114389	Semiannual	Ind. Area	RFCA	X	X		X		X	X													
P209289	Semiannual	Carbon Tet	RFCA, RCRA	X	X	X	X	X	X	X	X	X											
P209389	Semiannual	Carbon Tet	RFCA, RCRA	X	X	X	X	X	X	X	X	X											
P209489	Semiannual	Solar Ponds		X	X	X	X	X	X	X	X	X											
P218089	Semiannual	Bldg. 707		X	X		X		X												X		
P218389	Semiannual	Solar Ponds	RFCA, RCRA	X	X	X	X	X	X	X	X	X											
P219089	Semiannual	Bldg. 771		X	X	X	X		X	X											X		
P219189	Semiannual	Carbon Tet	RFCA, RCRA	X	X	X	X	X	X	X	X	X											
P219489	Semiannual	Solar Ponds	RFCA, RCRA	X	X	X	X	X	X	X	X	X											
P313589	Semiannual	Ind. Area	RFCA, IM/IRA for IA	X	X		X		X	X													
P314289	Semiannual	Ind. Area	RFCA, IM/IRA for IA	X	X		X		X	X													
P317989	Semiannual	Bldg. 865/886		X	X		X		X	X													
P416689	Semiannual	Ind. Area	RFCA, IM/IRA for IA	X	X		X		X	X													

Well Number	Frequency	Plume/Area	Drivers	VOC Suite	Metals Suite	Tritium	PU/AM	SR 89/90	Uranium	Nitrate	Fluoride	Sulfate	Cyanide	Cesium - 137	Chloride	Sulfide	TOC	Methane	Ethene	Water Quality Suite	Np-237	TPH	PCB
P416789	Semiannual	Ind. Area	RFCA, IM/IRA for IA	X	X		X		X	X													
P416889	Semiannual	Ind. Area	RFCA, IM/IRA for IA	X	X		X		X	X													
P419689	Semiannual	Bldg. 444		X	X	X			X	X			X										
891COLWEL	Quarterly	881 Hillside		X	X				X														
ETP ef	Semiannual	East Trenches		X	X (T)							X			X								
ETP in	Semiannual	East Trenches		X	X (T)							X			X								
R1-0	Semiannual	Mound		X	X (T)		X		X (T)			X			X					X			
R2-E	Semiannual	Mound		X	X (T)		X		X (T)			X			X					X			
371 Basement	Semiannual	Bldg. 371/374		X	X		X		X	X												X*	
371 SubBasement	Semiannual	Bldg. 371/374		X	X		X		X	X												X*	
FD-559/561	Semiannual	Bldg. 559		X	X		X		X	X													X*
FD-707-4	Semiannual	Bldg. 707		X	X		X		X												X		
771FDOut#2	Semiannual	Bldg. 771		X	X	X	X		X	X											X		
BS-865-2	Semiannual	Bldg. 865		X	X				X	X													
SW099	Quarterly	Landfill		X																			
SW100	Quarterly	Landfill		X																			
SW13494	Quarterly***	881 Hillside/Bldg. 881		X	X		X		X	X													X*

Notes:
* If not detected in samples from first sampling round, discontinued from analytical suite.
** Full IMP suite semiannually, reduced Solar Ponds Plume suite in remaining quarters.
*** IMP suite quarterly, with additional Bldg. 881 samples semiannually.
(D), (T) Field filtered, unfiltered, respectively.

