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HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

GTI Project 053353014

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Prepared for:

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EXECUTIVE SUMMARY

This report evaluates the potential human health and environmental risks associated with the detected chemicals at the Giant Refining Company (GRC) site. The data collected during the field investigations from the different environmental media (soil, groundwater, surface water, and sediment) are collectively used to determine if there are compounds present at the site that may have adverse effects on human and ecological receptors. The risk assessment evaluates the probability and the magnitude of these effects, currently and in the future. The risk estimates are used to evaluate whether remedial actions are needed at the site and, if necessary, which remedial alternatives are most appropriate. The risk assessment is also the basis for establishing proposed cleanup goals for the site.

Analyses of the collected data indicated that the media of concern at the GRC site are the surface soil, the shallow groundwater, and the Hammond Ditch sediments. The potential human receptors are the on-site worker, the off-site resident, and the ecological receptors that may be present or forage at the Hammond Ditch. The potential risks/hazards posed to these receptors, due to exposure to the chemicals of potential concern (COPCs) in the different media of concern, were calculated. The results of the risk calculations are used to determine whether the chemical levels due to the operations of the GRC Refinery will have adverse health effects on human receptors and/or incur adverse ecological effects on identified receptors.

In spite of the conservative assumptions and the uncertainties inherently present in risk assessments, the data suggest that there is no potential risk posed to the on-site worker and to the off-site resident. There may be a potential risk to the hypothetical off-site resident in the unlikely scenario that the shallow saturated zone is used as a potable water supply in the future.

The results of the risk assessment indicate that there are no unacceptable risks (human health or environmental) associated with COPCs in soil, sediments or dissolved phase chemicals in groundwater. GRC has been operating a remediation system to remove separate phase hydrocarbons (SPHs). SPH removal is a clear corrective action objective (CAO) for the site, as it is a requirement of the New Mexico Water Quality Conservation Commission (WQCC) regulations. Additional remedial activities will be proposed under the corrective measures phase to enhance the effectiveness of SPH removal activities.

The evaluation of risks due to exposure to the shallow aquifer is, in itself, a conservative, non-realistic premise because the natural water quality in the shallow aquifer does not make it a possible source of potable water. Furthermore, the presence of an impermeable layer between the shallow and deeper aquifers excludes potential vertical migration of the COPCs to the deeper aquifer which is a likely source of water supply.

The evaluation of the available data also concluded that there are no potential ecological risks to receptors that may be present at the GRC site and vicinity. Thus, the overall conclusion is:
The chemical levels in the environment due to discharges from the GRC facility do not pose any human health or ecological risks. These conclusions are supported by the performance of a human health or ecological risk assessment conducted under very conservative assumptions and baseline (no-action) conditions. The lack of potential risks is augmented by remediation measures that have been implemented by GRC in order to remove the SPHs, thus eliminating the possibility of a continuing source of contamination.

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1.0 INTRODUCTION

The human health risk assessment conforms to the guidance presented in the following documents:

- Risk Assessment Guidance for Superfund (RAGS), Vol. I, Human Health Evaluation Manual, Part A (USEPA, 1989a);
- Risk Assessment Guidance for Superfund, Vol. 1, Human Health Evaluation Manual, Supplemental Guidance, "Standard Default Exposure Factors" (USEPA, 1991);
- Exposure Factors Handbook (USEPA, 1989);
- Dermal Exposure Assessment: Principles and Applications (USEPA, 1992); and
- Supplemental Guidance to RAGS: Calculating the Concentration Term (USEPA, 1992).

The ecological risk assessment is conducted in accordance with the guidelines presented in the following documents:

- Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (USEPA, 1989); and
- Framework for Ecological Risk Assessment (USEPA, 1992).

At this time, USEPA Region VI does not have state-specific guidelines for human health and ecological risk assessment (USEPA Region VI, personal communication). Therefore, the risk assessment is conducted in accordance with the USEPA guidelines mentioned above.

1.1 Scope of Work and Objectives

The scope of the risk assessment includes the review of the information presented in the Resource Conservation Recovery Act (RCRA) Facility Investigation (RFI), the evaluation of the data for useability in the risk assessment, a site visit (May 1995) to identify exposure parameters that will be integrated into the risk assessment, a theoretical estimate of the risks posed by the current chemical concentrations, an evaluation of the risk characterization, and the derivation of cleanup goals if the risk assessment determines that remediation is required.

2.0 SITE BACKGROUND

The GRC facility is located at #50 Country Road 4990 (Sullivan Road), south of the town of Bloomfield, New Mexico, in San Juan County (Figure 1). The town of Bloomfield begins across the San Juan River immediately north of the facility, with the center approximately 1 mile further north and has a population of approximately 5,000 (GTI, March 1993).

The Hammond Project is located in San Juan County, New Mexico, and provides a full service irrigation supply to 3,933 acres of land (USDOI, 1993). The project extends along the southern bank of the San Juan River in a 20-mile strip south of Bloomfield, New Mexico. The GRC facility has been identified as being responsible for releasing, or causing to be released, petroleum constituents that have presumably affected portions of the Hammond Irrigation Project.

On April 10, 1992, the United States Environmental Protection Agency (USEPA) Region VI issued GRC an Administrative Consent Order under RCRA Section 3008(h) requiring that corrective action/measures be taken "to protect human health and/or the environment."

2.1 Site Operations

The process areas at the site are divided into four geographic areas (Figure 2). A detailed description of the facility operations and structures was presented in the RFI Task I Report - Description of Current Conditions (GTI, March 1993).

2.1.1 Area 1

Area 1 is located on the west end corner of the site and includes the following units:

- The wastewater treatment system includes the API separator, the south oily water pond (SOWP), and the north oily water pond (NOWP). The API Oil/Water Separator is a double-chambered, steel-reinforced concrete tank that acts as a physical separator of water and oil. Oil is skimmed in the separator and returned to the refinery process, water underflows a weir to the SOWP, and sludges accumulate in the bottom. NOWP and SOWP treat approximately 80 gallons per minute (gpm) of water.

- The current spent caustic tank was installed in 1987 to the west of the SOWP and NOWP. The tank (12 feet in diameter, 20 feet in height) rests on a concrete pad and is surrounded by a concrete containment wall. A transfer pump to remove spent caustic from the tank is located within the containment area.

- The Former and Current Drum Storage Area(s): the north bone yard currently stores empty drums and the warehouse west of the refinery area stores chemicals and lubricating oils used in the refinery processes.
- Major Processing Units.
- Tank Area for Tanks 3, 4, and 5 and Former Location of Tanks 6 and 7. Tanks 6 and 7 were dismantled from service in mid-1987 to make way for process expansions. These tanks were out-of-service due to poor condition. Tanks 3, 4, and 5 have capacities of 420,000 gallons each and currently contain JP4 Jet Fuel (Tanks 3 and 4) and premium unleaded gasoline (Tank 5).

2.1.2 *Area 2*

Area 2 of the facility consists of the main AST farm. Product releases (documented and undocumented) from the ASTs and associated piping are believed to be the source of subsurface impacts at the GRC facility.

2.1.3 *Area 3*

Area 3 is the portion of the site to the south of Sullivan Road and includes the following units:

- Transportation Terminal Sump: An earthen sump was located to the south of the liquid propane gas (LPG) bullets in the southern portion of the refinery (south of Sullivan Road) and was used as a truck cleaning area at one time. The area was backfilled with soil in 1986 and is no longer used.
- Heat Exchanger Bundle (HEB) Cleaning Area and RCRA 90-Day Area: The HEB cleaning area is located to the south of Sullivan Road in a room on the east end of the auxiliary warehouse. The room is fully enclosed with sheet metal walls and a concrete floor. A concrete sump in the floor of the cleaning area collects sludges generated during cleaning of the bundles.
- Crude Loading Area: The crude and product loading areas and underground lines are locations of known or suspected releases.
- Product Loading Rack; and
- Underground Piping.

2.1.4 Area 4

The fourth geographic area includes the following units:

- Evaporation Ponds (north and south): Treated wastewater from the NOWP is transferred first to the south evaporation pond, then into the north evaporation pond, both of which are located to the east of the AST area. The earthen dikes and bottoms of the ponds are lined with 4 to 6 inches of bentonite. The units are inspected daily to assure no overtopping of the ponds occurs. The two ponds are scheduled to be decommissioned in 1995 since the new underground injection well has become operational.

- Landfill: The "landfill" is the low-lying area to the east of the process area into which sludges and contaminated soils from the SOWP and NOWP were placed in 1982.

- Fire Training Area: The Fire Training Area is located to the east of the north evaporation pond in the northeast corner of the site. It is used to practice extinguishing fires similar to those that might occur at the facility. The area includes a fuel tank on the south end of the training area, and diesel fuel, gasoline, and other fuels are used to set the fires for training. The area is covered with gravel, and tanks and vessels in which the fires are set are distributed across the area. The area is outside the floodplain, but because of limited containment features, runoff from this area may be transported to surface waters, including Hammond Ditch.

- Spray Irrigation Area: The spray irrigation area is located to the southeast of the refinery and consists of a 10-acre parcel of land onto which water from the north evaporation pond is sprayed through stationary sprinkler heads (mainly from March through October). The area is diked to prevent runoff. It was noted during the 1987 inspection that contamination of surface waters by flooding or runoff from the spray irrigation field was not likely. This area is fenced with 3-strand barbedwire. This area is no longer in use (spray irrigation ceased in early 1995 once the injection well was operational).

2.2 Topography and Surface Features

The climate is arid and the soil is dry and barren. The site is located on a bluff approximately 100 feet above the San Juan River, a perennial river that flows to the west. The topography of the property on top of the bluff is flat with a slight downward slope to the south, southwest. A steep, unpaved road, built alongside the bluff, extends from the top of the northern side of the property down onto the San Juan riverbank. Overland migration of dissolved petroleum constituents to water bodies is limited by the site-wide stormwater runoff control system.

The one-story facility building and laboratory building, as well as the parking lots, are situated in the west end of the property. Two single-story homes are located approximately 400 feet south of the spray irrigation area. The homes are on a slight incline that slopes toward the facility. Based on the available data, these homes are located upgradient of the site. Residential, federal, and industrial facilities are located adjacent to the property boundaries of GRC (Figure 3) (GTI, March 1993).

Hammond Ditch, a manmade channel for irrigation water supply, is located on the bluff between the river and the process area of the facility and borders all but the southern portion of the site. The process areas of the facility are inaccessible by the public due to a fence and 24-hour surveillance. Process areas are paved with curbed concrete. Access to areas undergoing construction or remediation is available only to facility personnel and contractors. Furthermore, projects involving soil excavation require compliance with OSHA requirements and with the site-specific Health and Safety Plan.

2.3 Surface Water

The surface waters in the vicinity of the GRC facility include the San Juan River and the Hammond Ditch. The San Juan River flows in a general west/southwest direction to Shiprock, New Mexico, where it changes direction, heading northwest to the Four Corners area. The river then flows westward and enters the Colorado River about 30 miles upstream from the Arizona-Utah line (USDOI, 1993). Most of the flow of the San Juan River is spring runoff from winter snowpack in the San Juan Mountains in Colorado. The flows decrease rapidly after the spring runoff and are usually lowest during December and January (USDOI, 1993). The San Juan River is used for potable water for the town of Bloomfield and surrounding areas, and is controlled by the upstream Navajo Dam (GTI, March 1993).

The Hammond Ditch is a manmade channel used for irrigation of agriculture and livestock. It is unlined in the portion that borders GRC. The water in the ditch is not being used for human consumption. Hammond Ditch flows actively during the irrigation season (April 15 through October 15) for agricultural purposes and is diked by GRC during the non-irrigation season. The Hammond Ditch provides a barrier to SPH migration between the facility and the San Juan River.

2.4 Geological/Hydrogeological Characteristics

A detailed discussion of the geological/hydrogeological setting of the site was presented in the RFI (GTI, March 1993). This section will only discuss the characteristics that are relevant in the performance of the risk assessment.

A permeable cobble layer directly overlies the bedrock at the site, the Tertiary Nacimiento Formation. The Nacimiento Formation is a gray to blue-green clay to shale that is approximately 570 feet thick. The bluff that crops out along the San Juan River near the site is similarly composed of these lithologies.

Groundwater at the site ranges from 6 to 40 feet below ground surface. This depth to groundwater increases from west to east across the site. The direction of the groundwater flow is generally to the north-northwest, toward the Hammond Ditch and San Juan River. Hammond Ditch contributes significantly to groundwater recharge at the site. When full, the Hammond Ditch creates a mounding effect, inhibiting groundwater flow.

Groundwater in the perched aquifer migrates through the permeable sands, silts and cobble zone along the relatively impermeable Nacimiento Formation, which is reported to dip toward the north. The seeps along the bluff occur at the interface between the cobble zone and the Nacimiento.

A well inventory conducted by Tierra Environmental Company, Inc. showed that out of the 22 wells that were identified, 8 wells were within a 1-mile radius from the center of the GRC site (Figure 4) (GTI, March 1993). Well #1, located south of the site, is owned by C.W. Wooten. This well is double-cased and is screened between 266 and 306 feet. Well #6, owned by D.C. Looney, is located west of the site on the opposite side of the San Juan River. This well is screened between 22 and 32 feet below ground surface. Well #5, owned by E.H. Brown (Aztec, NM), is located southwest of the site, on the opposite side of the Hammond Ditch, and is reportedly cased to 20 feet. Five wells (Wells #3, 7, 13, 15, and 22) are located north of the site and across the San Juan River. Due to their location and/or the depths of the screened intervals, none of these wells are potentially impacted by off-site migration of chemicals.

3.0 BIOLOGICAL RESOURCES

The information presented in this section was collected from literature and a biological survey conducted by the United States Fish and Wildlife Service (USFWS, 1987). No biological surveys have been conducted at the GRC site itself, thus, the flora and fauna listed in this section are primarily species observed or expected to occur in the area of the San Juan River Basin. No information on aquatic invertebrates in the San Juan River was found.

3.1 Habitats and Vegetation

The San Juan River basin supports major habitats including freshwater aquatic, riparian, grassland, desert shrub, pinon/juniper woodland, ponderosa pine, mixed conifer, and alpine tundra. Based on limiting factors such as precipitation and elevation of the site and surrounding area (approximately 5,500 feet above mean sea level - amsl; annual average precipitation of approximately 9 inches), habitats which may occur in the vicinity of the site include freshwater aquatic, desert shrub, mixed conifer, and pinon/juniper woodland. Alpine tundra only occurs at elevations significantly higher (12,000+ feet amsl) than those in the site vicinity (Sivinski & Lightfoot, 1994). Ponderosa pine habitats are not likely to be encountered in the vicinity of the site because precipitation limits their distribution to areas with a minimum of 25 inches annual precipitation (Mayer & Laudenslayer, 1988).

The *Inventory of Rare and Endangered Plants of New Mexico* (Sivinski & Lightfoot, 1994), classifies the terrestrial habitats in this area as Great Basin Desert Scrub, Plains and Great Basin Grassland, and Great Basin Conifer Woodland. Great Basin Desert Scrub is a dry, cold winter desert habitat dominated by shrubs such as sagebrush, saltbush, winterfat, and greasewood. The Plains and Great Basin Grassland habitat consists mostly of short-grass plains including grama, wheatgrass, three-awn, muhly, galleta, and buffalograss. When the grasslands are continuously grazed by livestock, snakeweed becomes the dominant plant. The Great Basin Conifer Woodland is typified as a cold adapted evergreen woodland at intermediate elevations dominated by pinon pine and juniper. Spaces between the pinon pine and juniper are generally covered with a variety of grasses and shrubs depending on elevation.

Based on the U.S. Fish and Wildlife classification of wetland areas, the various wetlands that may occur in the area consist of:

a) Palustrine emergent persistent wetlands with dominant vegetation cover types of sedge, rush, cattail, bulrush, salt grass, and common reed;

b) Palustrine scrub-shrub/forested broad leaved deciduous wetland with dominant vegetation cover types of willow, tamarisk, Russian olive, and cottonwood;

c) Riverine lower perennial streambeds which consist of the San Juan River and unvegetated wastes; and

d) Lacustrine littoral open water that includes all ponds in the area.

The wetland or riparian areas that occur near, but not immediately adjacent to, the Hammond canal consist primarily of cottonwood, Russian olive, and tamarisk. Wetlands vegetation associated with agricultural drains are primarily composed of cattails, bulrush, sedges and rushes.

Endangered, threatened and listed plants which may be present in the vicinity of the refinery were identified through reviews of State and Federal endangered species lists. The Mesa Verde cactus (*Sclero cactus mesae-verdae*) is listed as threatened by the State of New Mexico and is on the federal endangered species list. The Mesa Verde Cactus occurs on dry, exposed hillsides of Mancos or Fruitland shales, in San Juan County, New Mexico and Montezuma County, Colorado. The Knowlton Cactus (*Pediocactus knowltonii*) is protected by the State and is found in northeast San Juan County. The Mancos Milkvetch (*Astragalus humillimus*) is listed by the State and is only found Point Lookout and Cliff House Sandstones. Federal candidate species that may occur in the area are the San Juan Milkweed (*Asclepias sanjuanensis*), Mancos Saltbush (*Proatriplex pleiantha*), and Beautiful Gilia (*Gilia formosa*). The State has also listed the Gilia Formosa (*Aztex gilia*) as endangered. Gilia Formosa occurs in Great Basin Desert Scrub and Conifer Woodland habitats. The San Juan Milkweed is a new species known from San Juan County, New Mexico, between Bloomfield and Shiprock. It occurs on erosive, sandy soils in pinyon-juniper woodlands along slopes and floodplains of the San Juan River Valley. The Mancos Saltbush occurs in San Juan County, New Mexico, and Montezume County, Colorado. It is found in barren, gray soil on mesa slopes at 5,000 feet in elevation. The Beautiful Gilia's only known location is in San Juan County, New Mexico where it inhabits sandstone outcrops at approximately 5,800 feet in elevation.

As mentioned previously, the site is located on a bluff that is 100 feet above the San Juan River. A darker area (referred to as a seepage area) was observed where the road ends on the bluff approximately 25 feet above the river bank. However, the area around the seepage area has become more vegetated since the property was purchased in 1984. The side of the cliff and the riverbank are populated with cottonwoods and other riparian vegetation. There were no signs of stressed vegetation on the bluff or the river bank. However, some stressed vegetation was observed in the seepage area.

3.2 Fish and Wildlife

Identification of wildlife populations which may be present in the vicinity of the site was limited to a review of state and federal lists of listed species and to a biological survey conducted by the USFWS (1987) for the Hammond Irrigation Project. According to the USFWS (1987), the San Juan River Basin supports 311 bird species (including 198 species which are dependent on riparian habitats; 93 of which directly depend on riparian habitat for reproduction and survival), 99 mammal species, 34 reptile species, and 14 amphibians. The river provides habitat for migrating birds and raptors including bald eagles, peregrine falcons, and whooping cranes. Approximately 500,000 waterfowl winter on the San Juan River (USFWS, 1987). The USFWS (1987) also identified 50 fish species, including 16 native fish species, in the San Juan River.

State and federally listed endangered species identified as being potentially present in the area of the site include:

- Black Footed Ferret (*Mustela nigripes*); there has not been a verified sighting since 1960.
- Peregrine Falcon (*Falco peregrinus anatum*); maybe either resident or migratory and prefer transition life zones from 6,500 - 8,500 feet amsl although they may be found between 3,500 and 9,000 feet amsl.
- Bald Eagle (*Haliaeetus leucocephalus*).
- Colorado Squawfish (*Ptychochelis lucius*); three individuals were found in New Mexico in 1987. According to the State of New Mexico, this species may be extirpated from the lower San Juan River basin.
- Razorback Sucker (*Xyrauchen texanus*).

State threatened (ST), federal threatened (FT) and federal candidate (FC) species which may be found in San Juan County include:

- Roundtail Chub (*Gila robusta*); FC/ST
- Roundtail Chub (*Gila robusta grahami*); ST
- Flannelmouth Sucker (*Catastomus latipinnis*); FC
- White-faced Ibis (*Plegadis chihi*); FC
- Norther Goshawk (*Accipiter gentilis*); FC
- Ferruginous Hawk (*Buteo regalis*); FC
- Western Snowy Plover (*Charadrius alexandrinus nivosus*); FT/FC
- Mexican Spotted Owl (*Strix occidentalis lucida*); FT
- Southwestern Willow Flycatcher (*Empidonax traillii extimus*); ST
- Loggerhead Shrike (*Lanius ludovicianus*); FC
- Gray Vireo (*Vireo vicinior*); ST
- Baird's Sparrow (*Ammodramus bairdii*); FC/ST
- Occult Little Brown Bat (*Myotis lucifugus occultus*); FC
- Swift Fox (*Vulpes velox velox*); FC

4.0 PREVIOUS INVESTIGATIONS

This section describes the results of the soil, groundwater, stream, and sediment sampling investigations.

4.1 Soil Investigations

Soil investigations were conducted at the GRC site in February, 1994 (GTI, March 94) as part of the Phase II investigation to characterize the soils in the potential source areas identified by the USEPA during the 1987 inspection. Soil samples were also collected from spill areas that had no previous data. The rationale for the selection of soil samples was presented in Table 1 of the report on the Results of the Phase II RFI-Soil Boring Installations (GTI, March 1994). Two samples were collected from the area of the Transportation Terminal Sump (B-1 and B-2), two samples were collected from the crude/product loading area (B-3 and B-4), two samples were collected west of the evaporation ponds (B-5 and B-6), one sample each from the southwest section of the Fire Training Area (B-6), the southeast section of the Fire Training Area (B-8), the northwest section (B-9), and the northeast section (B-10) (Figure 5). The samples were collected from a depth of 2-12 feet and were analyzed for volatile organic compounds (VOCs) by USEPA Method 8240, base/neutral acid extractable semi-volatile organic compounds (BNAs) by USEPA Method 8270, total petroleum hydrocarbons (TPH) by USEPA Method 418.1, and priority pollutant metals by USEPA Method 6010/7000 series.

Detectable concentrations of BTEX compounds (benzene, toluene, ethylbenzene, xylenes) were present in only one of the soil boring samples collected from the crude and product loading area at a depth of 8-10 feet (Appendix A-1). Furthermore, the concentrations are too low to be indicative of a release. No BNAs were detected. Several metals were detected in all of the samples but they were all within the range of background concentrations. A discussion of the background sampling is presented in Section 5.1.