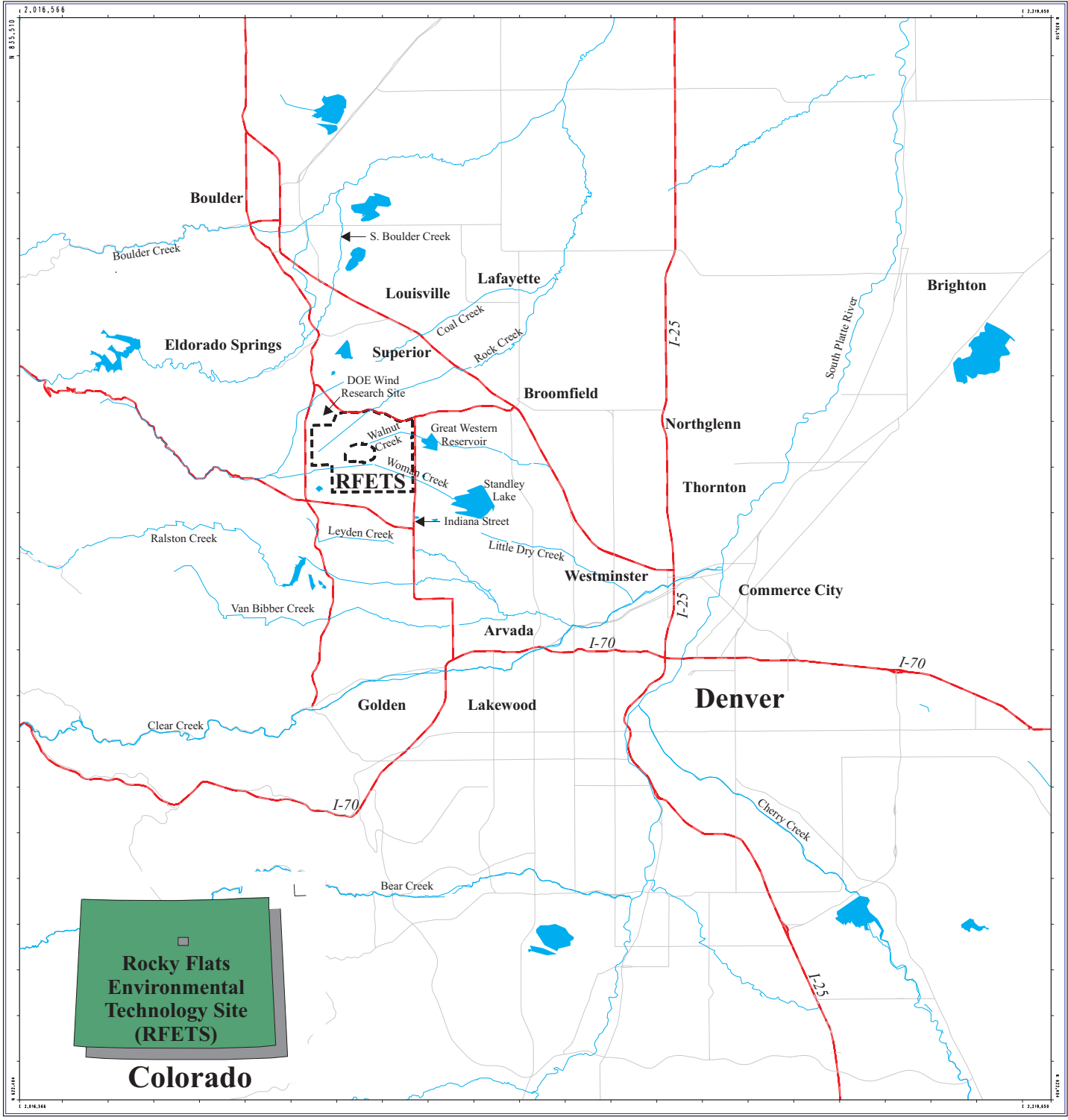

Figure 1-1 Location of Rocky Flats Environmental Technology Site (RFETS) 2001 Annual RFCA Groundwater Monitoring Report

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Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464 Golden, CO 80402-0464

N

5,000' 0' 10,000' 20,000'
Scale in Feet

w:/projects/fy2002/02-0781/fig1-1.cdr

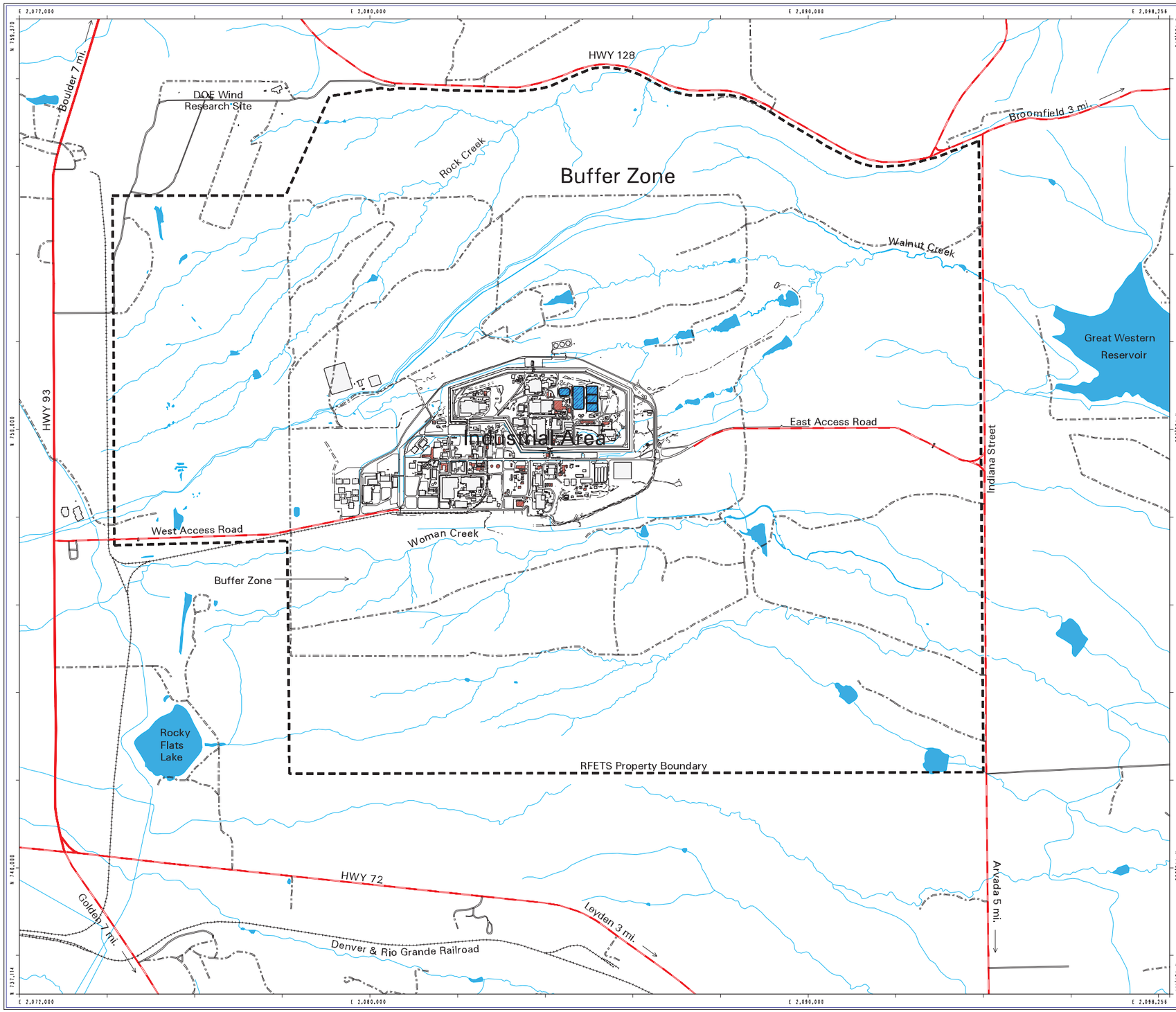

Figure 1-2

Rocky Flats Environmental Technology Site Map

2001 Annual RFCA Groundwater Monitoring Report

EXPLANATION

Standard Map Features

- Buildings and other structures
- Demolished buildings
- Solar Evaporation Ponds (SEPs)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Heavy duty paved roads
- Medium duty paved roads
- Light duty paved roads
- Dirt roads
- Railroads

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Scale = 1 : 28720
1 inch represents approximately 2393 feet