4.2 Groundwater Investigations

Groundwater Technology supervised the installation of seven monitoring wells in May 1994 as part of the Phase III RFI (Figure 5). The purpose of the investigation was to complete the delineation of the dissolved-phase and SPH plumes. One monitoring well was installed in the northwestern portion of the facility (MW-28), one well is in the north-central portion of the facility (MW-29), and the remaining five wells are located along the southern end of the facility (MW-30 and MW-31), including three on property owned by the Bureau of Land Management (MW-25, MW-26, and MW-27). The depth of the wells ranged from 22 to 38 feet. Groundwater flows to the west of the site, toward Hammond Ditch.

There are also eleven recovery wells at the GRC site (Figure 5). The SPH thickness in most of the active recovery wells was noted as a sheen (GTI, June 1994). Two of the newly installed monitoring wells contained measurable SPH (0.17 feet in MW-27 and 0.08 feet in MW-28). Wells which contained SPH were not sampled. Otherwise, the newly installed wells were sampled for VOCs, SVOCs, TPH, and metals.

No VOCs and SVOCs were detected in seven wells (MW-1, -3, -5, -8, -12, -13, and -29) that were sampled. Benzene was detected in MW-20 (5.5 ug/L); benzene and ethylbenzene in MW-21 (1400 ug/L and 260 ug/L, respectively); benzene, ethylbenzene, and total xylenes in MW-11, MW-25, MW-26, RW-1, and RW-3; benzene, toluene, ethylbenzene, xylene (BTEX) in MW-30 and MW-31. Chrysene and phenanthrene were detected in RW-1 at approximate concentration of 150 ug/L and 130 ug/L, respectively.

In August 1994, another round of groundwater samples was collected from monitoring and recovery wells that did not contain SPH. All of the wells that were sampled in both sampling events showed the same suite of compounds but with decreased concentrations. An exception is RW-1, which showed a slightly higher concentration of benzene but non-detectable concentrations of ethylbenzene and total xylenes, compounds previously detected in the first sampling event.

The groundwater samples were also analyzed for metals and, as in the case of the first round of sampling, showed concentrations within the background range and below corresponding MCLs. In the Phase III RFI report (GTI, Sept. 1994), it was proposed that analyses for metals be eliminated from any future groundwater monitoring at the site.

In order to delineate the extent of the hydrocarbon to the southwest of the facility, three additional wells were installed on the BLM right-of-way in February 1995. MW-32 is located southeast of MW-26 and MW-27, MW-33 is located south-southwest of MW-27 and south-southeast of MW-11, and MW-34 is located southwest of MW-11. The newly installed wells were sampled and analyzed for VOCs and SVOCs. The only compound detected in MW-32 is 1,1,1-trichloroethane (5 ug/L) and no VOCs were detected in MW-33. MW-34 had detectable concentrations of benzene (300 ug/L), toluene (30 ug/L), and m,p-xylene (1,300 ug/L). No SVOCs were detected in any of the samples.

All site wells were checked for the presence of SPH on March 1, 1995. Wells MW-28, MW-9, and RW-23 in the northeastern portion of the facility contained measurable SPH. SPH sheen was also noted in MW-26 and MW-27, southwest of the facility. Based on the report titled *Results of the Offsite Well Installations/Groundwater Sampling* (GTI, April 1995a), the delineation of the lateral extent of the SPH was considered complete although MW-34 had detectable levels of benzene, toluene, and xylenes which were above the corresponding New Mexico Water Quality Control Commission (WQCC) criteria. The installation of additional monitoring wells further downgradient of MW-34 will be performed if necessary during a subsequent phase of cleanup activities to further delineate the groundwater plume and/or monitor cleanup results.

4.3 Stream and Sediment Investigations

Stream and sediment sampling was conducted between August 10 and 12, 1994 for both the San Juan River and the Hammond Ditch in the site vicinity. Surface water and sediment samples were collected from three locations in the San Juan River and 14 locations in the Hammond Ditch (Figure 5). The San Juan River water samples were collected from approximately 1 foot below water surface while those collected from the Hammond Ditch were collected from approximately 3 feet below the water surface. The sampling procedures are discussed in greater detail in *Results of the Phase V RFI - Stream and Sediment Sampling* (GTI, October 1994).

Both sediment and surface water samples were analyzed for VOCs, SVOCs, total petroleum hydrocarbons, and metals. Sediment samples were also analyzed for total organic carbon (TOC). Surface water samples were also analyzed for the following general water quality parameters: ammonia, nitrogen, TOC, total dissolved solids (TDS), total suspended solids (TSS), biological oxygen demand (BOD), chemical oxygen demand (COD), and phosphorus.

Results of Stream Analyses

With the exception of methylene chloride, no VOCs were detected in any of the surface water samples from either the San Juan River or the Hammond Ditch. Methylene chloride was detected in one river sample and six ditch samples at concentrations ranging from 13 to 47 ug/L. All three trip blanks contained concentrations of methylene chloride ranging from 54 to 74 ug/L, indicating that methylene chloride is a laboratory artifact. This issue is discussed in greater detail in Phase V RFI report (GTI, October 1994). All other organic analytes including SVOCs and TPH were not detected in any of the surface water samples. The only metals detected in any of the surface water samples were lead (two samples from the Hammond Ditch) and zinc (three samples from the Hammond Ditch). No metals were detected in water from the river (GTI, October 1994).

Results of Sediment Analyses

With the exception of methylene chloride (which is considered a laboratory artifact), no VOCs, SVOCs, or TPH were detected in the San Juan River sediment samples. Arsenic, chromium, copper, nickel, and zinc were detected in at least one of the three San Juan River sediment samples (see Appendix A-2 for a summary of these results).

With the exception of methylene chloride (a laboratory artifact), toluene was the only VOC detected in any of the Hammond Ditch sediment samples (GTI, October 1994). In addition, one SVOC, phenanthrene, was detected in two Hammond Ditch sediment samples. TPH was not detected in any of the sediment samples from the ditch. Arsenic, beryllium, chromium, lead, nickel, and zinc were detected in multiple ditch sediment samples and selenium was detected in one ditch sediment sample (GTI, October 1994).

5.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

The data collected from the field investigations are evaluated for useability in risk assessment. The data evaluation includes a review of the reported data and the corresponding analytical methods, method blanks, and laboratory controls. Compounds that are generally due to laboratory contamination, i.e., acetone, methylene chloride, are also identified and excluded from the risk assessment. Analytical data are labeled with the appropriate qualifiers, if necessary, thus, identifying the values that may be used in the risk assessment. Data that are qualified as unusable for risk assessment are excluded.

The risk assessment eliminates from consideration any data which indicate that a compound is present within the range of natural background concentrations. A compound present at background concentrations is probably not a contaminant released from the GRC facility. Chemicals that are present above background concentrations are then compared to enforceable regulatory levels specified for each chemical in each medium, if available. The COPCs that will be evaluated in the risk assessment are compounds that exceed background level and/or the corresponding regulatory levels, i.e., maximum contaminant levels (MCLs) for groundwater. Chemicals with a frequency of detection of 5 percent or less (n= 20 samples) are also eliminated from the risk assessment (USEPA, 1989).

5.1 Determination of Background Concentrations

Background samples of the different environmental media (soil, sediment, groundwater) were collected from areas that are not impacted by the activities at the GRC site. Four soil samples, eight sediment samples (2 from the San Juan River, 6 from Hammond Ditch), and 35 groundwater samples were collected for the evaluation of background concentrations of inorganic constituents.. Results reported as non-detectable (less than the method detection limits) are included in the background calculations with a value of one-half the detection limit.

The data set for the background soil samples is not large enough (less than 10) to indicate a statistical significance even when there is a difference between the site concentrations and the background concentrations. Therefore, in order to be more health-protective, the lower threshold limit (LTL), rather than the upper tolerance limit (UTL), is used for the determination of background concentrations. When the UTL is used to calculate a concentration based on a very limited number of samples (less than 10), there is a tendency to have a UTL value that is higher than the appropriate background concentration. On the other hand, the lower tolerance level of the background concentrations was calculated to represent a value wherein there is a 10 percent confidence that 95 percent of the distribution will be in this lower range. This suggests that the actual background concentration may actually be higher than the LTL. Thus, by using the LTL, a degree of conservatism is assumed so that inorganic chemicals are not excluded from the risk assessment due to a comparison to inaccurate background concentrations. Another approach used to establish background concentrations used for this assessment was to add two standard deviations to the mean background concentration.

Tables 1 through 3 illustrate a comparison of the calculated background values in the soil, sediment, and groundwater based on the maximum concentrations, UTLs, and LTLs of the data set. The results indicate that the use of the maximum detected concentration in the background samples would be more health-protective because it is the lower value compared to either the UTL or LTL. This statistical aberration is attributed to the number of samples being insufficient to support a statistical analysis of the data.

San Juan River and Hammond Ditch background sediment samples were analyzed separately because there was no documentation that the sediments from the two locations are of similar types. Background concentrations for different sediment types generally exhibit significant variability. Therefore, the background sediment samples collected from the San Juan River are used to identify the chemicals of potential ecological concern (COPECs) in the sediment collected from the river. Sediment samples collected from the Hammond Ditch are compared to the maximum detected levels in the background sediment samples from the Hammond Ditch.

The number of background samples collected for groundwater is sufficient to support the use of the UTL for determining the background concentration. Thus, for groundwater, the background concentration based on the calculated UTL was compared to the background value calculated by using another method, that is, mean plus two standard deviations. In the evaluation of the groundwater data, the background concentrations derived by calculating the mean plus two standard deviations were found to be lower, thus, more conservative. Based on these results, the background concentrations calculated through the latter approach were used as the reference concentrations.

5.2 COPCs for Human Health Risk Assessment

The list of COPCs in the soil and groundwater are presented in Tables 4 and 5. The detection limits, the maximum detected concentration, the frequency of detection, the background concentration, and the rationale for selecting a specific chemical as a COPC are also shown on these tables.

5.2.1 COPCs in Soil

Based on a comparison with background levels and the frequency of detection, the soil COPCs include BTEX, copper, lead, nickel, and zinc (Table 4). However, lead was not selected as a COPC because the maximum on-site concentration (11 mg/kg) is below the level of 400 mg/kg that is considered protective of children, the most sensitive human receptors for lead exposure (USEPA, 1994).

Acetone and methylene chloride were both detected in on-site soil samples. However, they are common laboratory contaminants and are not evaluated in the risk assessment. Thus, the soil COPCs are BTEX, copper, nickel, and zinc.

5.2.2 COPCs in Groundwater

The list of COPCs in groundwater is presented in Table 5. Based on the comparison to background and the frequency of detection, the groundwater COPCs are BTEX, 2,4-dimethylphenol, 2-methylnaphthalene, 3-methylphenol, naphthalene, and phenol. Four of the five metals detected in groundwater (arsenic, chromium, lead, and zinc) were all within background concentrations and therefore, were not identified as COPCs. No background data was available for copper, thus, the maximum detected groundwater concentration (0.034 mg/L) was compared to the Federal Secondary MCL (1.0 mg/L) for drinking water. Based on this comparison, copper was not selected as a COPC. Therefore, metals are not identified as COPCs in groundwater.

5.2.3 COPCs in Sediment

The detected chemicals in the sediments are addressed in the ecological assessment because of the potential for direct exposure to aquatic receptors. Human receptors are not likely to come into direct contact with sediments, are at a higher trophic level in the food chain and will, consequently, be affected only through ingestion of aquatic species, (e.g., fish) that may be exposed to the sediments. Unless the ecological assessment demonstrates that aquatic receptors may be adversely affected by constituents detected in the sediment or that the chemicals may be bioaccumulated, this medium is not a concern in the human health risk assessment.

5.3 Chemicals of Potential Ecological Concern (COPECs)

Sediment and surface water in the Hammond Ditch and San Juan River were evaluated for the presence of COPECs. Groundwater, is not a medium of concern for the ecological assessment because there is no likelihood that ecological receptors will have a complete exposure pathway. As previously stated (Sec. 2.4), the shallowest depth to groundwater is six feet. The types of vegetation that occur/might occur at the GRC site or its vicinity do not have root systems deep enough to allow for transport of groundwater chemicals via root uptake. Soil is also not a medium of concern for ecological receptors because the only areas of impacted soil are within the refinery boundaries and there are no habitats which could support ecological receptors within the property line. Therefore, there are no complete exposure pathways through which chemicals in soil and groundwater may contact ecological receptors.

5.3.1 COPECs in Hammond Ditch and San Juan River Sediments

Sediment COPECs were initially identified by comparison to background (metals only). Inorganic analytes that exceed the background concentrations, as well as all detected organic constituents, are compared to the sediment screening criteria recommended by the National Oceanic and Atmospheric Administration (NOAA). The sediment screening levels are based on the Effects Range-Low (ER-L) which is the lower 10-percentile of the range of concentrations in which adverse effects were observed or predicted to occur. Based on these criteria, the sediment COPECs for the Hammond Ditch are phenanthrene, copper, and zinc (Table 6). There were no COPECs identified in San Juan River sediments because the maximum concentrations for the detected inorganic constituents are below the corresponding background levels and the NOAA sediment screening criteria. No organics were detected in San Juan River sediments.

5.3.2 COPECs in Hammond Ditch and San Juan River Surface Water

Surface water COPECs were identified by comparison of detected concentrations to the USEPA's Ambient Water Quality Criteria Chronic (AWQCc) for the protection of freshwater aquatic life. No organics (except methylene chloride which is a laboratory artifact) or metals were detected in the San Juan River water samples. Therefore, there are no COPECs in San Juan River surface water (Table 7). Likewise, no organics, except methylene chloride, were detected in Hammond Ditch surface water samples. The only metals detected in Hammond Ditch water samples were lead and zinc at maximum concentrations of 4 ug/L and 30 ug/L, respectively. The AWQCc for lead and zinc are 3.2 ug/L and 110 ug/L, respectively. Based on this comparison and the fact that no organics were detected in Hammond Ditch water samples, there are no COPECs in Hammond Ditch surface water (Table 7).

6.0 EXPOSURE ASSESSMENT

This section identifies the complete exposure pathways and describes the receptors that may be potentially exposed to the COPCs/COPECs. The exposure assessment considers the current and future land use of the site as well as the adjacent or off-site populations that may be exposed to chemicals that have migrated off-site. Information regarding important physical characteristics of the GRC site that may influence the potential exposure pathways, such as climatology and geology, are also incorporated in the exposure assessment.

6.1 Land Use

The site is zoned as an industrial site whereas the surrounding area is zoned for commercial/industrial use. There is no indication that the designated use of the area will change in the future.

There are two one-story residential homes located approximately 400 feet south of the inactive spray irrigation area. The homes are on a slight incline that slopes toward the facility. Based on the collected data, these homes are upgradient of the site and should not be impacted by the COPCs.

Public property managed by the BLM borders the southern portion of the facility. A single story office building is located on a hill that slopes toward the north-northeast (toward the GRC facility). Undeveloped public and private lands, as well as several gravel pits, border the eastern portion of the property. Private, undeveloped land borders the western side of the property.

The town of Bloomfield is located immediately north of the refinery, across the San Juan River, and has a population of approximately 5,000. The major portion of the undeveloped land in the vicinity of the refinery is used extensively for oil and gas production and, in some instances, for grazing.

6.2 Conceptual Site Model

The conceptual site model describes the different mechanisms by which chemicals that are released from identified sources are transported through the environmental media and come into contact with potential human and ecological receptors. Spills from above-ground tanks are transported to the surface soil through surface dispersion and migrate to the subsurface soil and the groundwater through leaching or infiltration/percolation. Chemicals that leak from the evaporation ponds are also transported through these same mechanisms. Compounds that are present in the surface soil may come in contact with potential receptors through incidental ingestion, inhalation, dermal contact, volatilization and/or dust-borne particulate matter. Chemicals that have migrated to the groundwater may come in contact with potential receptors through incidental ingestion, dermal contact and/or inhalation of volatiles.

Ecological receptors may be potentially exposed to sediment and surface water COPCs through direct contact or via the food chain.

6.3 Identification of Potential Human Receptors and Associated Exposure Pathways

This section describes the human and ecological receptors that may be potentially exposed to the COPCs/COPECs. The exposure parameters that are applied in the human health risk assessment are presented in the spreadsheets used to calculate exposure, risk and hazard indices (see Appendix B).

6.3.1 On-Site Worker

Based on the current industrial use of the site, the on-site worker may be exposed to chemicals in the surface soil through incidental ingestion, dermal contact, and inhalation of volatiles and dust-borne particles. Exposure to subsurface soil is incomplete for the on-site worker because excavations that may occur at the facility are implemented with the proper protective clothing and applicable health and safety measures.

Although the shallow perched water-bearing zone has been impacted, data from the monitoring wells do not provide evidence that the deeper aquifer has been impacted. A confining layer, the relatively impermeable Nacimiento Formation, is present between the deeper aquifer, Ojo Alamo, and the shallow, perched zone. Thus migration of water and chemicals from the shallow saturated zone to the Ojo Alamo aquifer is not a significant concern. The current operations at the site do not use groundwater as a source of potable or industrial water. As mentioned earlier, the future land use of the site, as well as the groundwater use, is expected to remain the same. Thus, the only potential exposure that an on-site worker may have to the COPCs in the groundwater is through inhalation of volatile components via vapor intrusion into the buildings. This, of course, is an insignificant increment to other fugitive emissions that are likely to occur in refinery operations.

6.3.2 Off-site Adult Resident

Information about the future use of the site does not warrant that a hypothetical future on-site resident be evaluated since the zoning and property use will remain industrial. It should be noted that according to the New Mexico WQCC regulations (Part 3-103.C), the water quality of the perched aquifer (TDS > 1,000 mg/kg) makes it unsuitable for potable or irrigation uses. However, the risks posed to off-site residential receptors due to the presence of chemicals in the groundwater will be evaluated based on limited exposures of irrigation water.

The residents in the area to the south-southwest of GRC are currently being supplied with water from the municipal water supply, thus, the use of the shallow groundwater for "gray water" purposes such as lawn irrigation is the only scenario that is possible for future exposure. In order to fulfill the requirements of a standard baseline risk assessment, risks associated with potable use of the shallow groundwater are presented for comparative purposes. The risk assessment evaluates potential risks to an adult resident who may be potentially exposed to the dissolved phase hydrocarbons in the groundwater through inhalation of volatiles and dermal absorption while watering the lawn. Exposure to a child resident is not essential because the parameters for this scenario assume the adult to have a higher exposure frequency and duration than a child, and thus, a greater potential risk.

Potential exposure of current and future off-site residents to COPCs in surface and subsurface soils will not be evaluated because there are no identified COPCs in the surface and subsurface soil off-site.

6.4 Identification of Potential Ecological Receptors and Associated Exposure Pathways

The primary purpose of the Hammond Ditch is to provide water for irrigation of agricultural fields within the Hammond project area. Coincidentally, the Hammond Ditch also supports adjacent wetlands, through seepage of water from the unlined ditch, and riparian habitats along the ditch corridor. Waterfowl have been observed in the ditch near the site and the ecological assessment assumes that both resident and transitory wildlife in the area may use the ditch as a source of water and food. However, no COPECs were identified in Hammond Ditch water.

As discussed in Section 5.3, COPECs were identified in the Hammond Ditch sediments but no COPECs were identified in Hammond Ditch water, San Juan River water or San Juan River sediments. Thus, the only ecological receptors which may be exposed to COPECs in the Hammond Ditch are those which come into contact with the sediments either through direct exposure or indirectly through the food web.

Benthic invertebrates were identified as appropriate ecological receptors associated with Hammond Ditch that may have the highest direct exposure to the sediments. While no survey of benthos in the Hammond Ditch sediments has been completed, it is unlikely that the majority of the ditch sediments support a significant benthic community due to the fact that most of the ditch only contains water during the irrigation season (April 15 through October 15). However, the portion of the ditch adjacent to the site is diked during the non-irrigation season and contains water year round. This may result in a resident benthic community. Lacking a survey of benthic organisms, this assessment is limited to an evaluation of benthic invertebrates as a group.

In addition, resident and migratory ducks may be exposed to COPECs in Hammond Ditch sediments through incidental ingestion of sediments while feeding and through the food web. The diets of many of the duck species which are likely to feed in the ditch include aquatic plants and benthic invertebrates. Again, since there are no ducks on the lists of state and federally listed species, ducks of the family Anatidae will be evaluated as a group.

While benthic invertebrates and waterfowl may be exposed to Hammond Ditch sediments containing COPECs, the limited area of sediments containing COPECs above NOAA sediment screening guidelines is very small. The identified COPECs in Hammond Ditch sediments are phenanthrene, copper, and zinc. Phenanthrene was detected in only two of 28 Hammond Ditch sediment samples (HD-4B and HD-9B) indicating limited distribution of phenanthrene in sediments. Furthermore, copper and zinc concentrations only exceeded the NOAA sediment screening guidelines in two and one of 28 samples, respectively (copper in HD-8S and HD-4B and zinc in HD-8S). While benthic organisms in these areas could potentially be exposed, it is likely that any possible benthic community in the Hammond Ditch would not be significantly impacted. In addition, ducks feeding in the ditch are likely to forage over a much larger area than those impacted by sediment COPECs reducing potential exposures and subsequently reducing the potential for exposure to result in significant impacts on local duck populations.

7.0 ENVIRONMENTAL FATE AND TRANSPORT MODELING

Data from the site assessments indicate that hydrocarbons are present in groundwater at the site. This section evaluates the migration of the selected chemicals in groundwater to hypothetical receptor locations, located off site.

7.1 Background to Modeling the Migration of Chemicals in Soil and Groundwater

Chemicals in the subsurface environment are subject to a variety of transportation and transformation processes. These processes can be put into several categories: advection, sorption, transformation/ degradation, and volatilization. Mathematical fate and transport models can be used to simulate these processes which occur singly or in concert. These mathematical representations of natural processes are limited in their degree of accuracy by the mathematical simulation of each process and the interactions between them. Several of these processes and their effect on chemical movement in the saturated (groundwater) zones are discussed in more detail below.

7.1.1 *Advection*

Transport of chemicals in the subsurface environment occurs in the pore spaces of the soil matrix. Transport of chemicals can occur in three fluid phases: (1) chemical dissolved in soil moisture; (2) volatilized chemical in pore gas; and (3) immiscible phase chemical. Movement of these fluids is governed by pressure differentials and potential energy differentials, primarily caused by gravity. Therefore, the main direction of flow for these fluids is from an area of high pressure or high potential energy to an area of lower pressure or potential energy.

The migration of chemicals in these fluids may include several separate pathways and mechanisms. These include: runoff into streams and other water bodies, volatilization into the atmosphere, and leaching through soil to groundwater. The aqueous solubility of a compound is a critical property affecting the mass of material that can be transported as a function of time. Highly soluble chemicals can be rapidly leached from soils and are generally mobile in groundwater. The solubilities of organic chemicals generally range from approximately 1 μg/L for polychlorinated biphenyls (PCBs) to greater than 100,000 ug/L for acetone and dioxane (Howard, 1990).

7.1.2 *Sorption*

Sorption is the removal of the solute from a solution through electrostatic or chemical interactions with a solid surface (S & M, 1987). Sorption can occur as a result of the affinity of the solute for the solid, or the lack of affinity of the solute for the solution. The lack of a solute's affinity for water is termed *hydrophobicity* and is typified by many non-polar organic compounds. Hydrophobic chemicals adsorb readily to soil organic matter and clay particles and will not migrate significantly in pore water from the region of the soil profile in which they are initially introduced.

The sorption of hydrophobic chemicals to soils can be correlated to the organic carbon content of the soil. Hydrophobic chemicals undergo a partitioning between the organic carbon of the soil and the water. The adsorption or distribution coefficient (K_d) is the ratio of the adsorbed concentration of a compound to its dissolved concentration (Dragun, 1988). Thus, chemicals with a large value of K_d will be sorbed to a greater extent than chemicals with low K_d values. For organic molecules K_d is the product of the K_{oc} and the fraction organic carbon content of the soil (f_{oc}). This partitioning is similar to the partitioning of the chemical between water and an immiscible organic solvent, such as octanol. Thus, the octanol-water partition coefficient (K_{ow}) can be used to calculate the K_{oc}. The normal range of K_{oc} is from 1.0 L/kg for a compound such as acetone which does not partition into the organic fraction, to greater than 100,000 L/kg for some PCBs, indicating almost total adsorption onto the organic fraction of the soil.

7.1.3 Transformation-Degradation

Transformation and degradation processes include the chemical and biological mechanisms that determine the fate of a chemical and its persistence in soil or groundwater. The dominant processes include biotransformation, chemical hydrolysis, photolysis, and oxidation reduction. These processes can be either aerobic or anaerobic depending upon the nature and extent of the contamination. The time scale for these processes is usually discussed in terms of the half-life for the chemical and can range from days for acetone to tens of years for PCBs.

Biodegradation has been observed to be a significant removal mechanism for BTEX and other petroleum hydrocarbons in both soil and groundwater (Sullivan *et al.*, 1991). The rate of biodegradation for a chemical in an environmental media can vary due to a number of factors. Among these factors are the presence and population density of microbial populations which can degrade the chemical, the presence of mineral nutrients required by these microbes, and the concentration of the chemical in the media. Additionally, the temperature, oxygen content, and pH of the media can affect the rate of degradation (Dragun, 1988).

With so many variables that can affect biodegradation, selection of an appropriate rate to use in a risk assessment at a specific site is difficult. The use of a conservative rate will tend to underestimate the rate of degradation. Thus, the amount of available chemical will be overestimated. Use of this procedure will be protective of public health since it will result in conservative estimates of risk from the chemicals being evaluated (Sullivan *et al.,* 1991).

7.2 BIOPLUME Modeling

BIOPLUME is a computer code for "Two Dimensional Contaminant Transport Under the Influence of Oxygen Limited Biodegradation in Ground Water" (Rifai, *et al.*, 1987). This numerical model was developed at the National Center for Ground Water Research of Rice University. The model is based on the USGS Method Of Characteristics (MOC) program (Konikow & Bredehoeft, 1978) and adds the optional process of oxygen-limited biodegradation. BIOPLUME solves the solute transport equation twice; once for the concentration of hydrocarbon or organic chemical and then again for oxygen. This model can simulate the migration of a chemical plume which has initial concentrations that vary with location, and allows for non-homogenous characteristics of an aquifer, such as variable gradient and transmissivity values. Due to the availability of site data such as individual point concentrations of chemicals dissolved in groundwater, and the presence of the Hammond Ditch, which influences the gradient, this model was selected for modeling the transport of chemicals in the saturated zone.

7.2.1 BIOPLUME Input Data

BIOPLUME is a numerical model that simulates groundwater migration of chemicals through a user-defined grid. Up to 20 intervals can be delineated on the x axis and up to 30 intervals can be delineated along the y axis. Each intersection of these intervals is termed a "node". Values for transmissivity, aquifer thickness, initial or constant water elevations, initial chemical concentrations, and oxygen concentration can be designated for each node. Additionally, pumping, recharge, and observation wells may be specified at nodes. At nodes that are specified as observation wells, chemical concentrations and water elevations are calculated at specified time intervals.

A 20 by 30 grid was constructed for the input of data to the BIOPLUME model. The grid encompasses an area including all on-property monitoring wells and extending 2,600 feet downgradient of the facility's southwest corner. The grid's long axis (y-axis) was aligned with the direction of groundwater flow (17 degrees south of west). Thus, there are 30 nodes along the west/east axis, spaced at 200 foot intervals, and 20 nodes along the north/south axis, also spaced at 200 foot intervals. This grid is shown with an overlay of the facility boundary in Figure 6.

7.2.1.1 Aquifer Parameters. Aquifer parameters for which BIOPLUME requires quantification include gradient, thickness, transmissivity, bulk density, effective porosity, and distribution coefficient. The values for these parameters were derived from site-specific measurements and literature values.

The gradient of the aquifer across the facility was estimated by dividing the difference in groundwater elevation at MW-8 and MW-34 based on water levels measured on March 1, 1995 by the distance between these points (3,300 ft.). This results in a gradient of 0.002 ft./ft. in a direction 17° south of west. This gradient was entered in BIOPLUME by setting constant head boundaries along the west and east sides of the grid. The difference in the head elevations along these two boundaries was 10.8 feet and the distance between these boundaries was 5,400 feet, thus yielding a gradient of 0.002.

To stimulate the effect of the "mounding" caused by the diking and filling of the Hammond Ditch, constant head boundaries were also set along the length of the ditch. The values set along the ditch ranged from 5,502 ft. to 5,492 ft., and were iteratively set so that the predicted initial heads correlated well with measured values. An average thickness of 8 feet was assumed for the saturated zone.

Porosity, density, organic carbon content, and transmissivity values were obtained from field samples and data collected by Groundwater Technology. Samples from the subsurface were collected during the drilling of B-2, B-6, and B-10 were submitted for physical laboratory analyses (IML, 1994). These samples were taken at depths ranging 2 to 8 feet below grade. Results of these analyses are given in Table 8.

The total porosity of a soil is a measurement of the fraction of the soil volume that is not occupied by soil particles. This is a measurement of the "empty spaces" in soil which can be occupied by either air or water. The value for total porosity for the aquifer based on the sample analyzed is 35%.

When water occupies the pore spaces in soil it can exist in a number of forms. Hygroscopic water is the fraction of the pore water which is tightly held to soil particles. This hygroscopic water is not mobile (Dragun, 1988). The effective porosity is the fraction of soil volume through which water can move when the soil is saturated. Thus, the effective porosity represents the total porosity minus the fraction of the porosity occupied by water that does not move, which is represented by the hygroscopic water. The value of effective porosity determined by this analysis was 24%.

The transmissivity of an aquifer is defined as the product of the thickness of the aquifer and the hydraulic conductivity of the aquifer. The transmissivity measures the potential for an aquifer to be developed as a water source (Freeze & Cherry, 1979). The transmissivity values measured during the pumping tests ranged between 64 ft^2/day and 1412 ft^2/day. The lowest of these values, 64 ft^2/day, was used based on comparison of the results of initial modeling runs to historical groundwater analyses.

The distribution coefficient (K_d) describes the extent to which chemicals will sorb to aquifer material. It is defined as the product of the fraction organic carbon content of the aquifer (f_{oc}) and the organic carbon-water partition coefficient of the chemical (K_{oc}). The amount of organic carbon detected in the analysis of the collected sample was 0.0013 and was assumed to be representative of the aquifer. Using this value in conjunction with the K_{oc} values for the indicator chemicals yielded the K_d values listed in Table 9.

BIOPLUME allows for the simulation of degradation through two methods. The first method is through specification of a constant degradation rate. The second method is through the input of dissolved oxygen concentrations and assuming that three oxygen molecules will degrade one hydrocarbon molecule instantaneously. While the second method can be more site specific, it can be misleading if oxygen is not the limiting parameter for hydrocarbon degrading bacteria.

Based on the analyses of five well samples for bacteria enumeration and biological indicators, bacteria in groundwater at the site are present in very low concentrations. The growth of these bacteria is predicted to be limited not by oxygen, but by nutrients, particularly orthophosphate. Therefore, oxygen limited degradation was not used. A conservative degradation half-life of 10 years was used, which was derived by incorporating a safety factor of 5 to the anaerobic degradation half-life of 2 years for benzene (Howard, et al., 1991).

7.2.1.2 Initial Chemical Concentrations. Initial values of hydrocarbon concentrations can be input at each node in BIOPLUME. To derive these values all analyses of indicator chemicals for groundwater at the site were used (Table A-2). For each chemical, the last recorded concentration at each well were assumed to be present. For wells in which SPH was present during the last sampling event, the maximum measured concentration for each BTEX component in all wells was used. These values are 9,500 ug/L, 26,000 ug/l, 28,800 ug/l, and 27,300 ug/L for benzene, toluene, ethylbenzene, and xylenes, respectively. At wells in which measurable thickness (greater than a "sheen") of SPH were present (RW-2, RW-19, RW-23, MW-9, and MW-28), it was assumed that there was a continuing sources of BTEX at the maximum recorded concentrations.

Using an inverse distance-squared interpolation of these data points, SURFER (Golden, 1990) created the resulting isocons of the distribution of the chemical concentrations in the vicinity of the site. These isocons are presented in Figures 7 through 10.

7.2.1.3 Location of Groundwater Receptor Points. The maximum number of receptor locations that can be specified in BIOPLUME is five. These receptors were located on the grid at positions that would correspond to potential receptors. Receptor well 1 was located corresponding to water well location 1 from the water well inventory conducted by Tierra (1992) and presented in Figure 4. Receptor well 2 was located at monitoring well MW-34, the farthest downgradient monitoring well. Another three receptor wells (3, 4, and 5) were located directly downgradient of MW-34 at distances of 600, 1,200, and 1,800 ft., respectively.

7.2.2 *Results of BIOPLUME Modeling*

The output from BIOPLUME includes all input values used, calculated hydraulic heads at all nodes, and concentrations of chemicals at the receptor points at each designated time step. For this modeling study, concentrations were calculated at 5 year intervals for a period of 95 years. These data are presented for each chemical in Tables 10 through 13.

The results given in Tables 10 through 13 indicate that BTEX will not migrate to Well #1, located south of the site. During the 95 years simulated, detectable concentrations of toluene, ethylbenzene, and xylenes are not predicted to reach receptor well 5, and detectable concentrations of benzene will not reach this point until 90 years have elapsed. Additionally, detectable concentrations of ethylbenzene are not predicted to reach receptor well 4 during the 95 year simulation.

These data also give an indication of the amount of attenuation due to adsorption, degradation, and dispersion which will occur as these plumes migrate downgradient to MW-34 and the three hypothetical receptor wells (3, 4, and 5). The maximium concentration of benzene which is predicted to occur at MW-34 is 8,573 ug/L in 70 years. This is 90% of the maximum concentration currently assumed to be present in groundwater. Thus, a 10% attenuation will occur as benzene migrates to MW-34. The maximum concentration of benzene measured at receptor well 3 is 6,795 ug/L, which indicates an attenuation of 29%. The benzene concentrations at receptor wells 4 and 5 are still increasing at the end of the 95 year simulations, so it is not possible to calculate the amount of attenuation which will occur during the transport of benzene to these points, although it will be greater than 29% due to the greater distance to these wells.

The amount of attenuation of toluene, ethylbenzene, and xylenes which would occur during the transport of these chemicals to the various receptor wells can not be predicted since the maximum predicted concentrations of these chemicals at MW-34 occur at the end of the 95 year simulation. However, since the degradation rates used for all chemicals was the same, the degree of attenuation of these chemicals would be related to their K_{oc} values. Therefore, since toluene, ethylbenzene and xylenes have greater K_{oc} values than benzene, they would be expected to have greater attenuation values than benzene at each well location.

7.2.3 Conservatism Associated with Environmental Fate Modeling

A number of assumptions were used in the modeling section which may introduce a measure of uncertainty and conservatism into the assessment. The use of conservative assumptions in the modeling results in the overestimation of the transport of chemicals in the saturated zone. Conservative assumptions used to evaluate the migration of chemicals using the BIOPLUME model include:

(1) The thickness of the regional aquifer was modeled as 8 feet. This was done since this is an average thickness of this layer which is observed by the monitoring wells at the site, and so represents the thickness of the aquifer for which data are available. However, by restricting the thickness to this size, the dilution of chemicals within the whole aquifer is limited. Thus, the chemical concentrations predicted by the model may be conservatively high, if the aquifer is thicker in the downgradient direction.

(2) The maximum dissolved concentrations of chemicals measured during all sampling was assumed to be present in monitoring wells containing SPH. This potentially overestimates the concentrations and the total mass of chemicals present in groundwater.

(3) In the BIOPLUME simulations, degradation of chemicals was assumed to occur at levels 5 times slower than the anaerobic rates listed in Howard (1991). The half-life for benzene in groundwater has been reported to range as low as 10 days to two years (Howard, 1991). Incorporation of a half-life of 2 years, as opposed to the 10 year value used for benzene would greatly decrease the resulting concentrations at the receptor wells.

(4) Since BIOPLUME II is a two-dimensional model, concentrations were assumed to be present throughout the saturated thickness. In actuality, these concentrations of hydrocarbons are only present in the top one or two feet of this layer. This could quadruple the amount of chemicals assumed to be present.

(5) No account was made for the pumping of the recovery wells. This pumping probably results in a large amount of hydraulic control of the bulk of the plume, and is removing SPH and dissolved chemicals.

(6) It was assumed that the perched aquifer is continuous to a distance of at least 2,600 feet downgradient of the site. Due to the lack of monitoring wells downgradient of the site, this assumption cannot be confirmed. If this perched zone does "pinch out" before reaching the receptor wells, this transport could not occur.

8.0 TOXICITY ASSESSMENT

The toxicity assessment examines the information concerning the potential human health effects due to exposure to the COPCs. The toxicity information provides, for each listed COPC, a basis for the risk characterization.

The toxicity evaluation involves a critical review and interpretation of toxicity data from epidemiological, clinical, animal, and in vitro studies. The review of the scientific data ideally determines both the nature of the health effects associated with a particular chemical and the probability that a given dose of a chemical could result in an adverse health effect. The information considered important for the quantitative risk assessment includes the potential for a chemical to initiate and/or promote tumors; the potential for chronic non-cancer, adverse health effects; the ability to affect reproduction; and the ability to cause short-term, acute effects.

8.1 Carcinogens

Identification of constituents as known, probable, or possible human carcinogens is based on a USEPA weight-of-evidence classification scheme in which chemicals are systematically evaluated for their ability to cause cancer in mammalian species and conclusions are reached about the potential to cause cancer in humans. The six classifications based on the weight of available evidence (USEPA, 1989) are as follows:

A	-	known human carcinogen
B1	-	probable human carcinogen, limited evidence in humans
B2	-	probable human carcinogen, sufficient evidence in animals and inadequate data in humans
C	-	possible human carcinogen, limited evidence in animals
D	-	inadequate evidence to classify
E	-	evidence of noncarcinogenicity

Some chemicals in Class D may have the potential to cause cancer, but adequate data are not currently available to change the classification.

The cancer slope factor is the toxicity value used to quantitatively express the carcinogenic hazard of cancer-causing constituents. The slope factor (SF) is expressed in units of $(mg/kg/day)^{-1}$ and represents the cancer risk per unit daily intake of carcinogenic chemical. The SFs for carcinogenic COPCs at the GRC facility are presented in Table 14.

8.2 Noncarcinogens

For noncarcinogens, it is assumed that a dose exists below which no adverse health effects will be seen, i.e., a threshold dose. The reference dose (RfD) is the toxicity value used to quantitatively express the hazard of noncarcinogenic constituents. The RfD is expressed in units of mg/kg/day and represents a daily intake of contaminant per kilogram of body weight that is not sufficient to cause the threshold effects of concern for the contaminant, even in sensitive subpopulations. Exposure doses above the RfD could cause adverse health effects. RfDs are for a given route of administration (oral, inhalation, or dermal) and for a given exposure duration (acute, subchronic, or chronic). The RfDs for the noncarcinogenic COPCs at the GRC facility are also presented in Table 14.

8.3 Sources of Toxicity Values

The slope factors of the COPCs that are evaluated in this risk assessment were obtained from the Integrated Risk Information System (IRIS). If a compound has no available toxicity value in the IRIS data base, the values were taken from the Health Effects Assessment Summary Table (HEAST). Oral RfDs were used for inhalation RfDs when the latter are not available.

9.0 RISK CHARACTERIZATION

This section of the risk assessment describes how calculated exposure doses are converted into health risks. Risk characterization involves the integration of health effects information developed as part of the toxicity assessment and exposure estimates developed as part of the exposure assessment.

9.1 Results of the Human Health Risk Characterization

This section discusses the calculated health risks posed to potential human receptors of the COPCs detected in the soil and groundwater. Section 9.2 discusses the potential ecological effects of COPCs in the sediments at the GRC site.

9.1.1 Risks Due to Exposure to Soil COPCs

The potential risks posed to the on-site worker due to exposure to BTEX, copper, nickel, and zinc in the soil at the GRC site were evaluated and presented in Appendix B. The exposure pathways that were considered complete were through incidental soil ingestion, dermal contact, and inhalation of volatile emissions and dust-borne particulates. The equations for calculating the daily intake (dose) of each COPC via each pathway and the calculated risks/hazard are presented in Appendix B-1, Tables B-1 through B-4. The exposure parameters used in calculating the dose are also presented based on standard assumptions established by USEPA (USEPA, 1991).

The cumulative cancer risk due to exposure of an **on-site worker** to surface soil COPCs is **3 E-10** and the cumulative noncancer risk is **1.62 E-04** (Appendix B-9). The acceptable cancer risk established by USEPA is in the range of 1 E-04 to 1 E-06 and the noncancer risk or hazard index that is considered protective of adverse health effects is 1.0. Based on these target cancer and noncancer risks that are considered health-protective, the potential exposure of an on-site worker to the surface soil does not pose a likelihood of adverse cancer and noncancer health effects.

The evaluation of potential risks to the off-site human receptors due to exposure to soil COPCs is not warranted because it has been demonstrated that chemical concentrations in the surface soil at the site do not present a likelihood of adverse health effects to the on-site receptors who will have the highest exposure.

9.1.2 Risks Due to Exposure to Groundwater COPCs

The current and future land use of the GRC site do not use groundwater as a source of potable water supply. Similarly, the water that is used in the industrial processes is obtained from the San Juan River, thus, there is no complete exposure of an **on-site worker** to the groundwater underneath the site through incidental ingestion and dermal contact. The only potential pathway is via the inhalation of vapors that may intrude through the cracks of the foundations and walls of the buildings at the site.

The calculated risk/hazard (Appendix B-5) posed to the **on-site worker** is based on the 95% upper confidence limit (UCL) of the detected concentrations of on-site wells during the last two quarters of monitoring. It should be noted that the baseline risk assessment is premised on the following conservative assumptions:

a) The risk is due to exposure to maximum detected chemical concentrations within the last three quarters of monitoring and do not take into account reductions in the concentrations due to natural attenuation or ongoing or proposed corrective measures.

b) The estimated risk is based on standard default assumptions which may have exposure frequencies and durations that are longer than the site-specific worker scenarios.

Based on the assumptions stated above, the estimated cumulative cancer and noncancer risks due to inhalation of volatiles from the groundwater while working inside the buildings are **$2E^{-5}$** and **0.016**, respectively (Appendix B-9). The estimated cancer risk value is within the acceptable range of 10^{-4} and 10^{-6} and may actually approach 10^{-6} when one considers the inherent uncertainty of the estimate due to the conservative nature of the standard default assumptions. The estimated noncancer risk is below 1.0. Therefore, the COPCs identified in the groundwater at the site do not pose a potential risk to the on-site worker.

The baseline risk assessment also evaluated the potential exposure of **off-site residents** to COPCs in the groundwater. In the baseline risk assessment, the chemical concentrations at the point of exposure is the arithmetic mean of the concentrations detected in three monitoring wells, located on BLM-owned property immediately downgradient of the site, during the previous monitoring events. The calculated cumulative cancer and noncancer risks due to exposure of a hypothetical off-site resident to the groundwater through incidental ingestion, dermal contact, and inhalation of volatiles are **6 E-03** and **0.69**, respectively.

It should be noted that the only contributor to the cumulative cancer risk is the chemical concentration of benzene over a period of three quarters of monitoring. Furthermore, the probability that the BLM-owned property, if converted to a residential area, will use the shallow perched zone as a water supply is extremely remote. Aside from the fact that the water quality of the shallow aquifer is not conducive to being used as a source for potable water, the San Juan River and the deeper aquifer are currently used as the water supply for residents in the area. The only scenario that can be realistically assumed for future residential use of the shallow groundwater is as a source of gray water for lawn irrigation. The estimated cancer risk from dermal contact and inhalation of vapor is **1 E-06** while the total HI is 0.0021. There is an existing aquitard between the shallow and deeper aquifer so that the likelihood that the shallow groundwater COPCs will eventually impact the deeper aquifer does not exist.

The baseline risk assessment also assumes that no removal of the SPH will be implemented which would result in a continuing lateral migration of the groundwater COPCs. The results of the environmental fate and transport modeling demonstrates how the levels of benzene may progressively increase off-site, towards the direction of the BLM-owned property. When the current on-site dissolved-phase benzene concentrations are modeled towards the direction of the residential area, located southwest of the GRC facility, benzene is expected to remain at non-detectable concentrations until 90 years from now.