700 0 1400 2800 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

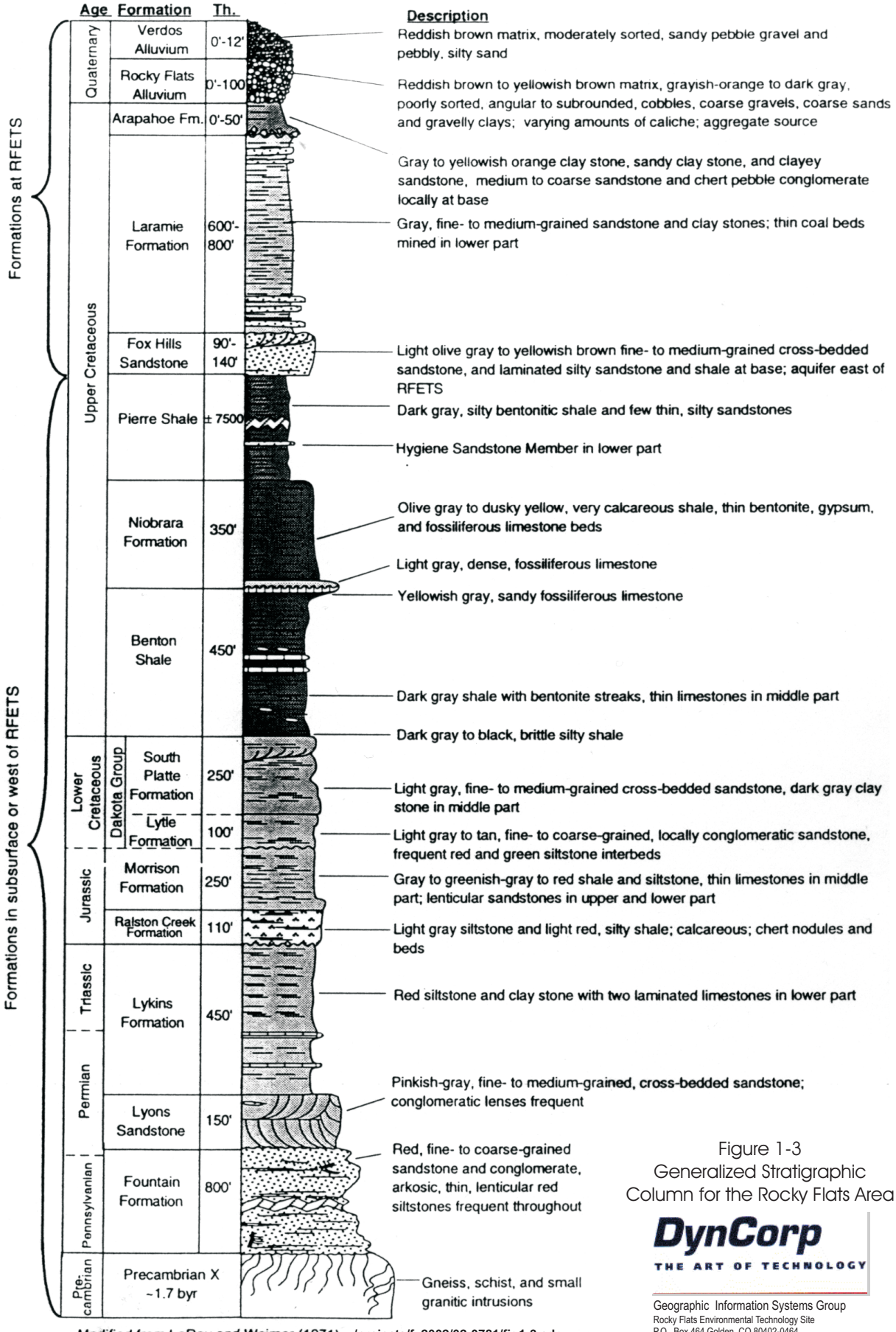
GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

Prepared for: KAISER•HILL COMPANY

August 08, 2002

NT_Svr w:/projects/fy2002/02-0781/fig1-2.aml



Modified from LeRoy and Weimer (1971)w:/projects/fy2002/02-0781/fig1-3.cdr

Figure 1-3
Generalized Stratigraphic Column for the Rocky Flats Area

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Geologic Units

- Qv — Verdos Alluvium
- Qrf — Rocky Flats Alluvium
- Ka — Arapahoe Formation
- Kl — Laramie Formation
- Kfh — Fox Hills Sandstone
- Kp — Pierre Shale/Hygiene Member
- Kn — Niobrara Formation
- Kb — Benton Shale
- Kd — Dakota Group
- Jm — Morrison Formation
- TR Pl — Lykins Formation
- PIP f — Lyons & Fountain Formations
- p€ — Undivided Igneous & Metamorphic Units

Structural interpretation from EG&G, 1993a.