The cumulative noncancer risk under baseline conditions do not indicate that adverse health effects will be posed to current and future hypothetical residential receptors due to exposure to the non-carcinogens in the groundwater.

9.2 Results of the Ecological Assessment

The only identified COPECs at the GRC site are phenanthrene, toluene, copper, and zinc in the Hammond Ditch sediments. A qualitative ecological evaluation will be performed on the potential effects of these COPECs on the selected ecological receptors. The receptors that will have the highest exposure to the sediments are benthic invertebrates in the Hammond Ditch.

9.2.1 Ecological Effects of Phenanthrene

The ultimate fate of PAHs that accumulate in sediments is biotransformation and biodegradation by benthic organisms (Eisler, 1987). Aquatic invertebrates can accumulate significant concentrations of PAHs, possibly due to inefficient or missing mixed-function oxidase systems. Some investigations have shown that aquatic invertebrates, fish, and amphibians collected from areas of high sediment PAH content show elevated frequencies of hyperplasia and neoplasis (Black, et.al., 1985). PAHs vary in their toxicity to aquatic organisms. In all but a few cases, PAH concentrations that are acutely toxic to aquatic organisms are several orders of magnitude higher than concentrations found in the most heavily polluted waters (Neff, 1979). Phenanthrene is metabolized by many species of aquatic organisms, including fish. However, the ecological impact of PAHs is still uncertain. PAHs show little tendency for bioconcentration, despite their high lipid solubility (Eisler, 1987), probably because PAHs are rapidly metabolized.

The maximum detected concentration of phenanthrene in the Hammond Ditch sediments is 1.3 mg/kg as compared to the sediment screening guideline of 0.24 mg/kg (NOAA, 1994). This comparison indicates that benthic organisms living in sediments containing phenanthrene concentrations above the screening guideline may exhibit chronic toxic effects. However, due to the limited area of sediments containing phenanthrene, it is unlikely that any potential benthic community in the Hammond Ditch will be significantly impacted.

Due to the lack of bioaccumulation of PAHs and the limited extent of sediments containing phenanthrene, ducks and other organisms which may feed on benthic organisms are not likely to experience toxic affects associated with food web exposures. In addition, due to the small area of phenanthrene in sediments and the relatively large area over which ducks are likely to forage, it is unlikely that any ducks will experience significant exposures or detrimental effects as a result of direct exposures to sediments.

9.2.2 *Ecological Effects of Copper*

Dissolved concentrations of copper ranging from 67 to 87 ug/L have been observed to affect growth and population viability in chironomids (midges). Acute mortality (lethal concentrations for 50% of the exposed population; LC_{50}) in chironomids have been noted at dissolved copper concentrations ranging from approximately 300 ug/L to greater than 10,000 ug/L. The bioaccumulation potential for most metals (including copper) is expected to be low due to the ability of organisms to metabolize, excrete, or sequester them.

It is unlikely that significant exposures or detrimental impacts on benthic organisms or ducks will occur based on: (1) the lack of bioaccumulation potential, (2) the low solubility of copper, (3) the limited area of sediments containing copper above the NOAA sediment screening guideline (34 ug/kg) relative to the area in which benthic populations may occur and waterfowl are likely to forage, (4) the toxicity information presented above, and (5) the lack of detected concentrations of copper in Hammond Ditch water.

9.2.3 *Ecological Effects of Zinc*

Zinc is an essential element for both plants and animals as part of a number of metalloenzymes involved with cell differentiation and growth. While zinc has been shown to depress embryonic development in some aquatic invertebrates, it is an essential component of numerous enzyme systems in higher animals. The bioaccumulation potential for most metals (including zinc) is expected to be low due to the ability of organisms to metabolize, excrete, or sequester them.

It is unlikely that significant exposures or detrimental impacts on benthic organisms or ducks will occur based on: (1) the lack of bioaccumulation potential, (2) the low solubility of zinc, (3) the limited area of sediments containing zinc above the NOAA sediment screening guideline (150 ug/kg) relative to the area over which benthic populations may occur and waterfowl are likely to forage, and (4) the lack of detected concentrations of zinc in Hammond Ditch water.

9.3 Risk-Based Preliminary Remediation Goals

Based on the results of this risk assessment, no remediation of soils or sediments is necessary to protect human health or the environment. In addition, dissolved phase COPCs in groundwater do not require corrective action to protect human health or the environment under reasonable groundwater use scenarios.

10.0 CONCLUSIONS

The results of the human health and ecological risk assessments suggest that the chemical levels in the soil and shallow aquifer at the GRC site are not likely to pose any adverse health effects to the on-site worker and to the most directly exposed ecological receptor. In spite of the conservative assumptions and the inherent uncertainties in the risk assessment, the residential area southwest of the site will not be impacted by detectable levels of benzene until after 90 years, should a no-action alternative be selected. The area owned by BLM, however, is expected to be impacted by the downgradient, lateral migration of shallow groundwater COPCs if removal of the SPHs is not implemented.

Unless there is a compelling reason to convert the BLM property to a residential area that relies on the shallow aquifer for its water supply, the potential exposure to the COPCs in the shallow groundwater does not pose an unacceptable risk. More importantly, the presence of the relatively impermeable Nacimiento Formation precludes potential migration of the COPCs from the shallow saturated zone to the deeper aquifer which may be a source of potable water supply.

GRC has taken the proactive role of implementing remediation measures to remove the SPHs in order to ensure that the identified COPCs in the groundwater are contained and reduced to levels that will be health-protective. GRC is also evaluating additional corrective measures to enhance the SPH removal efficiency. These additional measures will be described in a "Corrective Measure Study Report" due to USEPA in late December 1995.

Corrective Action Objectives

The media of potential concern at this site included on-site soil, groundwater in the shallow saturated zone, and sediments and surface water in the Hammond Ditch and San Juan River. Based on the results of the risk assessment, the following corrective action objectives are recommended for this site:

- Soils require no corrective action as there is no risk associated with chemicals of potential concern in soils.
- The recommended corrective action for groundwater involves continued removal of free phase hydrocarbons. The Corrective Measure Study report describes a remedial strategy to enhance the removal of SPH using soil vapor extraction/air sparging technologies. No removal of dissolved phase chemicals is recommended because the risk assessment shows that risks associated with any realistic potential uses of the shallow saturated zone are within acceptable limits.
- Surface water in the Hammond Ditch and San Juan River requires no corrective action as no chemicals of potential concern were detected in surface water samples. As a result, there is no risk associated with surface water and therefore, no need for corrective measures.
- San Juan River sediments require no corrective action as no chemicals of potential concern were detected in San Juan River sediment samples. As a result, there is no risk associated with San Juan River sediments and therefore, no need for corrective measures.
- Hammond Ditch sediments require no corrective action as there is no risk associated with chemicals of potential ecological concern in Hammond Ditch sediments.

It should be noted that the GRC facility is an active refinery, and is expected to continue to operate as such well into the future. The shallow, perched aquifer at the site is not used for potable water, and based on its water quality (elevated TDS), is not suitable for such use, or even for irrigation use (WQCC regulations, Part 3-103.C). As a conservative measure, this risk assessment assumed the possible use of this aquifer for "gray water" (lawn watering, car washing, etc.) and, even so, determined there was no risk to residents with existing dissolved concentrations, even if no corrective measures were implemented. The removal of SPH and monitoring of groundwater as the corrective measures are considered protective of human health and the environment.

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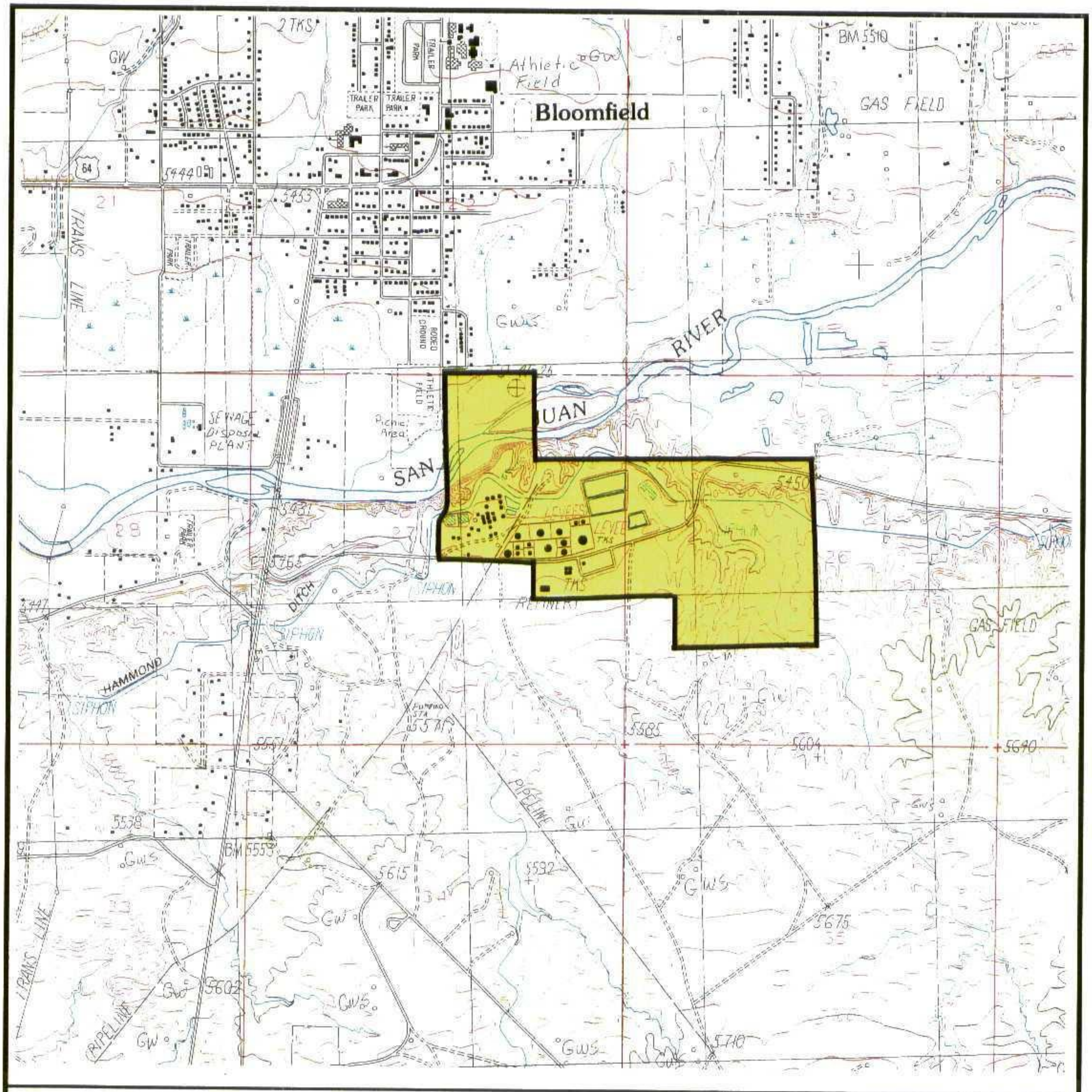


LEGEND

SITE BOUNDARY

QUADRANGLE LOCATION

N

1000 0 2000
SCALE IN FEET

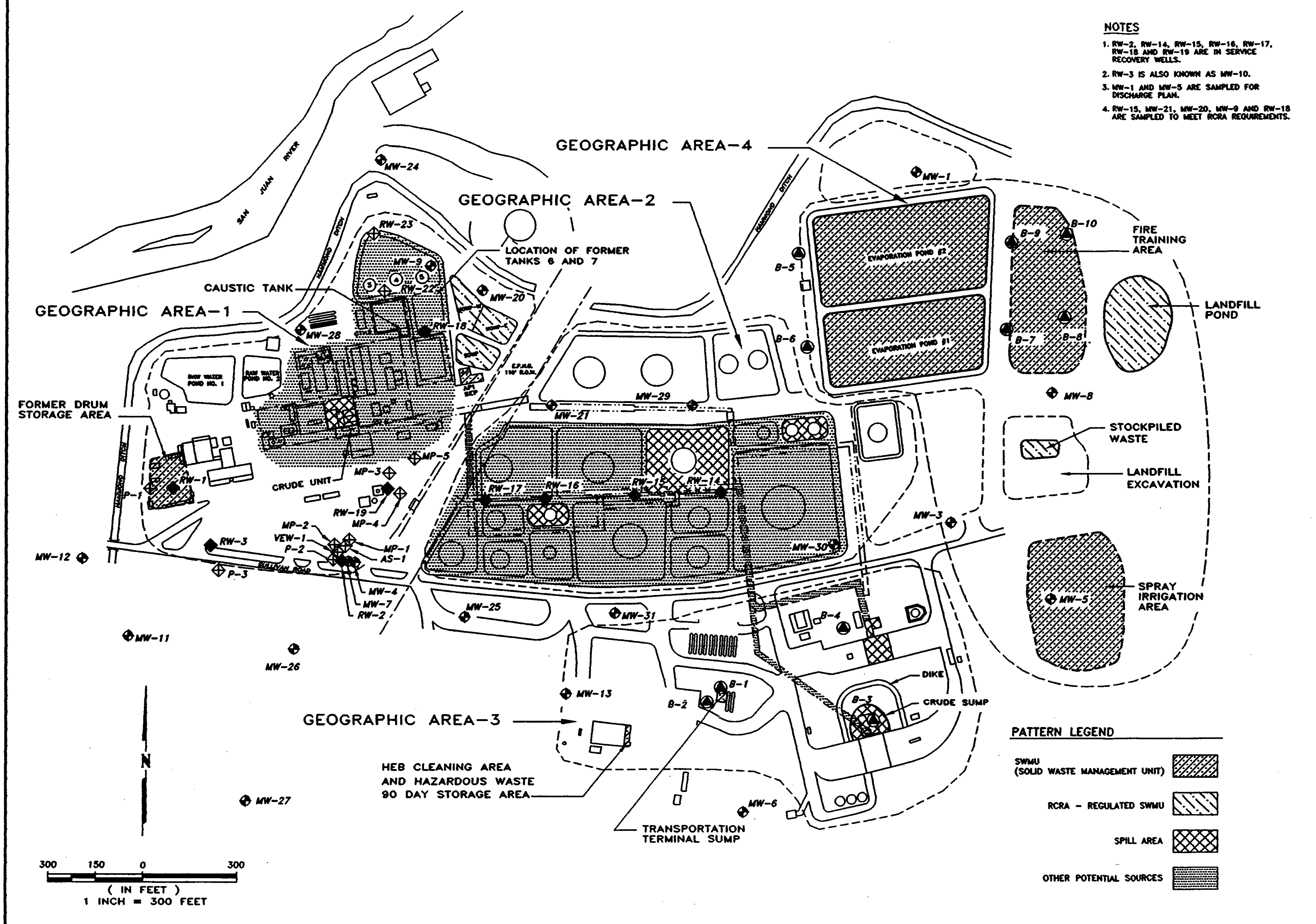
BLOOMFIELD, N. MEX.QUADRANGLE
PROVISIONAL EDITION
1985
36107-F8-TF-024

Giant Refining Company
#50 COUNTY ROAD 4990
BLOOMFIELD, NEW MEXICO

GROUNDWATER TECHNOLOGY
2501 YALE BLVD. SE, SUITE 204
ALBUQUERQUE, N.M. 87106 (505) 242-3113

SITE LOCATION

DESIGNED BY: CD	DETAILED BY: JU	CHECKED BY:
DATE: 12/19/95		FILE: SITELOC 12/95
PROJECT NO.: 053353014		CONTRACT:
DRAWING: FIGURE 1		REVISION: –



NOTES

1. RW-2, RW-14, RW-15, RW-16, RW-17, RW-18 AND RW-19 ARE IN SERVICE RECOVERY WELLS.
2. RW-3 IS ALSO KNOWN AS MW-10.
3. MW-1 AND MW-5 ARE SAMPLED FOR DISCHARGE PLAN.
4. RW-15, MW-21, MW-20, MW-9 AND RW-18 ARE SAMPLED TO MEET RCRA REQUIREMENTS.

PATTERN LEGEND

SWMU (SOLID WASTE MANAGEMENT UNIT)	▨
RCRA - REGULATED SWMU	▨
SPILL AREA	▦
OTHER POTENTIAL SOURCES	▒

NO.	DATE	BY	REVISION

LEGEND

- ‒ · ‒ · ‒ PIPEWAY
- – – – – – UNDERGROUND PIPEWAY
- — — — — AREA OF CONCERN
- ⊕ MW-1 EXISTING MONITORING WELL
- ◆ RW-1 EXISTING RECOVERY WELL
- ⬦ P-1 PROPOSED RECOVERY WELL
- ▲ B-10 SOIL BORING

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SIGNATURE	DATE
PROJECT GEO:	
PROJECT ENGR:	
PROJECT MGR: Cynantha Lukas	12/19/95
CLIENT: CL	12/19

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#50 COUNTY ROAD 4990
BLOOMFIELD, NEW MEXICO

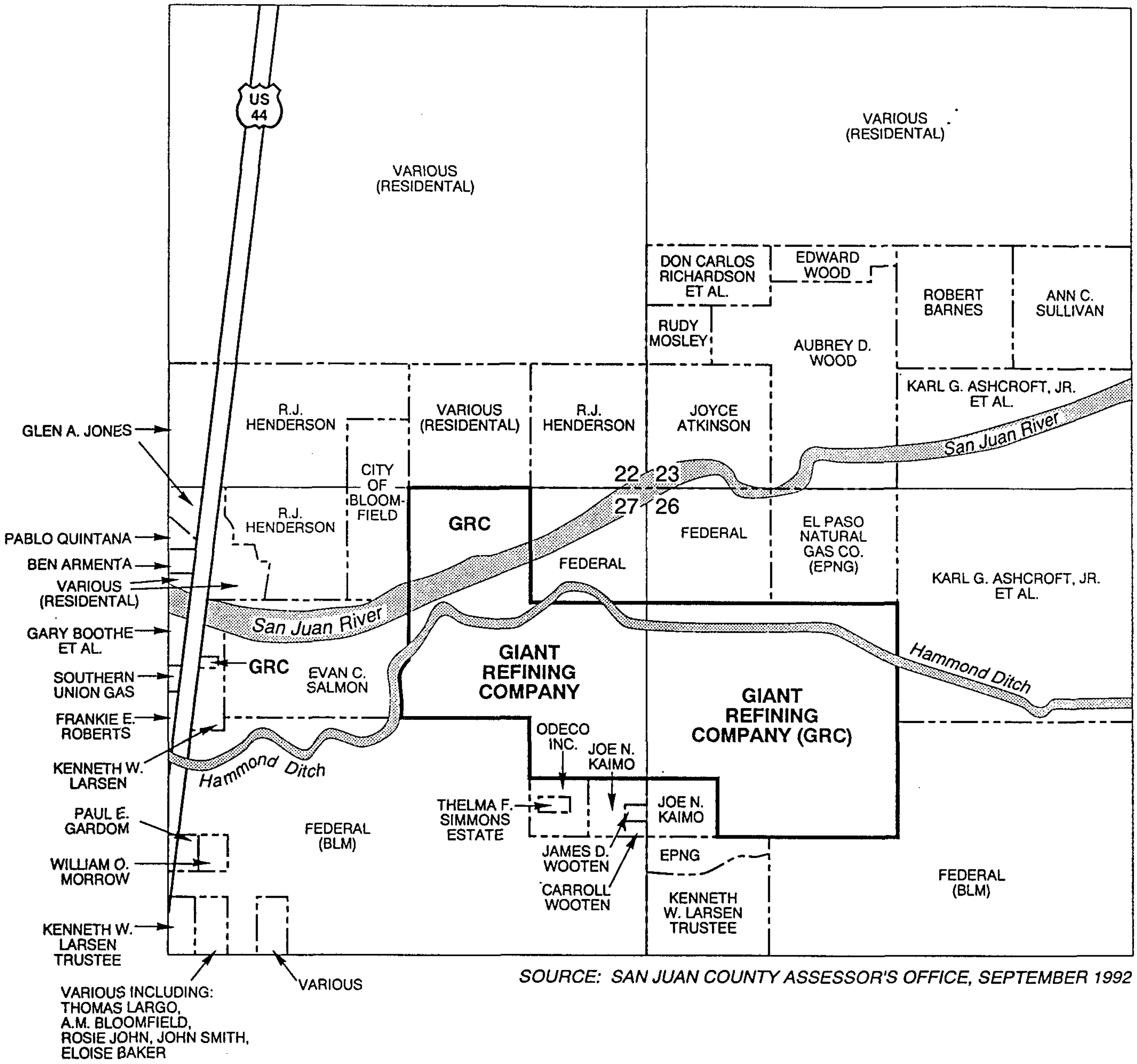
GROUNDWATER TECHNOLOGY
2501 YALE BLVD. SE, SUITE 204
ALBUQUERQUE, NEW MEXICO 87106
(505) 242-3113

SOLID WASTE MANAGEMENT UNITS AND POTENTIAL SOURCE AREAS

DESIGNED BY:	DRAFTED BY:	CHECKED BY:
	J. ML	

DATE: 12/18/95	FILE: SWMU.DWG
PROJECT NO.: 053353014	CONTRACT:
DRAWING: FIGURE 2	REVISION:

T29N R11W, SEC. 22, 23, 26 & 27



SOURCE: SAN JUAN COUNTY ASSESSOR'S OFFICE, SEPTEMBER 1992

LEGEND

- - - - PROPERTY BOUNDARY LINE

——— SECTION LINE

0 1/4 1/2 MILE

SCALE

N

NOTE:
LOCATIONS OF PROPERTY BOUNDARIES, IMPROVEMENTS, AND NATURAL FEATURES ARE APPROXIMATE.

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BLOOMFIELD, NEW MEXICO

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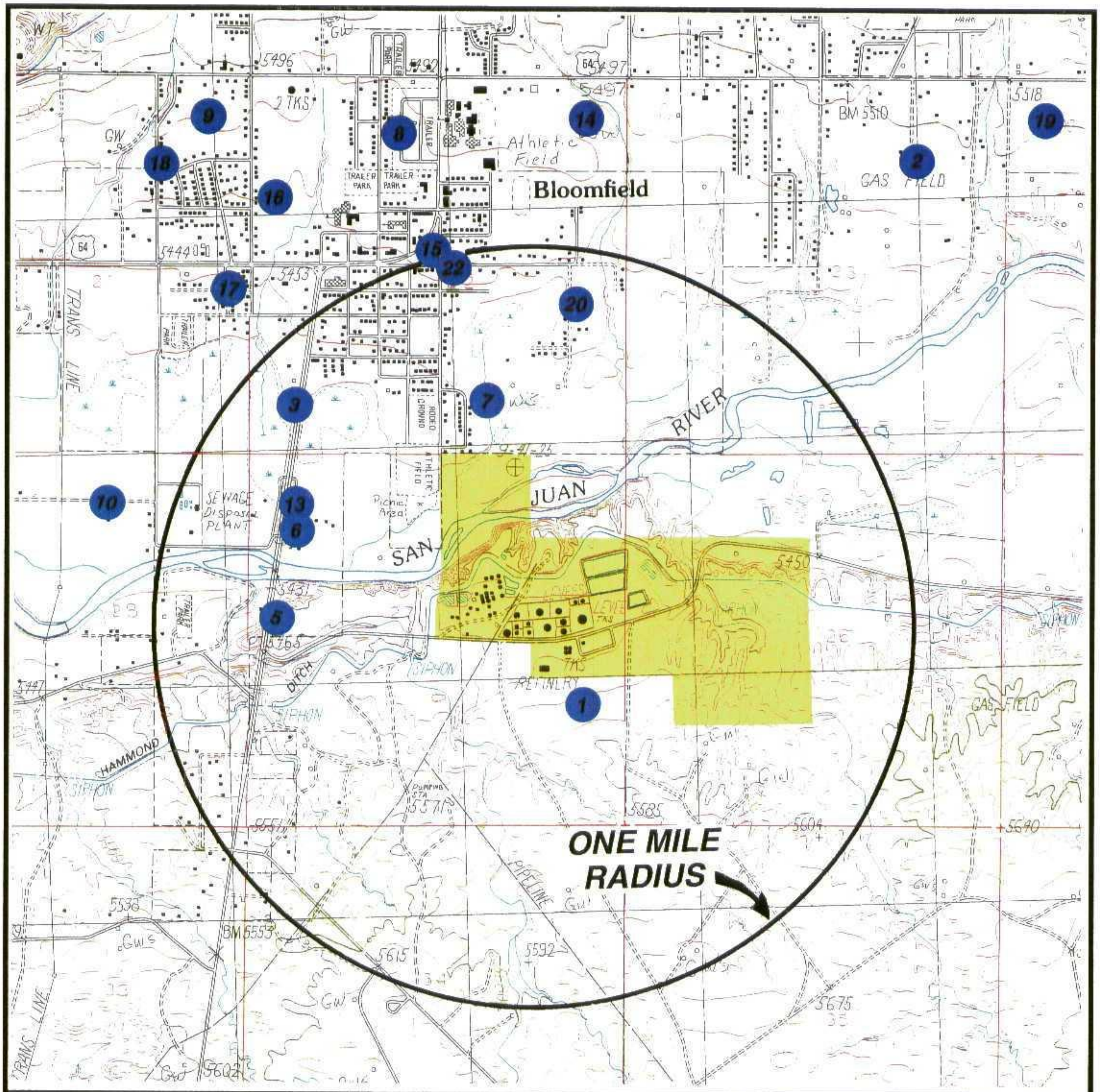
GIANT REFINING COMPANY AND SURROUNDING PROPERTIES

DESIGNED BY: PS	DETAILED BY: JU	CHECKED BY: CL
DATE: 12/19/95		FILE: PropOwner 12/95
PROJECT NO.: 053353014		CONTRACT:
DRAWING: FIGURE 3		REVISION: –



LEGEND

🟨 SITE

● WATER WELL LOCATION (SEE TABLE 1 FOR OWNER INFORMATION)

NOTES:

1) WELL NOS. 4, 11, & 12 NOT SHOWN SINCE LOCATIONS WERE NOT REPORTED ON WELL RECORDS. WELL NO. 21 IS NOT SHOWN, AS IT IS NOT IN THE VICINITY OF THE SITE.

2) WELLS NO. 15 AND 22 ARE APPROXIMATELY LOCATED.

BLOOMFIELD, N. MEX.QUADRANGLE
PROVISIONAL EDITION
1985
36107-F8-TF-024


QUADRANGLE LOCATION

SCALE IN FEET

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BLOOMFIELD, NEW MEXICO

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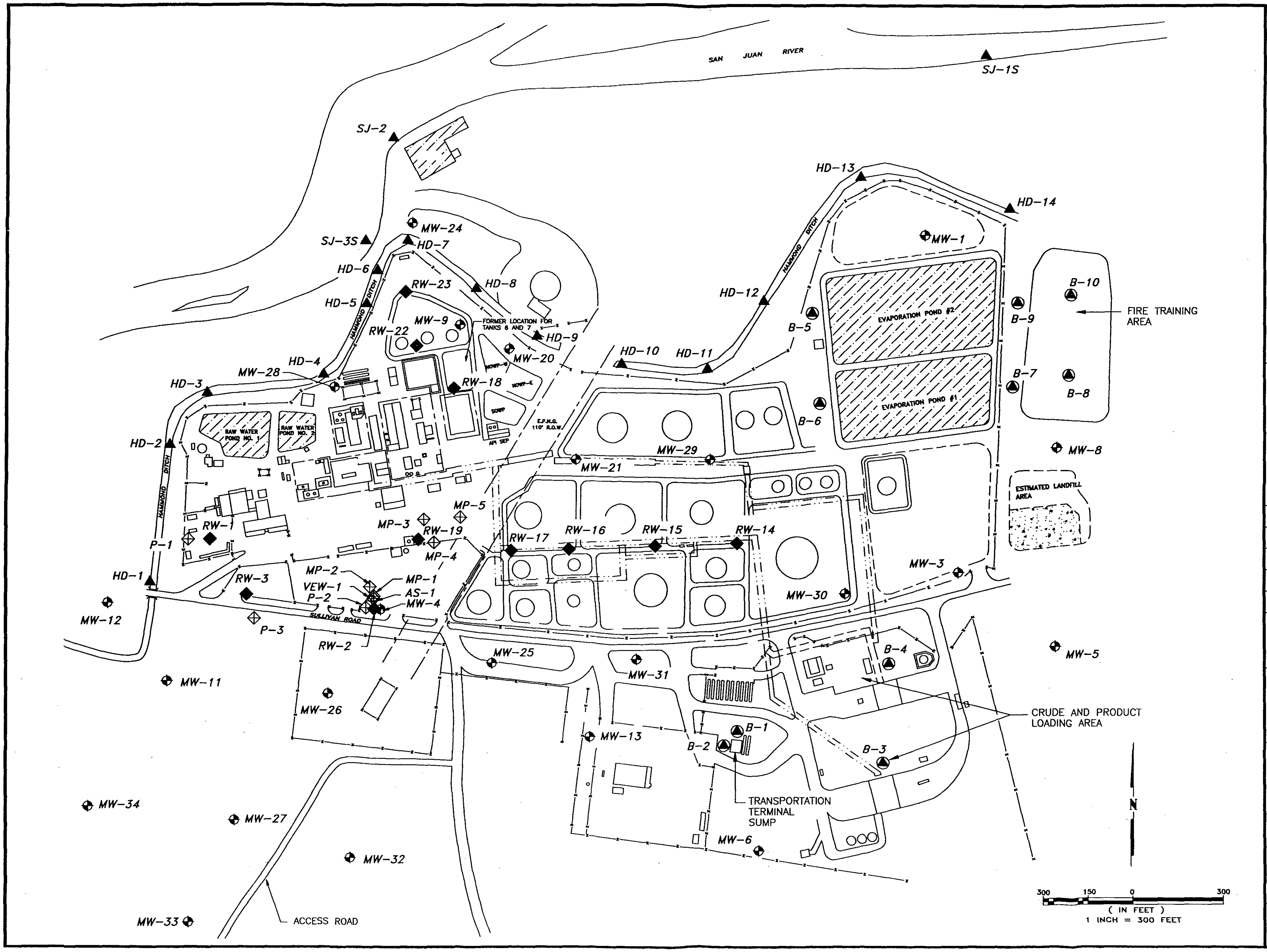
WATER WELLS WITHIN ONE MILE OF THE FACILITY

DESIGNED BY: CD	DETAILED BY: JU	CHECKED BY:
DATE: 12/19/95		FILE: WELL LOC 12/95
PROJECT NO.: 053353014		CONTRACT:
DRAWING: FIGURE 4		REVISION: –



NO.	DATE	BY	REVISION

LEGEND

- — · — · — PIPEWAY
- — — — — UNDERGROUND PIPEWAY
- —x— FENCE
- ⊕ MW-1 MONITORING WELL
- ◆ RW-1 RECOVERY WELL
- ▲ B-1 SOIL BORING
- ⊕ P-1 PIEZOMETER
- ▲ SJ-2 STREAM/SEDIMENT SAMPLES

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SIGNATURE	DATE
PROJECT GEO:	
PROJECT ENGR:	
PROJECT MGR:	
CLIENT:	

#50 COUNTY ROAD 4990
BLOOMFIELD, NEW MEXICO

GROUNDWATER TECHNOLOGY

2501 YALE BLVD. SE, SUITE 204
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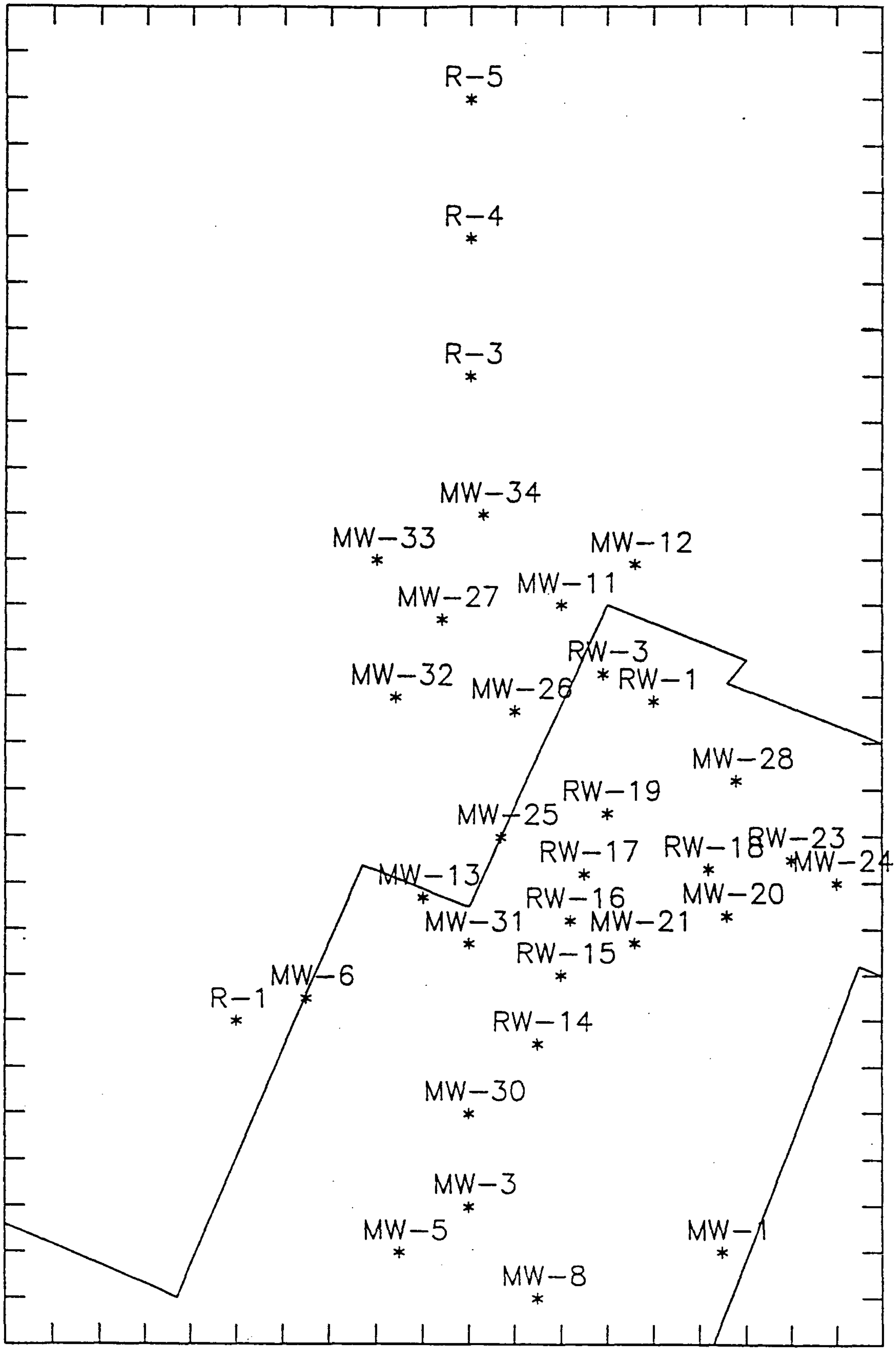
MONITORING WELL, SOIL BORING, SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS

DESIGNED BY:	DRAFTED BY: KMP	CHECKED BY: CL
DATE: 08/08/95		FILE: 3014-LOC
PROJECT NO.: 053353014		CONTRACT:
DRAWING: FIGURE 5		REVISION:

FIGURE 6



Modeling Grid

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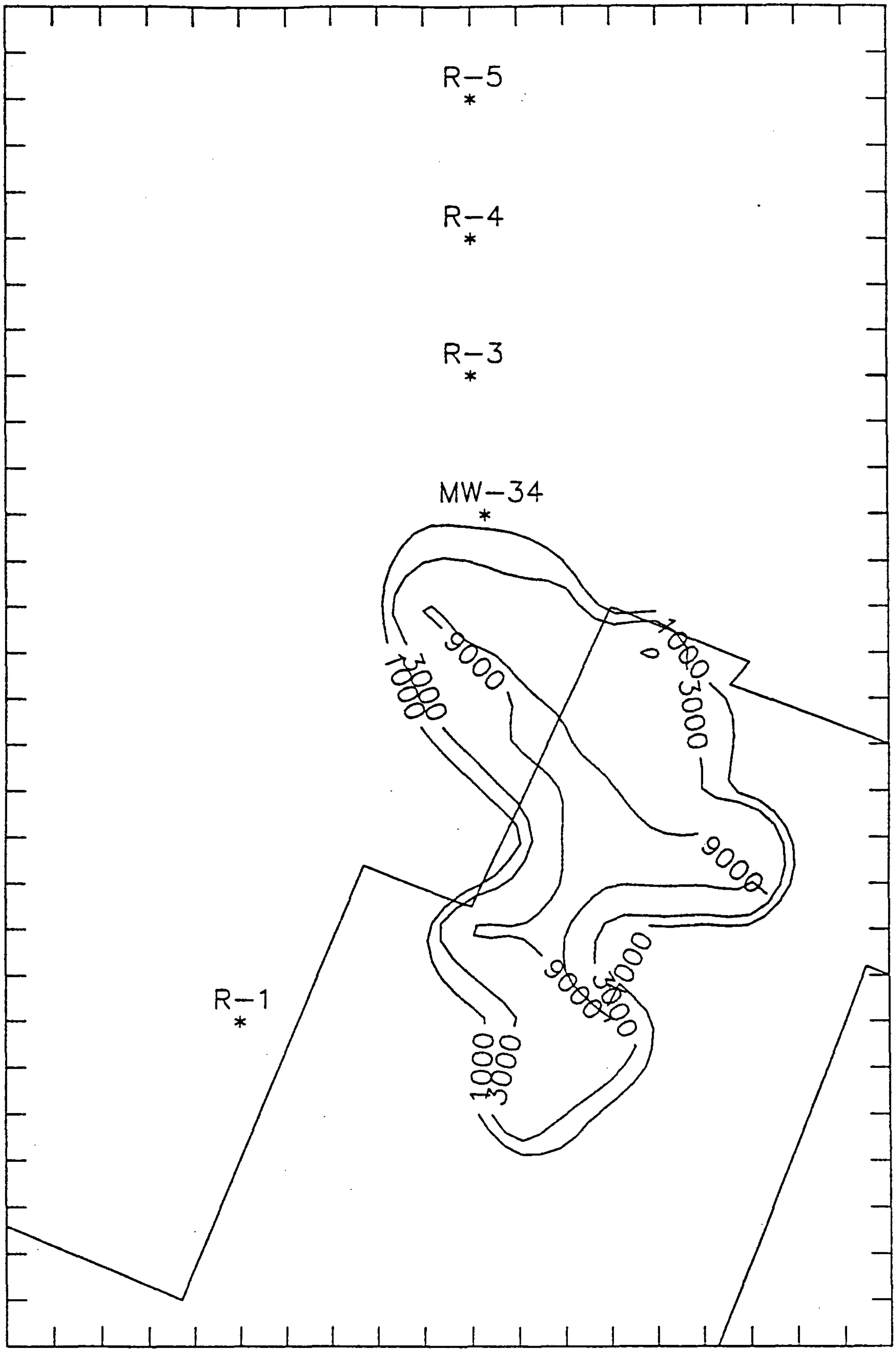
FIGURE 7



Current Benzene Concentrations (ug/L)

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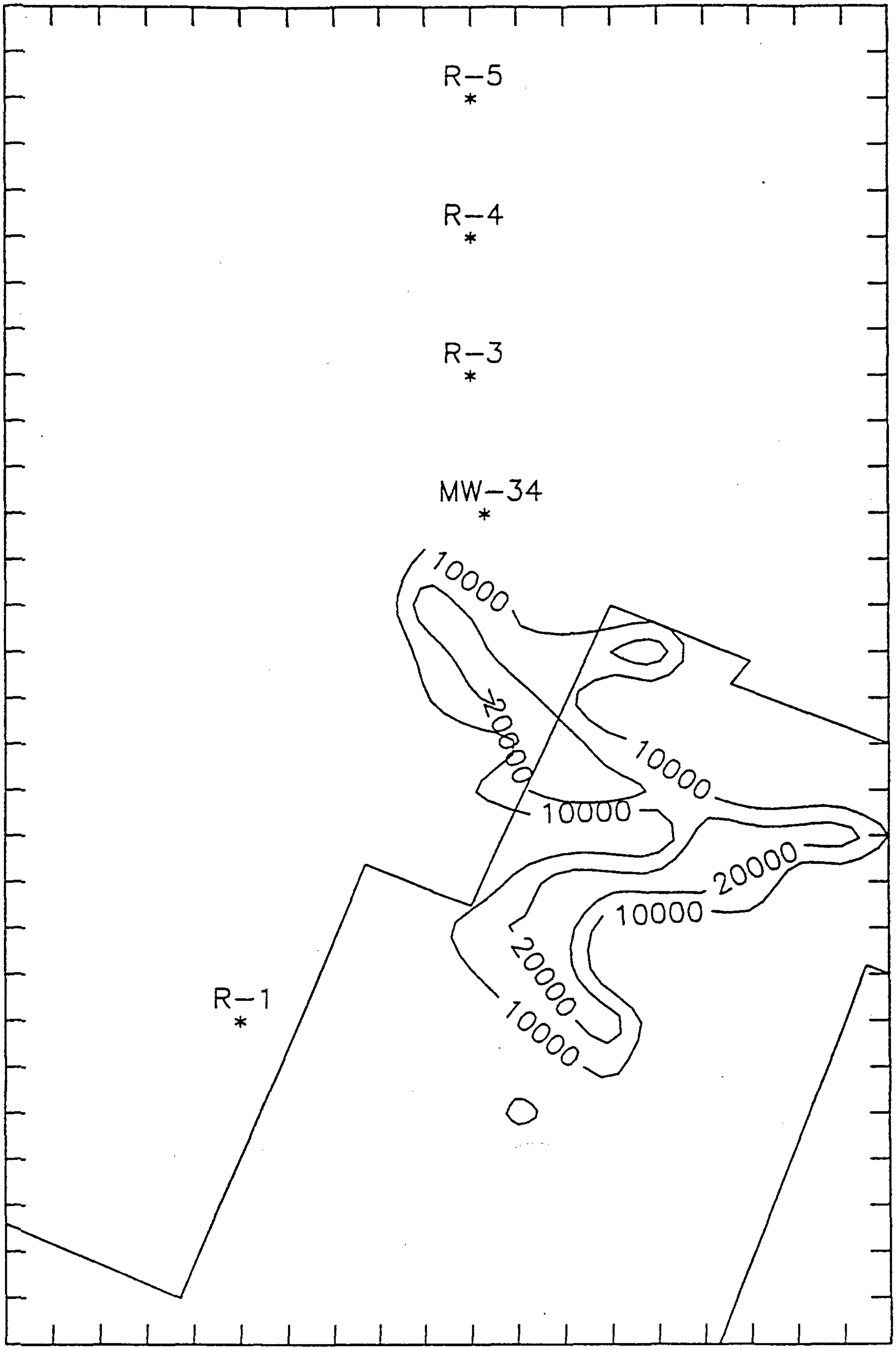
FIGURE 8



Current Toluene Concentrations (ug/L)