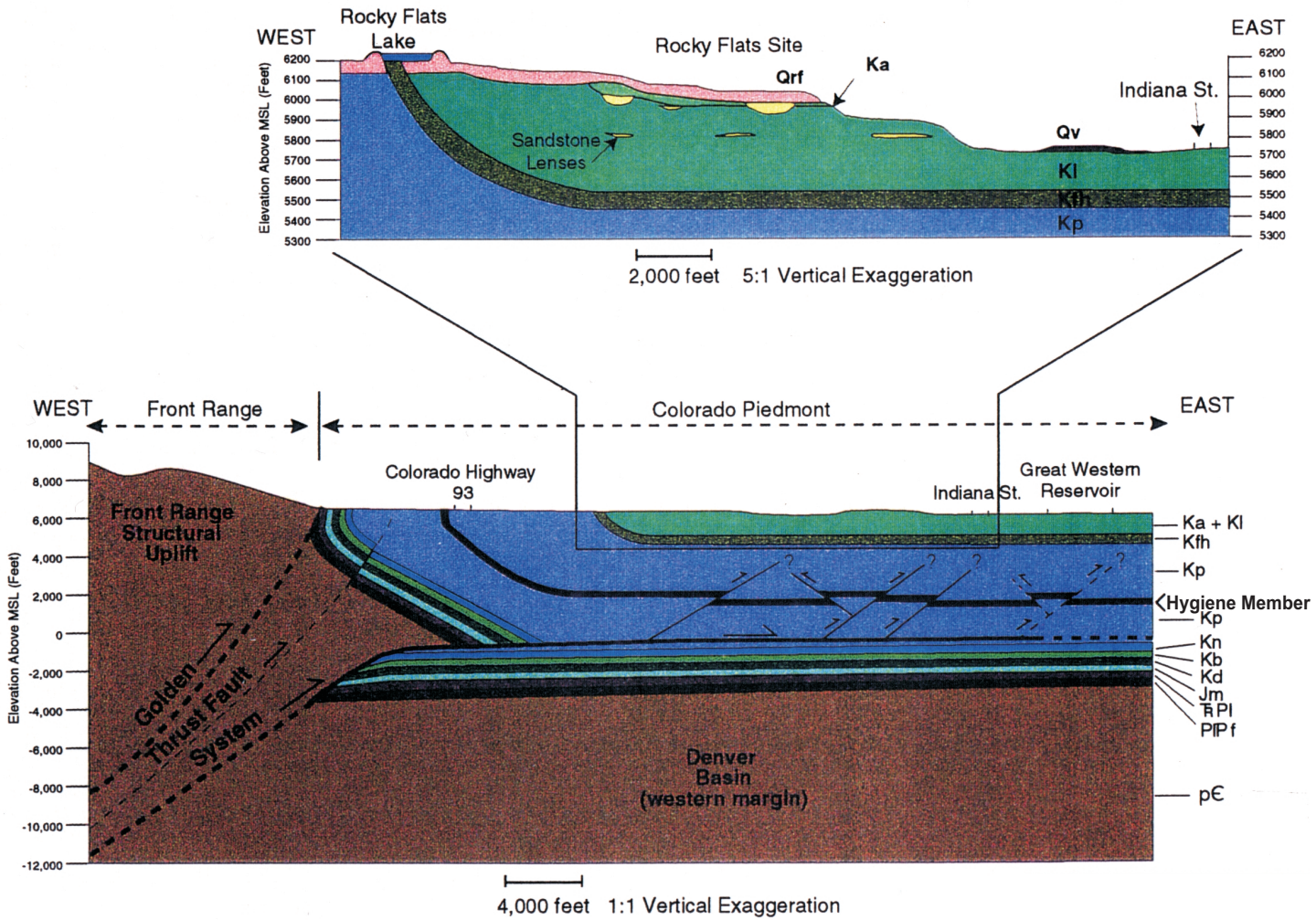

Figure 1-4
Generalized Geologic Cross Section of the Front Range and the Rocky Flats Area

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