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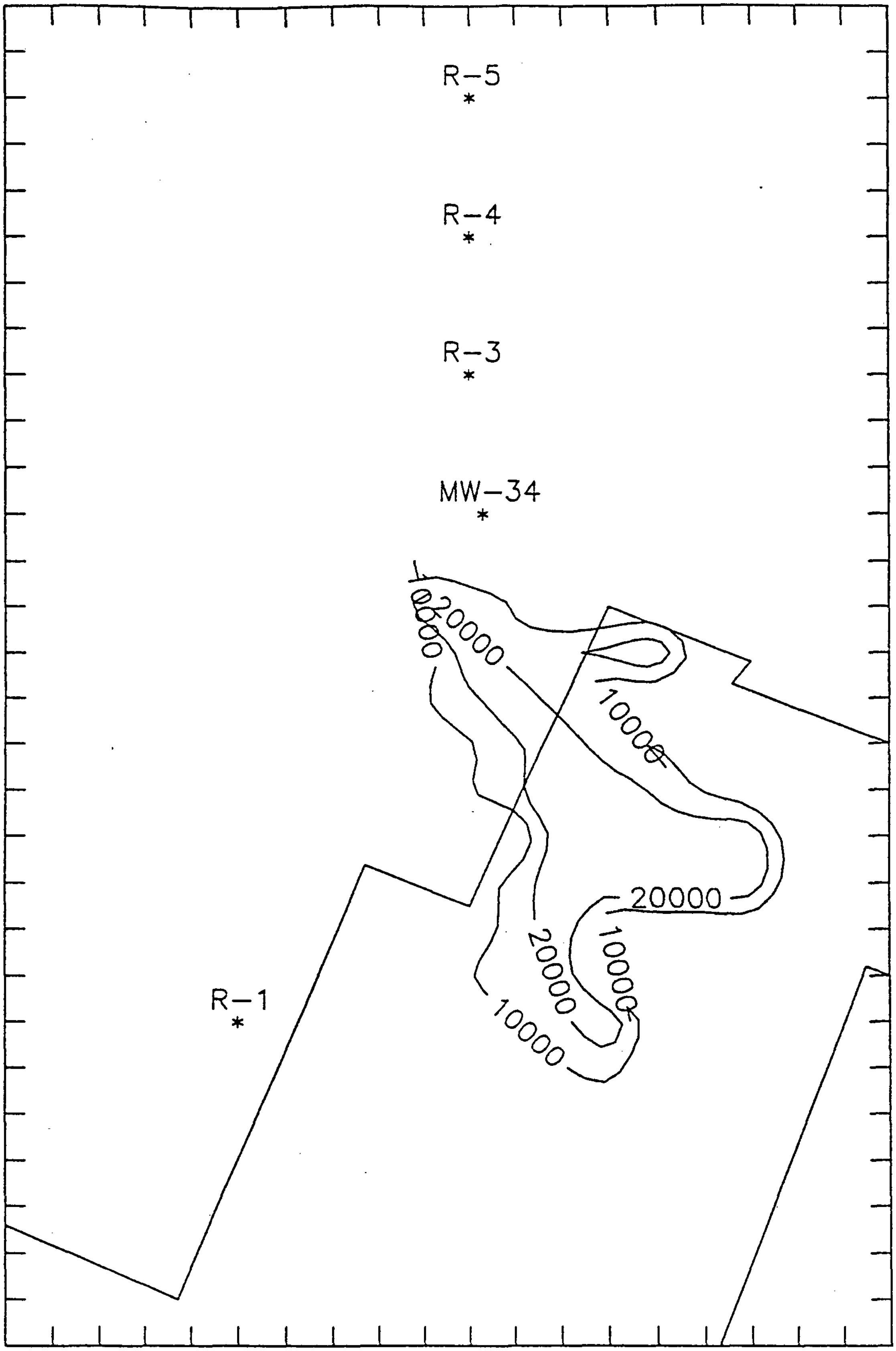
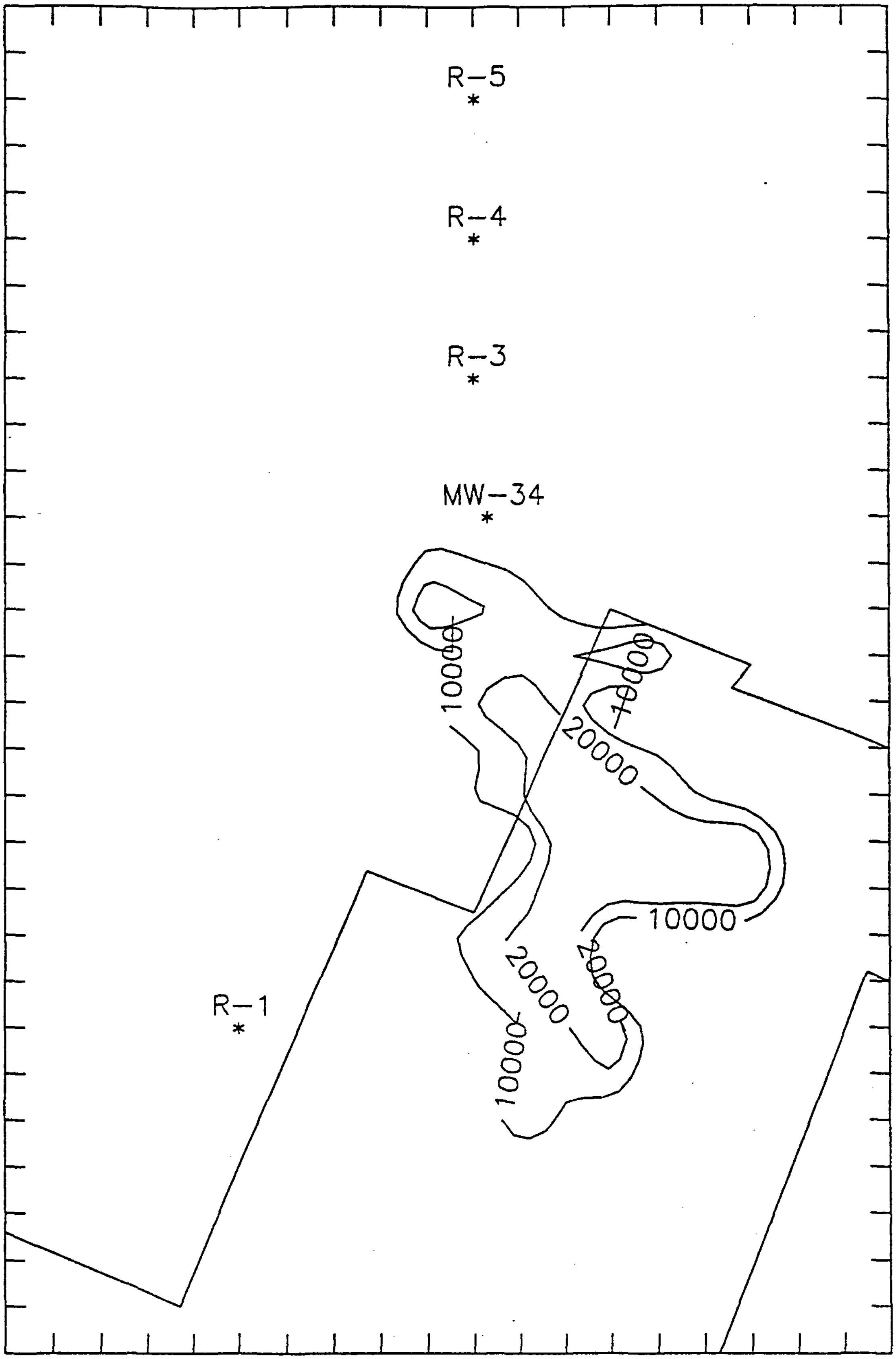
FIGURE 9



Current Ethylbenzene Concentrations (ug/L)

GROUNDWATER TECHNOLOGY

FIGURE 10



Current Xylene Concentrations (ug/L)

GROUNDWATER TECHNOLOGY

TABLE 1
GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
Determination of Background Concentrations - Soil

Chemical	Maxiumum Concentration (mg/kg)	Maximum Background (mg/kg)	UTL (mg/kg)	LTL (mg/kg)
Beryllium	0.76	1.2	2.66	1.59
Cadmium	4.5	3.2	6.75	4.32
Chromium	11	9.3	18.85	12.22
Copper	12	7.1	14.9	9.55
Lead	11	ND	5	NA
Nickel	10	7	14.89	8.97
Thallium	25	21	43.84	26.35
Zinc	46	33	68.77	41.46

UTL = Upper Confidence Limit
LTL = Lower Tolerance Limit

GROUNDWATER TECHNOLOGY

TABLE 2
GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
Determination of Background Concentrations
San Juan River and Hammond Ditch Sediments

SAN JUAN RIVER

Chemical	Maxiumum Concentration (mg/kg)	Maximum Background (mg/kg)	NOAA Sediment Screening Criteria (mg/kg)
Arsenic	16	16	8.2
Beryllium	<0.5	<0.5	NA
Chromium	8.6	8.6	81
Copper	5.8	5.8	34
Lead	<10	<5	46.7
Nickel	4.9	4.9	20.9
Selenium	<10	<10	NA
Zinc	19	19	120

HAMMOND DITCH

Chemical	Maxiumum Concentration (mg/kg)	Maximum Background (mg/kg)	UTL (mg/kg)	LTL (mg/kg)	NOAA Sediment Screening Criteria (mg/kg)
Arsenic	0.76	1.2	30.8	21.1	8.2
Beryllium	4.5	3.2	2.6	1.7	NA
Chromium	11	9.3	29.1	10	81
Copper	12	7.1	37.5	26	34
Lead	11	<10	30.6	19.3	46.7
Nickel	10	7	23.2	29.4	20.9
Selenium	25	21	5	5	NA
Zinc	46	33	104	72.7	120

UTL = Upper Confidence Limit
LTL = Lower Tolerance Limit
NOAA = National Oceanic and Atmospheric Administration

TABLE 3
GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
Determination of Background Concentrations - Groundwater

Chemical	Maximum Concentration (mg/L)	Maximum Background (mg/L)	Mean + 2 Std Dev (mg/L)	UTL (mg/L)
Arsenic	0.011	0.08	0.07	0.074
Chromium	0.015	0.03	0.02	0.026
Copper	0.034		1.00	
Lead	0.0087	0.2	0.156	0.176
Zinc	0.039	0.2	0.164	0.195

UTL = Upper Confidence Limit
LTL = Lower Tolerance Limit
Std Dev = Standard Deviation

TABLE 4
GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
Selection of Chemicals of Potential Concern for Soil

Chemical	Reporting Limit	Max. Detect (mg/kg)	% Frequency of Detection (10 samples)	Maximum Background (mg/kg)	Identified as a COPC? (Y/N)	Rationale
VOCs						
Acetone	0.005	0.13	10%	NA	N	Lab contaminant
Methylene chloride	0.005	0.11	10%	NA	N	Lab contaminant
Benzene	**0.005**	**0.012**	**10%**	**NA**	**Y**	**All organic compounds with a frequency of detection >5% are identified as COPCs**
Toluene	**0.005**	**0.012**	**30%**	**NA**	**Y**	
Ethylbenzene	**0.005**	**0.004**	**10%**	**NA**	**Y**	
Xylenes	**0.005**	**0.053**	**10%**	**NA**	**Y**	
METALS						
Beryllium	0.5	0.76	70%	1.2	N	Maximum detected concentration is below background
Cadmium	**0.5**	**4.5**	**100%**	**3.2**	**Y**	**Maximum detected concentration exceeds background**
Chromium	5	11	90%	9.3	N	Maximum detected concentration is below background
Copper	**5**	**12**	**90%**	**7.1**	**Y**	**Maximum detected concentration exceeds background**
Lead	10	11	10%	ND	N	Frequency of detection is <5%
Nickel	**1**	**10**	**100%**	**7**	**Y**	**Maximum detected concentration exceeds background**
Thallium	10	25	90%	21	N	Within range of background concentration
Zinc	**1**	**46**	**100%**	**33**	**Y**	**Maximum detected concentration exceeds background**

NA = Not analysed

TABLE 5
GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
Selection of Chemicals of Potential Concern for Groundwater

Chemical	Reporting Limit	Max. Detect (ug/L)	Frequency of Detection (36 samples)	BKG (mean+2 SDs) (mg/L)	Identified as a COPC? (Y/N)	Rationale
VOCs						
Benzene	5	13000	50%	NA	Y	All organic compounds with a frequency of detection >5% are identified as COPCs
Toluene	5	26000	11%	NA	Y	
Ethylbenzene	5	3500	39%	NA	Y	
Xylenes	5	23300	36%	NA	Y	
SVOCs						
Chrysene	10	150	3%	NA	N	Frequency of detection is <5%
2,4-Dimethylphenol	10	160	14%	NA	Y	Frequency of detection is >5%
2-Methylnaphthalene	10	580	36%	NA	Y	Frequency of detection is >5%
Bis(2-ethylhexyl)phthalate	50	16	3%	NA	N	Frequency of detection is <5%
2-Methylphenol	10	82	3%	NA	N	Frequency of detection is <5%
3-Methylphenol	10	210	6%	NA	Y	Frequency of detection is >5%
Naphthalene	10	850	44%	NA	Y	Frequency of detection is >5%
Phenanthrene	10	130	3%	NA	N	Frequency of detection is <5%
Phenol	10	110	25%	NA	Y	Frequency of detection is >5%
METALS		mg/L	12 samples	mg/L		
Arsenic	0.01	0.011	17%	0.07	N	Maximum detected concentration is below background
Chromium	0.01	0.015	8%	0.02	N	Maximum detected concentration is below background
Copper	0.025	0.034	8%	1.00	N	Below EPA MCL
Lead	0.003	0.0087	58%	0.156	N	Maximum detected concentration is below background
Zinc	0.02	0.039	50%	0.164	N	Maximum detected concentration is below background

BKG = background concentration
SDs = Standard Deviations
NA = Not Analysed

TABLE 6
GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
Selection of Chemicals of Potential Environmental Concern for Sediments

Chemical	Reporting Limit	Max. Detect (mg/kg)	NOAA (ER-L) (mg/kg)	% Frequency of Detection (31 samples)	Maximum Background (mg/kg)	Identified as a COPEC? (Y/N)	Rationale
HAMMOND DITCH SEDIMENTS							
VOCs							
Methylene chloride	0.005	0.057	NA	39%	NA	N	Lab contaminant
Toluene	0.005	0.012	0.786 (EqP)	10%	NA	N	Below sediment screening criteria
SVOCs							
Phenanthrene	0.66	1.3		6%	NA	Y	Exceeds sediment screening criteria
METALS							
Arsenic	10	16	8.2	45%	16	N	Maximum detected concentration is within range of background
Beryllium	0.5	1.3	NA	61%	1.3	N	Maximum detected concentration is within range of background
Chromium	5	20	81	94%	17	N	Maximum detected concentration is below sediment screening criteria
Copper	5	180	34	97%	19	Y	Maximum detected concentration exceeds background and sediment screening criteria
Lead	10	18	46.7	42%	11	N	Maximum detected concentration is below sediment screening criteria
Nickel	1	12	20.9	100%	12	N	Maximum detected concentration is within range of background
Selenium	10	11	NA	3%	<10	N	Frequency of detection is <5%
Zinc	1	180	150	100%	56	Y	Maximum detected concentration exceeds background and sediment screening criteria
SAN JUAN RIVER SEDIMENTS							
VOCs							
Methylene chloride	0.005	0.012	NA	39%	NA	N	Lab contaminant
METALS							
Arsenic	10	16	8.2	45%	16	N	Maximum detected concentration is within range of background
Beryllium	0.5	<0.5	NA	61%	<0.5	N	Not detected in any San Juan River sediment samples
Chromium	5	8.6	81	94%	8.6	N	Maximum detected concentration is below sediment screening criteria
Copper	5	5.8	34	97%	5.8	N	Maximum detected concentration is below sediment screening criteria
Lead	10	<10	46.7	42%	<5	N	Not detected in any San Juan River sediment samples
Nickel	1	4.9	20.9	100%	4.9	N	Maximum detected concentration is below sediment screening criteria
Selenium	10	<10	NA	3%	<10	N	Not detected in any San Juan River sediment samples
Zinc	1	19	120	100%	19	N	Maximum detected concentration is below sediment screening criteria

NA = Not Analysed

EqP = Equilibrium Partitioning Approach

NOAA = National Oceanic and Atmospheric Administration

ER-L = Effects Range-Low

TABLE 7
GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
Selection of Chemicals of Potential Environmental Concern for Surface Water

SAN JUAN RIVER
VOCs

Chemical	Reporting Limit	Max. Detect (μg/L)	Frequency of Detection (19 samples)	AWQCc (μg/L)	Identified as a COPEC? (Y/N)	Rationale
Methylene Chloride	5	13	5%	NA	N	Lab contaminant
METALS						
Beryllium	5	<5	0%	NA	N	All samples considered non-detect
Cadmium	5	<5	0%	NA	N	All samples considered non-detect
Chromium	10	<10	0%	NA	N	All samples considered non-detect
Copper	25	<25	0%	NA	N	All samples considered non-detect
Lead	3	<3	0%	NA	N	All samples considered non-detect
Nickel	40	<40	0%	NA	N	All samples considered non-detect
Thallium	10	<10	0%	NA	N	All samples considered non-detect
Zinc	20	<20	0%	NA	N	All samples considered non-detect

HAMMOND DITCH
VOCs

Chemical	Reporting Limit	Max. Detect (μg/L)	Frequency of Detection (19 samples)	AWQCc (μg/L)	Identified as a COPEC? (Y/N)	Rationale
Methylene Chloride	5	47	32%	NA	N	Lab contaminant
METALS						
Beryllium	5	<5	0%	NA	N	All samples considered non-detect
Cadmium	5	<5	0%	NA	N	All samples considered non-detect
Chromium	10	<10	0%	NA	N	All samples considered non-detect
Copper	25	<25	0%	NA	N	All samples considered non-detect
Lead	3	4	11%	6.19	N	Below AWQCc limits
Nickel	40	<40	0%	NA	N	All samples considered non-detect
Thallium	10	<10	0%	NA	N	All samples considered non-detect
Zinc	20	30	16%	36.5	N	Below AWQCc limits

NA = Not Analysed
AWQCc = Ambient Water Quality Criteria Chronic
NOTE : Maximum detected concentrations for all constituents are at the corresponding reporting limits.

Table 8

Summary of Soil Property Analysis
Giant Refining Company - Bloomfield, New Mexico

Moisture (%)	Bulk Density	Total Porosity (%)	Effective Porosity (%)	pH	CEC	K (cm/s)	Grain Size Distribution	Organic Carbon
1.9	1.66	35	24	7.4	7.04	2.0×10^{-4}	68% Sand 32% Silt/Clay	0.013

Reference: IML, 1994

Table 9

DISTRIBUTION COEFFICIENTS (K_d) FOR INDICATOR CHEMICALS IN SATURATED ZONE

Giant Refining Company, Bloomfield, New Mexico

Chemical	K_{oc} (L/kg)	K_d (m^3/kg)
Benzene	65	8.5×10^{-5}
Ethylbenzene	220	2.9×10^{-4}
Toluene	120	1.6×10^{-4}
Total Xylenes	237	3.1×10^{-4}

K_{oc} values from EHRAV, 1995.

TABLE 10

CONCENTRATIONS OF BENZENE AT RECEPTOR WELLS PREDICTED BY BIOPLUME

Years	Water Well #1	MW-34	R-3	R-4	R-5
0	0	300	0	0	0
5	0	1192	0	0	0
10	0	1851	0	0	0
15	0	2609	0.1	0	0
20	0	4424	0.1	0	0
25	0	5463	0	0	0
30	0	6276	192	0	0
35	0	6903	286	0	0
40	0	7497	968	0	0
45	0	7836	1562	0.2	0
50	0	7875	1396	0.3	0
55	0	8257	3207	0.3	0
60	0	8197	4306	172	0
65	0	8364	5074	274	0
70	0	8573	5038	408	0
75	0	8015	6298	603	0.1
80	0	8173	6684	526	0.2
85	0	8390	6795	997	0.1
90	0	8327	6572	1712	26
95	0	8266	6189	1123	6

TABLE 11

CONCENTRATIONS OF TOLUENE AT RECEPTOR WELLS PREDICTED BY BIOPLUME

Years	Water Well #1	MW-34	R-3	R-4	R-5
0	0	30	0	0	0
5	0	2619	0	0	0
10	0	4233	0	0	0
15	0	6175	0	0	0
20	0	7480	0	0	0
25	0	8579	0	0	0
30	0	8387	0	0	0
35	0	10033	9	0	0
40	0	10326	18	0	0
45	0	8743	26	0	0
50	0	9297	791	0	0
55	0	10066	1144	0	0
60	0	11851	1962	0	0
65	0	13331	1435	0	0
70	0	13626	2276	0	0
75	0	13284	1672	6	0
80	0	11830	1504	14	0
85	0	11592	1467	20	0
90	0	13730	5363	19	0
95	0	14147	10441	7	0

TABLE 12

CONCENTRATIONS OF ETHYLBENZENE AT RECEPTOR WELLS PREDICTED BY BIOPLUME

Years	Water Well #1	MW-34	R-3	R-4	R-5
0	0	0	0	0	0
5	0	0.3	0	0	0
10	0	0.8	0	0	0
15	0	1.4	0	0	0
20	0	2.3	0	0	0
25	0	2.9	0	0	0
30	0	4363	0	0	0
35	0	3838	0	0	0
40	0	6666	0	0	0
45	0	9772	0	0	0
50	0	9550	0	0	0
55	0	10230	0.2	0	0
60	0	9664	0.2	0	0
65	0	8920	0.8	0	0
70	0	9809	1.0	0	0
75	0	10384	2.1	0	0
80	0	10150	2.8	0	0
85	0	12607	2.7	0	0
90	0	12549	1.9	0	0
95	0	12614	1.9	0	0

TABLE 13

CONCENTRATIONS OF TOTAL XYLENES AT RECEPTOR WELLS PREDICTED BY BIOPLUME

Years	Water Well #1	MW-34	R-3	R-4	R-5
0	0	1300	0	0	0
5	0	4468	0	0	0
10	0	4404	0	0	0
15	0	6796	0	0	0
20	0	6698	0.1	0	0
25	0	9295	0.1	0	0
30	0	12160	0.2	0	0
35	0	11282	0.4	0	0
40	0	12946	0.5	0	0
45	0	12758	0.5	0	0
50	0	14973	377	0	0
55	0	14473	494	0	0
60	0	13064	730	0	0
65	0	12161	1079	0	0
70	0	11905	1063	0	0
75	0	11575	2572	0	0
80	0	12314	3286	0.1	0
85	0	12135	3805	0.2	0
90	0	14366	5123	0.5	0
95	0	15198	4545	0.8	0

TABLE A - 1
SUMMARY OF SOIL SAMPLE RESULTS
GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO

All values given in mg/kg

SAMPLE ID	DATE	Depth (feet)	Phenolics	B	E	T	X	MEK	Acetone	Methylene Chloride	Arsenic	Beryllium	Cadmium	Cr	Copper	Pb	Nickel	Thallium
51469-01	10/16/85	0-0.5	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	11	NA	10	NA	NA
51469-02		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	8.9	NA	9.8	NA	NA
51469-03		0-0.5	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	9.9	NA	9	NA	NA
51469-04		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	7.6	NA	6.7	NA	NA
51469-05		0-0.5	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	7.8	NA	7.6	NA	NA
51469-06		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	7.4	NA	7	NA	NA
51469-07		0-0.5	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	9.1	NA	8.2	NA	NA
51469-08		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	7	NA	7.7	NA	NA
51469-09		0-0.5	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	6.2	NA	9	NA	NA
51469-10		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	8.1	NA	8.5	NA	NA
51469-11		0-0.5	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	7.8	NA	8.9	NA	NA
51469-12		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	10	NA	12	NA	NA
51469-13		0-0.5	ND	0.0013	ND	ND	ND	NA	NA	NA	NA	NA	NA	8	NA	12	NA	NA
51469-14		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	7.8	NA	13	NA	NA
51469-15		0-0.5	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	2.3	NA	4	NA	NA
51469-16		unk	ND	ND	ND	ND	ND	0.053	NA	NA	NA	NA	NA	2.4	NA	4	NA	NA
51469-17	10/15/85	0-0.5	ND	ND	ND	ND	0.0074	NA	NA	NA	NA	NA	NA	4.4	NA	5	NA	NA
51469-18		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	5.3	NA	5	NA	NA
51469-19		0-0.5	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	5.5	NA	5	NA	NA
51469-20		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	14	NA	1	NA	NA
51469-21		0-0.5	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	6.8	NA	5.1	NA	NA
51469-22		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	27	NA	5.9	NA	NA
51469-23		0-0.5	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	4.9	NA	6	NA	NA
51469-24		0-0.5	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	7.8	NA	4	NA	NA
51469-25		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	3.2	NA	6	NA	NA
51469-26		0-0.5	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	3.6	NA	5	NA	NA
51469-27		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	2.3	NA	3	NA	NA
51469-28		0-0.5	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	2.9	NA	3	NA	NA
51469-29		0.5-1	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	12	NA	4	NA	NA
B-1	2/1/94	2.5-4.5	NA	<0.005	<0.005	<0.005	<0.005	NA	<0.1	<0.05	ND	0.66	4.5	9.7	12	<10	9.8	25
B-2		10.0-12.0	NA	<0.005	<0.005	<0.005	<0.005	NA	<0.1	<0.05	ND	0.53	3	8.5	8.9	<10	7	15
B-3		6.0-8.0	NA	<0.005	<0.005	<0.005	<0.005	NA	<0.1	0.11	ND	0.54	3.2	8	8.8	<10	7.4	15
B-4		8.0-10.0	NA	0.012	0.004	0.023	0.053	NA	<0.1	<0.05	ND	0.53	3.1	9.9	8.2	<10	7.2	19
B-4		10.0-12.0	NA	<0.005	<0.005	<0.005	<0.005	NA	0.13	<0.05	ND	0.76	4	11	11	11	10	23
B-5		2.0-4.0	NA	<0.005	<0.005	<0.005	<0.005	NA	<0.1	<0.05	ND	<0.5	2.3	7.2	6.5	<10	5.9	16
B-6		2.0-4.0	NA	<0.005	<0.005	<0.005	<0.005	NA	<0.1	<0.05	ND	0.54	3.2	8.1	9.1	<10	6.8	20
B-7		6.0-8.0	NA	<0.005	<0.005	<0.005	<0.005	NA	<0.1	<0.05	ND	<0.5	1.8	5.7	5.3	<10	4.8	14
B-8		8.0-10.0	NA	<0.005	<0.005	<0.005	<0.005	NA	<0.1	<0.05	ND	0.57	3.2	9.3	7.1	<10	7	21
B-9		2.0-4.0	NA	<0.005	<0.005	<0.005	<0.005	NA	<0.1	<0.05	ND	<0.5	0.77	<5	<5	<10	1.6	<10
B-10		10.0-12.0	NA	<0.005	<0.005	<0.005	<0.005	NA	<0.1	<0.05	ND	1.2	2.3	6	<5	<10	4.7	13

▨ SHADED = Above Detection Limits NA = Not Analysed ND = Not Detected

Selenium	Zinc	SVOCs	TPH	SAMPLE ID
NA	NA	NA	NA	51469-01
NA	NA	NA	NA	51469-02
NA	NA	NA	NA	51469-03
NA	NA	NA	NA	51469-04
NA	NA	NA	NA	51469-05
NA	NA	NA	NA	51469-06
NA	NA	NA	NA	51469-07
NA	NA	NA	NA	51469-08
NA	NA	NA	NA	51469-09
NA	NA	NA	NA	51469-10
NA	NA	NA	NA	51469-11
NA	NA	NA	NA	51469-12
NA	NA	NA	NA	51469-13
NA	NA	NA	NA	51469-14
NA	NA	NA	NA	51469-15
NA	NA	NA	NA	51469-16
NA	NA	NA	NA	51469-17
NA	NA	NA	NA	51469-18
NA	NA	NA	NA	51469-19
NA	NA	NA	NA	51469-20
NA	NA	NA	NA	51469-21
NA	NA	NA	NA	51469-22
NA	NA	NA	NA	51469-23
NA	NA	NA	NA	51469-24
NA	NA	NA	NA	51469-25
NA	NA	NA	NA	51469-26
NA	NA	NA	NA	51469-27
NA	NA	NA	NA	51469-28
NA	NA	NA	NA	51469-29
ND	46	ND	NA	B-1
ND	34	ND	NA	B-2
ND	35	ND	NA	B-3
ND	32	ND	NA	B-4
ND	44	ND	NA	B-4
ND	26	ND	NA	B-5
ND	33	ND	NA	B-6
ND	21	ND	NA	B-7
ND	33	ND	NA	B-8
ND	8	ND	NA	B-9
ND	22	ND	NA	B-10

TABLE A - 2
SUMMARY OF GROUNDWATER SAMPLE RESULTS
GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO

		VOCs - ug/L				METALS - mg/kg					SVOCs - ug/L				
SAMPLE	DATE	B	T	E	X	Arsenic	Chromium	Copper	Lead	Zinc	2,4 - Dimethylphenol	3-Mehtylphenol	Methyl Naphthalene	Naphthalene	Phenol
MW-1	5/24/94	<5	<5	<5	<5	--	- -	--	--	--	<10	<10	<10	<10	<10
MW-3	5/24/94	<5	<5	<5	<5	--	- -	--	--	--	<10	<10	<10	<10	<10
MW-5	5/24/94	<5	<5	<5	<5	--	- -	--	--	--	<10	<10	<10	<10	<10
MW-8	5/24/94	<5	<5	<5	<5	--	- -	--	--	--	<10	<10	<10	<10	<10
MW-11	5/24/94	5000	<50	500	9400	--	- -	--	--	--	59	<10	16	62	32
MW-12	5/24/94	<5	<5	<5	<5	--	- -	--	--	--	<10	<10	<10	<10	<10
MW-13	5/24/94	<5	<5	<5	<5	--	- -	--	--	--	<10	<10	<10	<10	<10
MW-20	5/24/94	5.5	<5	<5	<5	--	- -	--	--	--	<10	<10	<10	<10	<10
MW-21	5/24/94	1400	<50	260	<50	--	- -	--	--	--	<10	<10	<10	18	13
MW-25	5/24/94	88	<50	42	81	<10	<10	<25	<30	<20	17	<10	63	97	<10
MW-26	5/24/94	4700	<200	1100	13000	<10	<10	<25	5.9	35	58	<10	41	84	19
MW-29	5/24/94	<5	<5	<5	<5	<10	<10	<25	5.7	37	<10	<10	<10	<10	<10
MW-30	5/24/94	7800	20000	3500	18700	11	15	34	8.7	39	160	70	580	850	80
MW-31	5/24/94	13000	26000	2500	13300	<10	<10	<25	<30	<20	77	210	280	650	110
RW-1	5/24/94	2800	<50	80	40	--	--	--	--	--	<200	<200	300	170	<200
RW-3	5/24/94	7200	<200	<200	3600	--	--	--	--	--	<10	<10	8	46	16
MW-1	8/3/94	<5	<5	<5	<5	--	--	--	--	--	<10	<10	<10	<10	<10
MW-3	8/3/94	<5	<5	<5	<5	--	--	--	--	--	<10	<10	<10	<10	<10
MW-5	8/3/94	<5	<5	<5	<5	--	--	--	--	--	<10	<10	<10	<10	<10
MW-8	8/3/94	<5	<5	<5	<5	--	--	--	--	--	<10	<10	<10	<10	<10
MW-11	8/3/94	4600	<200	400	7800	--	--	--	--	--	<10	<10	15	58	24
MW-12	8/3/94	<5	<5	<5	<5	--	--	--	--	--	<10	<10	<10	<10	<10
MW-13	8/3/94	<5	<5	<5	<5	--	--	--	--	--	<10	<10	<10	<10	<10
MW-20	8/3/94	6	<5	<5	<5	--	--	--	--	--	<10	<10	<10	<10	<10
MW-21	8/3/94	970	<50	180	<5	--	--	--	--	--	<10	<10	<10	10	11
MW-25	8/3/94	120	<5	55	23	<10	<10	<25	4	<20	<10	<10	22	80	<10
MW-26	8/3/94	4000	<200	880	10000	<10	<10	<25	4	30	<10	<10	12	56	9
MW-29	8/3/94	<5	<5	<5	<5	<10	<10	<25	14	50	<10	<10	<10	<10	<10
MW-30	8/3/94	7300	13000	3200	17000	10	<10	<25	9	30	<10	<10	340	790	<10
MW-31	8/3/94	9500	17000	2100	15100	<10	<10	<25	<3	<3	<10	<10	110	220	<10
RW-1	8/3/94	3300	<5	<5	<5	--	--	--	--	--	<10	<10	120	85	<10
RW-3	8/3/94	8300	<200	950	2800	--	--	--	--	--	<10	<10	<10	100	<10
MW-32	3/2/95	<5	<5	<5	<5	--	--	--	--	--	<10	<10	ND	ND	ND
MW-33	3/2/95	<5	<5	<5	<5	--	--	--	--	--	<10	<10	ND	ND	ND
MW-34	3/2/95	300	<50	30	1300	--	--	--	--	--	<10	<10	ND	ND	ND

(- -) = Not Sampled
ND = Not Detected

Shaded Above detection limits
Bold = Values given are the maximum concentrations of two duplicate samples

TABLE A - 3
SUMMARY OF SEDIMENT SAMPLE RESULTS
GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO

All values given in mg/kg

																	SVOCs	
SAMPLE ID	DATE	B	E	T	X	methylene chloride	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Nickel	Thallium	Selenium	Zinc	Phen	TPH
San Juan River Samples																		
SJ-1S	8/10/94	<0.005	<0.005	<0.005	<0.005	0.011	13	<0.5	ND	8.6	5.8	<10	4.9	ND	<10	16	ND	ND
SJ-2S		<0.005	<0.005	<0.005	<0.005	0.011	11	<0.5	ND	<5	5.6	<10	4.5	ND	<10	19	ND	ND
SJ-3S		<0.005	<0.005	<0.005	<0.005	0.012	<10	<0.5	ND	<5	<5	<10	1.8	ND	<10	10	ND	ND
Hammond Ditch Samples																		
HD-1S	8/10/94	<0.005	<0.005	<0.005	<0.005	<0.005	16	<0.5	ND	6.1	6.8	<10	5.3	ND	<10	26	ND	ND
HD-1B		<0.005	<0.005	<0.005	<0.005	0.007	<10	0.9	ND	9.6	16	<10	10	ND	11	45	ND	ND
HD-2S		<0.005	<0.005	<0.005	<0.005	<0.005	<10	<0.5	ND	6	6.6	<10	5.6	ND	<10	26	ND	ND
HD-2B		<0.005	<0.005	<0.005	<0.005	<0.005	<10	0.9	ND	9.4	17	12	9.8	ND	<10	43	ND	ND
HD-3S		<0.005	<0.005	<0.005	<0.005	0.057	16	1.2	ND	13	21	14	13	ND	<10	55	ND	ND
HD-3B		<0.005	<0.005	<0.005	<0.005	0.009	<10	1.1	ND	11	26	<10	12	ND	<10	60	ND	ND
HD-4S		<0.005	<0.005	<0.005	<0.005	0.01	<10	<0.5	ND	8.2	14	<10	5.2	ND	ND	69	ND	ND
HD-4B		<0.005	<0.005	<0.005	<0.005	0.006	<10	0.7	ND	8.8	180	<10	8.7	ND	ND	64	1.3	540
HD-5S		<0.005	<0.005	<0.005	<0.005	0.007	10	<0.5	ND	7.1	13	11	7.4	ND	ND	43	ND	ND
HD-5B		<0.005	<0.005	0.006	<0.005	0.006	13	0.9	ND	13	18	12	11	ND	ND	56	ND	ND
HD-6S		<0.005	<0.005	<0.005	<0.005	<0.005	<10	6	ND	18	14	<10	9.3	ND	ND	43	ND	ND
HD-6B		<0.005	<0.005	<0.005	<0.005	0.005	10	1	ND	12	18	<10	12	ND	ND	44	ND	ND
HD-7S		<0.005	<0.005	<0.005	<0.005	<0.005	<10	0.6	ND	7.9	12	11	7	ND	ND	37	ND	ND
HD-7B		<0.005	<0.005	0.012	<0.005	<0.005	<10	1	ND	12	19	6	12	ND	ND	53	ND	ND
HD-8S		<0.005	<0.005	<0.005	<0.005	<0.005	15	0.8	ND	15	35	18	9.1	ND	ND	180	ND	ND
HD-8B		<0.005	<0.005	<0.005	<0.005	<0.005	12	1	ND	20	17	<10	11	ND	ND	58	ND	ND
HD-9S		<0.005	<0.005	<0.005	<0.005	<0.005	<10	<0.5	ND	16	12	<10	6.7	ND	ND	44	ND	ND
HD-9B		<0.005	<0.005	<0.005	<0.005	<0.005	<10	1	ND	17	18	12	11	ND	ND	56	1.2	240
HD-10S		<0.005	<0.005	<0.005	<0.005	0.009	<10	<0.5	ND	9.4	17	11	5.6	ND	ND	59	ND	ND
HD-10B		<0.005	<0.005	<0.005	<0.005	0.006	13	0.9	ND	12	16	<10	9.8	ND	ND	38	ND	ND
HD-11S		<0.005	<0.005	<0.005	<0.005	<0.005	10	<0.5	ND	8.1	11	<10	6.2	ND	ND	38	ND	ND
HD-11B		<0.005	<0.005	<0.005	<0.005	<0.005	15	1	ND	14	17	11	11	ND	ND	51	ND	ND
HD-12S		<0.005	<0.005	<0.005	<0.005	<0.005	12	0.6	ND	12	11	<10	8.8	ND	ND	47	ND	ND
HD-12B		<0.005	<0.005	<0.005	<0.005	<0.005	15	1.3	ND	17	19	15	13	ND	ND	58	ND	ND
HD-13S		<0.005	<0.005	<0.005	<0.005	<0.005	<10	<0.5	ND	9.2	15	<10	7.8	ND	ND	36	ND	ND
HD-13B		<0.005	<0.005	<0.005	<0.005	<0.005	10	0.9	ND	9.5	17	11	10	ND	ND	39	ND	ND
HD-14S		<0.005	<0.005	<0.005	<0.005	<0.005	<10	<0.5	ND	6.7	11	<10	6	ND	ND	29	ND	ND
HD-14B		<0.005	<0.005	<0.005	<0.005	<0.005	<10	1.1	ND	11	18	11	12	ND	ND	50	ND	ND

SHADED = ▨ Samples exceed detection limits　ND = Not Detected　NOTE : All other SVOCs were not-detected

NA = Not Analysed　phen = Phenanthrene

TABLE A - 4
SUMMARY OF SURFACE WATER SAMPLES
GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
All values given in ug/L

SAMPLE ID	DATE	B	E	T	X	methylene chloride	Lead	Zinc	ALL SVOCs	TPH
San Juan River Samples										
SJ-1W	8/10/94	<5	<5	<5	<5	13	<3	<20	ND	ND
SJ-2W		<5	<5	<5	<5	<5	<3	<20	ND	ND
SJ-2WD		<5	<5	<5	<5	<5	<3	<20	ND	ND
SJ-3W		<5	<5	<5	<5	<5	<3	<20	ND	ND
Hammond Ditch Samples										
HD-1W	8/10/94	<5	<5	<5	<5	<5	<3	<20	ND	ND
HD-2W		<5	<5	<5	<5	9	<3	<20	ND	ND
HD-3W		<5	<5	<5	<5	32	<3	<20	ND	ND
HD-4W		<5	<5	<5	<5	<5	<3	<20	ND	ND
HD-5W		<5	<5	<5	<5	47	<3	<20	ND	ND
HD-6W		<5	<5	<5	<5	15	<3	<20	ND	ND
HD-7W		<5	<5	<5	<5	29	<3	<20	ND	ND
HD-8W		<5	<5	<5	<5	37	<3	<20	ND	ND
HD-9W		<5	<5	<5	<5	<5	4	20	ND	ND
HD-9WD		<5	<5	<5	<5	<5	<3	<20	ND	ND
HD-10W		<5	<5	<5	<5	<5	3	30	ND	ND
HD-11W		<5	<5	<5	<5	<5	<3	<20	ND	ND
HD-12W		<5	<5	<5	<5	<5	<3	<20	ND	ND
HD-13W		<5	<5	<5	<5	<5	<3	<20	ND	ND
HD-14W		<5	<5	<5	<5	<5	<3	<20	ND	ND

▨ SHADED = Above Detection Limits
NA = Not Analysed
ND = Not Detected

phen = Phenanthrene
NOTE : All other SVOCs were not-detected

TABLE B - 1

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
COMMERCIAL WORKER INCIDENTAL INGESTION OF SOIL
REASONABLE MAXIMUM EXPOSURE

EQUATION

$$\text{INTAKE} = \frac{\text{Cs} * \text{IR} * \text{CF} * \text{FI} * \text{ED} * \text{EY}}{\text{BW} * \text{AT}}$$

$$\text{RISK} = \text{INTAKEc} * \text{CSF}$$

$$\text{HI} = \frac{\text{INTAKEnc}}{\text{RfD}}$$

PARAMETER DESCRIPTIONS	UNITS	VALUES
Cs = Concentration in soil	mg/kg	see below
IR = ingestion rate	mg/day	50
CF = conversion factor	kg/mg	1.0E-6
FI = fraction ingested from source	unitless	1
ED = exposure duration	day/yr	250
EY = exposure duration	years	25
BW = body weight	kg	70
ATc = Averaging time Carcinogens	days	25,550
ATnc = Averaging time Non-Carcinogen	days	9,125
INTAKE	mg/kg-day	see below
Risk = Estimated Cancer Risk	unitless	see below
HI = Estimated Non-cancer Risk	unitless	see below
CSF = Cancer Slope Factor	kg-day/mg	see below
RfD = Reference Dose	mg/kg-day	see below

VOCs	Cs	INTAKEc	INTAKEnc	CSF	RfD	RISK	HI
benzene	0.012	2.10E-09	NA	0.029	NA	6E-11	NA
toluene	0.023	NA	1.13E-08	NA	0.2	NA	5.6E-08
ethylbenzene	0.004	NA	1.96E-09	NA	0.1	NA	2.0E-08
xylenes	0.053	NA	2.59E-08	NA	2	NA	1.3E-08
METALS							
copper	12	NA	5.87E-06	NA	0.037	NA	1.6E-04
nickel	10	NA	4.89E-06	NA	0.02	NA	2.4E-04
zinc	46	NA	2.25E-05	NA	0.3	NA	7.5E-05

TABLE B - 2

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
COMMERCIAL WORKER DERMAL CONTACT WITH SOIL
REASONABLE MAXIMUM EXPOSURE

EQUATIONS

$$\text{INTAKE} = \frac{Cs * SA * AF * ABS * ED * EY * CF}{BW * AT}$$

$$\text{RISK} = \text{INTAKEc} * \text{CSF}$$

$$\text{HI} = \frac{\text{INTAKEnc}}{\text{RfD}}$$

PARAMETER DESCRIPTIONS	UNITS	VALUES
Cs = Concentration in soil	mg/kg	see below
SA = exposed skin surface area	cm^2/day	5,800
AF = adherence rate for soil to skin	mg/cm^2	1
ABS = absorption factor	unitless	see below
ED = exposure duration	day/yr	250
EY = exposure duration	years	25
CF = conversion factor	kg/mg	1.0E-06
BW = body weight	kg	70
ATc= Averaging time Carcinogens	days	25,550
ATnc= Averaging time Non-Carcinogens	days	9,125
INTAKE	mg/kg-day	see below
Risk = Estimated Cancer Risk	unitless	see below
HI = Estimated Non-cancer Risk	unitless	see below
CSF = Cancer Slope Factor	kg-day/mg	see below
RfD = Reference Dose	mg/kg-day	see below

VOCs	Cs	ABS	INTAKEc	INTAKEnc	CSF	RfD	RISK	HI
benzene	0.012	0.03	7.3E-9	NA	0.029	NA	2E-10	NA
toluene	0.023	0.03	NA	3.9E-8	NA	0.2	NA	2.0E-7
ethylbenzene	0.004	0.03	NA	6.8E-9	NA	0.1	NA	6.8E-8
xylenes	0.053	0.03	NA	9.0E-8	NA	2	NA	4.5E-8
METALS								
copper	12	0.01	NA	6.8E-6	NA	0.037	NA	1.8E-4
nickel	10	0.01	NA	5.7E-6	NA	0.02	NA	2.8E-4
zinc	46	0.01	NA	2.6E-5	NA	0.3	NA	8.7E-5

Chromium = trivalent

NA = not avaliable

ABS = PEA manual

TABLE B - 3

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
COMMERCIAL WORKER (OUTDOORS) INHALATION OF DUST FROM SOIL
REASONABLE MAXIMUM EXPOSURE

EQUATIONS

PEF = (LS * V * DH * 3600 s/hr / A) * (1000 g/kg / 0.036 * (1-G) * (Um/Ut)^3 * F (x))
Ca = Cs / PEF
INTAKE = Ca * IR * EH * AC * 1/BW * ED * EY * 1/AT
RISK = INTAKEc * CSF
HI = INTAKEnc / RfD

PARAMETER DESCRIPTIONS	UNITS	VALUES
PEF = particulate emission factor	m^3/kg	4.03E+09
LS = width of contaminated area	m	58
V = wind speed in mixing zone	m/s	2.25
DH = diffusion height	m	2
A = area of contamination	m^2	3,000
0.036 = respirable fraction	g/m^2-hr	0.036
G = fraction of vegetative cover	unitless	0
Um = mean annual wind speed	m/s	4.5
Ut = equivalent threshold value of wind speed at 10 m	m/s	12.8
F (x) = function dependent on Um/Ut	unitless	0.0497
Ca = Concentration of Dust in Air	mg/m^3	see below
Cs = Concentration in soil	mg/kg	see below
IR = Inhalation rate	m^3/hr	2.5
EH= Exposure duration	hours/day	8
AC = Absorption coefficient	unitless	1
BW = Body weight	kg	70
ED = Exposure duration	days/year	250
EY = Exposure duration	years	25
ATc = Averaging Time Carcinogens	days	25,550
ATnc = Averaging Time Non-Carcinogens	days	9,125
INTAKE	mg/kg-day	see below
Risk = Estimated Cancer Risk	unitless	see below
HI = Estimated Non-cancer Risk	unitless	see below
CSF = Cancer Slope Factor	kg-day/mg	see below
RfD = Reference Dose	mg/kg-day	see below

Compounds	Ca	Cs	INTAKEc	INTAKEnc	CSF	RfD	RISK	HI
copper	3.0E-09	12	NA	5.8E-10	NA	0.037	NA	1.6E-08
nickel	2.5E-09	10	NA	4.9E-10	NA	0.02	NA	2.4E-08
zinc	1.1E-08	46	NA	2.2E-9	NA	0.3	NA	7.4E-09

NA = not avaliable

TABLE B - 4

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
COMMERCIAL WORKER (OUTDOORS) INHALATION OF VAPORS FROM SOIL
REASONABLE MAXIMUM EXPOSURE

EQUATIONS

$Pp = Pb / (1-n)$ $Kd = Koc * foc$ $$Ca = \frac{Cs * H' * Pb}{Kd * Pb + nw + na * H'}$$

$na = n - nw$ $Pf = Pb + nw$

PARAMETER DESCRIPTIONS	UNITS	VALUES
Cs = total concentration of chemical in soil	mg/kg	see below
Ca = soil vapor concentration	mg/L	see below
Kd = soil water partition coefficient	L/kg	see below
Koc = organic carbon partition coefficent	L/kg	see below
foc = soil organic carbon fraction	unitless	0.0013
Pb = dry soil bulk density	kg/L	1.66
n = total soil porosity	%	0.35
na = air filled soil porosity	%	0.33
Pp = particle density	kg/L	2.55
nw = water content	%	0.019
Pf = soil field density	kg/L	1.679
H' = dimensionless Henry's Law Constant	unitless	see below

Compounds	Cs	Koc	Kd	H'	Ca
benzene	0.012	65	8.45E-02	2.23E-01	1.91E-02
toluene	0.23	120	1.56E-01	2.43E-01	2.59E-01
ethylbenzene	0.004	220	2.86E-01	3.45E-01	3.77E-03
xylenes	0.053	237	3.08E-01	3.14E-01	4.35E-02

Soil Properties derived from GTI 3/94 Report

TABLE B - 4

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
COMMERCIAL WORKER (OUTDOORS) INHALATION OF VAPORS FROM SOIL
REASONABLE MAXIMUM EXPOSURE

EQUATIONS

$$De = \frac{H' * Da * na^{3.33}/n^{2} + Dw * nw^{3.33}/n^{2}}{Pf * Kd + nw + na * H'}$$

$$Ci = \frac{E * CF2}{LS * WS * MH} \qquad E = \frac{De * Ca * CF1 * A}{X}$$

PARAMETER DESCRIPTIONS	UNITS	VALUES
Da = Diffusion coefficent in air	m^2/hr	see below
Dw = Diffusion coefficent in water	m^2/hr	see below
De = Effective diffusion coefficient	m^2/hr	see below
X = Depth to contamination	m	2.75
CF1 = Conversion Factor	L/m^3	0.001
CF2 = Conversion Factor	hr/s	0.0003
E = Emission Rate	mg/hr	see below
A = Area of Emission	m^2	3000
Ci = Concentration in Air	mg/m^3	see below
LS = Length of side of area perpendicular to wind	m	58
WS = Wind speed	m/s	2.25
MH = Mixing height	m	2.00

Compounds	Da	Dw	De	E	Ci
benzene	3.36E-02	3.50E-06	6.6E-03	1.36E-04	3.2E-09
toluene	3.02E-02	3.10E-06	4.2E-03	1.18E-03	2.7E-08
ethylbenzene	2.69E-02	2.81E-06	3.1E-03	1.28E-05	3.0E-10
xylenes	2.66E-02	3.60E-06	2.7E-03	1.28E-04	3.0E-09

TABLE B - 4

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
COMMERCIAL WORKER (OUTDOORS) INHALATION OF VAPORS FROM SOIL
REASONABLE MAXIMUM EXPOSURE

EQUATION

$$\text{INTAKE} = \frac{\text{Ci} * \text{IR} * \text{EH} * \text{ED} * \text{EY}}{\text{BW} * \text{AT}}$$

$$\text{RISK} = \text{INTAKEc} * \text{CSF}$$

$$\text{HI} = \frac{\text{INTAKEnc}}{\text{RfD}}$$

PARAMETER DESCRIPTIONS	UNITS	VALUES
Ci = concentration in indoor air	mg/m^3	see below
IR = inhalation rate	m^3/hour	2.5
EH = exposure time	hours/day	8
ED = exposure duration	days/year	250
EY = exposure duration	years	25
BW = body weight	kg	70
ATc = Averaging time Carcinogens	days	25,550
ATnc = Averaging time Non-Carcinogens	days	9,125
INTAKE	mg/kg-day	see below
NA = not analyzed		
Risk = Estimated Cancer Risk	unitless	see below
HI = Estimated Non-cancer Risk	unitless	see below
CSF = Cancer Slope Factor	kg-day/mg	see below
RfD = Reference Dose	mg/kg-day	see below

Compounds	Ci	INTAKEc	INTAKEnc	CSF	RfD	RISK	HI
benzene	3.2E-09	2.2E-10	NA	0.029	NA	6E-12	NA
toluene	2.7E-08	NA	5.4E-9	NA	0.11	NA	4.9E-8
ethylbenzene	3.0E-10	NA	5.8E-11	NA	0.29	NA	2.0E-10
xylenes	3.0E-09	NA	5.8E-10	NA	2	NA	2.9E-10

TABLE B - 5

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
COMMERCIAL WORKER - (INDOORS) INHALATION OF VAPORS FROM GROUNDWATER

EQUATIONS

$$De = \frac{H * Da * na^{3.33}/n^{2} + Dw * nw^{3.33}/n^{2}}{Pf * Kd + nw + na * H}$$

$$F = \frac{De * Cg * CF}{X}$$

$$Ci = \frac{F * A * AF}{Q}$$

$$Q = V * E$$

PARAMETER DESCRIPTIONS

Da = Diffusion coefficent in air
Dw = Diffusion coefficent in water
De = Effective diffusion coefficient
X = Distance between contamination and surface
CF = Conversion Factor
F = Flux of chemical
V = Volume of building
E = Air exchange rate
Q = Ventilation rate of building
A = Area of building through which vapors will migrate
AF = Attenuation Factor
Ci = Concentration in indoor air

Compounds	Da m^2/hr	Dw m^2/hr	De m^2/hr	X m	CF L/m^3	F mg/m^2-h	V m^3	E olumes/h	Q m^3/hr	A m^2	AF	Ci mg/m^3
Benzene	3:4E-02	3.5E-06	6.5E-03	7.5	1000	1.48E+00	2591	0.5	1296	1000	0:01	1.1E-02
Toluene	3.0E-02	3.1E-06	4.2E-03	7.5	1000	9.96E-01	2591	0.5	1296	1000	0.01	7.7E-03
Ethylbenzene	2.7E-02	2.8E-06	3.1E-03	7.5	1000	1.70E-01	2591	0.5	1296	1000	0.01	1.3E-03
Xylene	2.7E-02	3.6E-06	2.7E-03	7.5	1000	8.42E-01	2591	0.5	1296	1000	0.01	6.5E-03

TABLE B - 5

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
COMMERCIAL WORKER - (INDOORS) INHALATION OF VAPORS FROM GROUNDWATER

EQUATIONS

$$\text{INTAKEc} = \frac{\text{Ci} * \text{IR} * \text{ED} * \text{EY}}{\text{BW} * \text{AT}} \qquad \text{INTAKEnc} = \frac{\text{Ci} * \text{IR} * \text{ED} * \text{EY}}{\text{BW} * \text{AT}}$$

$$\text{CANCER RISK} = (\text{INTAKEiv} * \text{CSFi}) \qquad \text{HAZARD INDEX} = \frac{\text{INTAKEiv}}{\text{RfDi}}$$

PARAMETER DESCRIPTIONS

IR = Human inhalation rate
BW = Body weight
ED = Exposure duration
EY = Exposure duration
AT = Averaging time
INTAKEc = Intake (cancer)
INTAKEnc = Intake (non-cancer)
Risk = Cancer Risk (Carcinogens)
HI = Hazard Index (Non-Carcinogens)
CSFi = Inhalation Cancer Slope Factor
RfDi = Inhalation Reference Dose

Compound	IR m^3/day	BW kg	ED days/yr	EY years	AT days	INTAKEc mg/kg-day	INTAKEnc mg/kg-day	RfDi mg/kg-day	CSFi kg-day/mg	HI unitless	Risk unitless
Benzene	20	70	250	25	25550	8.0E-04	NA	NA	0.029	NA	2.E-05
Toluene	20	70	250	25	9125	NA	1.5E-03	0.11	NA	1.4E-02	NA
Ethylbenzene	20	70	250	25	9125	NA	2.6E-04	0.29	NA	8.9E-04	NA
Xylene	20	70	250	25	9125	NA	1.3E-03	2	NA	6.4E-04	NA

TABLE - 6

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
RESIDENT INGESTION OF TAPWATER

EQUATION

$$\text{INTAKE} = \frac{\text{CW} * \text{IR} * \text{ED} * \text{EY}}{\text{BW} * \text{AT}} \qquad \text{RISK} = \text{INTAKEc} * \qquad \text{HI} = \frac{\text{INTAKEnc}}{\text{RfD}}$$

PARAMETER DESCRIPTIONS	UNITS	VALUES
CW = Concentration of Chemicals in Wate	mg/L	see below
IR = Ingestion Rate	L/day	2.00
BW = Body Weight	kg	70
ED = Exposure Duration	days/year	350
EY = Exposure Duration	years	30
ATc = Averaging Time Carcinogens	days	25,550
ATnc = Averaging Time Non-Carcinogens	days	10,500
INTAKE	mg/kg-day	see below
CSF = Cancer Slope Factor	kg-day/mg	see below
RfD = Reference Dose	mg/kg-day	see below
RISK = Estimated cancer risk	unitless	see below
HI = Estimated non-cancer Risk	unitless	see belo

Compounds	CW	INTAKEc	INTAKEnc	CSF	RfD	RISK	HI
VOCs							
benzene	3.72E+00	4.4E-02	NA	0.029	NA	1E-03	NA
toluene	7.00E-02	NA	2.0E-03	NA	0.2	NA	1.0E-02
ethylbenzene	5.82E-01	NA	1.7E-02	NA	0.1	NA	1.7E-01
xylenes	8.30E+00	NA	2.4E-01	NA	2	NA	1.2E-01
SVOCs							
2,4-Dimethylphenol	3.64E-02	NA	1.0E-03	NA	0.05	NA	2.1E-02
Methylnaphthalene	1.78E-02	NA	5.1E-04	NA	0.04	NA	1.3E-02
Naphthalene	5.30E-02	NA	1.5E-03	NA	0.04	NA	3.8E-02
Phenol	1.78E-02	NA	5.1E-04	AN	0.6	NA	8.5E-04

CW = values listed are the mean of concentrations from MW-11, MW-26, and MW-34 for dates 5/24/94, 8/3/94, and 3

TABLE B - 7

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
RESIDENT DERMAL CONTACT WITH TAPWATER

EQUATION

$$\text{INTAKE} = \frac{\text{PC} * \text{CF} * \text{CW} * \text{EH} * \text{SA} * \text{ED} * \text{EY}}{\text{BW} * \text{AT}} \qquad \text{RISK} = \text{INTAKEc} \qquad \text{HI} = \frac{\text{NTAKEnc}}{\text{RfD}}$$

PARAMETER DESCRIPTIONS	UNITS	VALUES
PC = Permeability Coefficient	cm/hr	see below
SA = Exposed Skin area	cm^2	20,000
CF = Unit Conversion Factor	L/cm^3	0.001
EH = Exposure duration	hrs/day	0.17
BW = Body weight	kg	70
CW = Concentration in water	mg/L	see below
ED = Exposure duration	days/year	350
EY = Exposure duration	years	30
ATc = Averaging Time Carcinogens	days	25,550
ATnc = Averaging Time Non-Carcinogen	days	10,500
INTAKE	mg/kg-day	see below
CSF = Cancer Slope Factor	kg-day/mg	see below
RfD = Reference Dose	mg/kg-day	see below
RISK = Estimated cancer risk	unitless	see below
HI = Estimated non-cancer Risk	unitless	see below

Compounds	PC	CW	INTAKEc	NTAKEn	CSF	RfD	RISK	HI
VOCs								
benzene	2.10E-02	3.72E+00	1.6E-03	NA	0.029	NA	5E-05	NA
toluene	4.50E-02	7.00E-02	NA	1.5E-04	NA	0.2	NA	7.7E-04
ethylbenzene	7.40E-02	5.82E-01	NA	2.1E-03	NA	0.1	NA	2.1E-02
xylenes	8.00E-02	8.30E+00	NA	3.2E-02	NA	2	NA	1.6E-02
SVOCs								
2,4-Dimethylphenol	1.50E-02	3.64E-02	NA	2.7E-05	NA	0.05	NA	5.3E-04
Methylnaphthalene	2.10E-01	1.78E-02	NA	1.8E-04	NA	0.04	NA	4.5E-03
Naphthalene	6.90E-02	5.30E-02	NA	1.8E-04	NA	0.04	NA	4.4E-03
Phenol	5.50E-03	1.78E-02	NA	4.8E-06	AN	0.6	NA	7.9E-06

CW = values listed are the mean of concentrations from MW-11, MW-26, and MW-34 for dates 5/24/94, 8/3/94,

TABLE B - 8

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
RESIDENT INHALATION OF VAPORS FROM TAPWATER

EQUATION

$$\text{INTAKE} = \frac{\text{CW} * \text{K} * \text{IR} * \text{ED} * \text{EY}}{\text{BW} * \text{AT}} \qquad \text{RISK} = \text{INTAKEc} * \text{CSF} \qquad \text{HI} = \frac{\text{INTAKEnc}}{\text{RfD}}$$

PARAMETER DESCRIPTIONS	UNITS	VALUES
CW = Concentration of Chemicals in Water	mg/L	see below
K = Volatilization factor	L/m^3	0.50
IR = Inhalation Rate (indoor)	m^3/day	15
ED = Exposure Duration	days/year	350
EY = Exposure Duration	years	30
BW = Body Weight	kg	70
ATc = Averaging Time Carcinogens	days	25,550
ATnc = Averaging Time Non-Carcinogens	days	10,500
INTAKE	mg/kg-day	see below
CSF = Cancer Slope Factor	kg-day/mg	see below
RfD = Reference Dose	mg/kg-day	see below
RISK = Estimated cancer risk	unitless	see below
HI = Estimated non-cancer Risk	unitless	see below

K is from a paper by Andelman, 1990, and is an upper bound value, assuming the following:
volume of water used/day=720 L; family of 4; volume of house=150,000 L; air exchange rate=0.25 vol./hr.;
and transfer efficiency for all water uses=0.5.

Compounds	CW	INTAKEc	INTAKEnc	CSF	RfD	RISK	HI
VOCs							
benzene	3.72E+00	1.6E-01	NA	0.029	NA	5E-03	NA
toluene	7.00E-02	NA	7.5E-03	NA	0.2	NA	3.8E-02
ethylbenzene	5.82E-01	NA	6.2E-02	NA	0.1	NA	6.2E-01
xylenes	8.30E+00	NA	8.9E-01	NA	2	NA	4.4E-01
SVOCs							
2,4-Dimethylphenol	3.64E-02	NA	3.9E-03	NA	0.05	NA	7.8E-02
Methylnaphthalene	1.78E-02	NA	1.9E-03	NA	0.04	NA	4.8E-02
Naphthalene	5.30E-02	NA	5.7E-03	NA	0.04	NA	1.4E-01
Phenol	1.78E-02	NA	1.9E-03	AN	0.6	NA	3.2E-03

TABLE B - 9

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
RESIDENT DERMAL CONTACT WITH IRRIGATION WATER

EQUATION

$$\text{INTAKE} = \frac{PC * CF * CW * EH * SA * ED * EY}{BW * AT} \qquad \text{RISK} = \text{INTAKEc} \qquad \text{HI} = \frac{\text{NTAKEnc}}{\text{RfD}}$$

PARAMETER DESCRIPTIONS	UNITS	VALUES
PC = Permeability Coefficient	cm/hr	see below
SA = Exposed Skin area	cm^2	1,980
CF = Unit Conversion Factor	L/cm^3	0.001
EH = Exposure duration	hrs/day	0.08
BW = Body weight	kg	70
CW = Concentration in water	mg/L	see below
ED = Exposure duration	days/year	104
EY = Exposure duration	years	30
ATc = Averaging Time Carcinogens	days	25,550
ATnc = Averaging Time Non-Carcinogens	days	10,950
INTAKE	mg/kg-day	see below
CSF = Cancer Slope Factor	kg-day/mg	see below
RfD = Reference Dose	mg/kg-day	see below
RISK = Estimated cancer risk	unitless	see below
HI = Estimated non-cancer Risk	unitless	see below

Compounds	PC	CW	INTAKEc	NTAKEn	CSF	RfD	RISK	HI
VOCs								
benzene	2.10E-02	3.72E+00	2.2E-05	NA	0.029	NA	6E-07	NA
toluene	4.50E-02	7.00E-02	NA	2.0E-06	NA	0.2	NA	1.0E-05
ethylbenzene	7.40E-02	5.82E-01	NA	2.8E-05	NA	0.1	NA	2.8E-04
xylenes	8.00E-02	8.30E+00	NA	4.3E-04	NA	2	NA	2.1E-04
SVOCs								
2,4-Dimethylphenol	1.50E-02	3.64E-02	NA	3.5E-07	NA	0.05	NA	7.0E-06
Methylnaphthalene	2.10E-01	1.78E-02	NA	2.4E-06	NA	0.04	NA	6.0E-05
Naphthalene	6.90E-02	5.30E-02	NA	2.4E-06	NA	0.04	NA	5.9E-05
Phenol	5.50E-03	1.78E-02	NA	6.3E-08	AN	0.6	NA	1.1E-07

CW = values listed are the mean of concentrations from MW-11, MW-26, and MW-34 for dates 5/24/94, 8/3/94, an

TABLE B-10

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
Off-Site Residential Receptor
Exposure Pathway: INHALATION OF VAPORS FROM IRRIGATION WATER
Calculation Endpoint: HAZARD INDICES

EQUATIONS

Q = CW * WR * TE * CF1/CF2

VOL = MH * LS * WS * WD * CF2 * CF3

CA = Q * WD * FF * CF2 * CF3/VOL
ADD = CA * EH * IR * BI * ED * EY/(BW * EL)
HI = ADD / RfD

SYMBOLS AND DESCRIPTIONS	*UNITS*	*VALUES*
CW = Concentration of Chemical in Water	mg/L	see table 2
WR = Water Flow Rate	gal/min	23
TE = Transfer Efficiency	unitless	see table 2
CF1 = Conversion Factor	L/gal	3.79
CF2 = Conversion Factor	sec/min	60
CF3 = Conversion Factor	min/hr	60
Q = Chemical Flux Rate	mg/s	see table 2
LS = Length of Side of Hypothetical Box	m	30
WS = Wind Speed	m/s	3
MH = Mixing Height	m	2
VOL = Volume of box	m^3	648000
FF = Fraction of Time Wind Blows into Box	unitless	1
WD = Daily Watering Duration	hours	1
CA = Concentration of Chemical in Air	mg/m^3	see table 2
EH = Exposure Duration	hours/day	1
IR = Inhalation Rate	m^3/hour	0.83
BI = Absorption Coefficient	unitless	1
BW = Body Weight	kg	70
ED = Exposure Duration	days/year	104
EY = Exposure Duration	years	30
EL = Exposure Duration	days	10950
ADD = Average Daily Dose	mg/kg-day	see table 2
RfD = Reference Dose	mg/kg-day	see table 2
HI = Hazard Index	unitless	see table 2

Table 2

Compound	TE	CW	Q	CA	ADD	RfD	HI
Toluene	0.555	7.00E-02	5.64E-02	3.14E-04	1.1E-06	0.57	**1.9E-06**
Ethylbenzene	0.501	5.82E-01	4.24E-01	2.35E-03	8.0E-06	0.1	**8.0E-05**
Xylenes	0.556	8.30E+00	6.70E+00	3.72E-02	1.3E-04	0.09	**1.4E-03**
							1.5E-03

GROUNDWATER TECHNOLOGY

TABLE B - 11

GIANT REFINING COMPANY - BLOOMFIELD, NEW MEXICO
Summary of Estimated Risks

Receptor	Media	Exposure Routes	Total Cancer Risk	Total Hazard Index
Commercial Worker	Soil	Inhalation of volatile emmisions from soil, inhalation of dust-borne particulates, incidental soil ingestion, dermal contact, and inhalation of volitiles through vapor intrusion into buildings.	3E-10	0.00012
	Groundwater	Inhalation of vapors from groundwater	2E-05	0.015
Off-site Resident	Potable Groundwater Use	Inhalation of vapors from tapwater, ingestion and dermal contact with tapwater	6E-03	1.8
Off-site Resident	Non-potable Groundwater Use	Inhalation of vapors and dermal contact with irrigation water	1E-06	0.0021