BIDDLE

# HYDROGEOLOGIC CHARACTERIZATION, GROUND WATER MONITORING PLAN, AND FACILITY DESIGN

## PICKLES BUTTE SANITARY LANDFILL

## CANYON COUNTY, IDAHO

July, 1994

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Holladay Engineering Company
Project Number T4 120491

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# ABSTRACT


The Pickles Butte Sanitary Landfill is situated in a large arid canyon located in south central Canyon County, Idaho. The facility began accepting waste April 1, 1983 and through April 1, 1994 approximately 1,080,000 cubic yards of material had been deposited. The original site capacity estimate was 16 million cubic yards (mcy) (Blakley, 1973 & 1975). The design advanced in this report increases the site's total capacity by 65% and estimates the remaining available capacity at 25.3 mcy.

Detailed mapping of the surface geology and evaluation of drillers' logs of proximate wells resulted in the formulation of a model of the vicinity's regional hydrogeologic system. Consequently, a detailed, two phased, ground water delineation drilling program with companion methane evaluation was performed over a two-year period to establish the local hydrogeology and determine its role in the regional system. Drilling also secured subsurface samples essential for evaluating the potential for leachate migration impacting ground water. This information also served as input for a quantitative predictive computer model for potential leachate generation and rate of migration. A monitoring well system is advanced, based on the characteristics of the site's hydrogeologic setting, which provides the County citizens confidence that the landfill is not effecting ground water resources.

Based on the hydrogeologic investigation conclusions and in conformance with the arid design criteria of 39-74 Idaho Code the landfill qualifies for continued development as an unlined facility. The design incorporates an aggressive surface water management system to enhance the native protection of the thick sequence of unsaturated sediments underlying the site. Evaluation of soil samples identified resource areas for final cover material using a design which balances precipitation, evaporation and the effective holding capacity of the resource soils. The arid climate of the area and the natural geologic protection of the site provide an ideal location of the Canyon County Sanitary Landfill making Pickles Butte one of the most valuable physical asset in Canyon County.

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# I. INTRODUCTION

Pickles Butte Sanitary Landfill in Canyon County, Idaho is located south of Lake Lowell approximately 12 miles south of Caldwell and 10 miles southwest of Nampa (see Figure 1, General Location Map) in an area known locally as Deadhorse Canyon. The landfill has been accepting solid waste since April 1, 1983 and currently is the only sanitary landfill operating in Canyon County.

The site was originally leased from the Bureau of Land Management (BLM) for a period of 25 years under provisions of the Federal Recreation or Public Purposes Act Lease No. I-6872. Two hundred sixty 260 acres of the original 320 acre lease was purchased by the county on August 21, 1991. The remaining 60 acres of the lease and an additional 20 acres located along the southern border of the landfill were purchased by the County from the BLM on May 12, 1994. Also, the County purchased 30 acres along the northwestern boundary for a total area of 370 acres (see Plate 1 General Site Map).

The Division of Environmental Quality (DEQ) approved the original design and operating plan on June 16, 1973, reconfirmed approval on May 2, 1975 and the facility was approved by the Southwest District Health Department (SWDHD) on December 14, 1979. The County received, in conformance with Title 39, Chapter 74, Idaho Solid Waste Facility Act, site certification approval from the (DEQ) on August 9, 1993 and approval of the facility operating plan by SWDHD on October 6, 1993.

This report has been developed to conform with the requirements of Title 39, Chapter 74, Idaho Solid Waste Facility Act regarding site hydrogeologic characterization, ground water monitoring plan and design, and landfill design including final cover. Canyon County, with this report, requests acceptance from DEQ of the hydrogeologic investigation and approval of the ground water monitoring plan and design, designation of the point of compliance, and 98-acre design footprint.

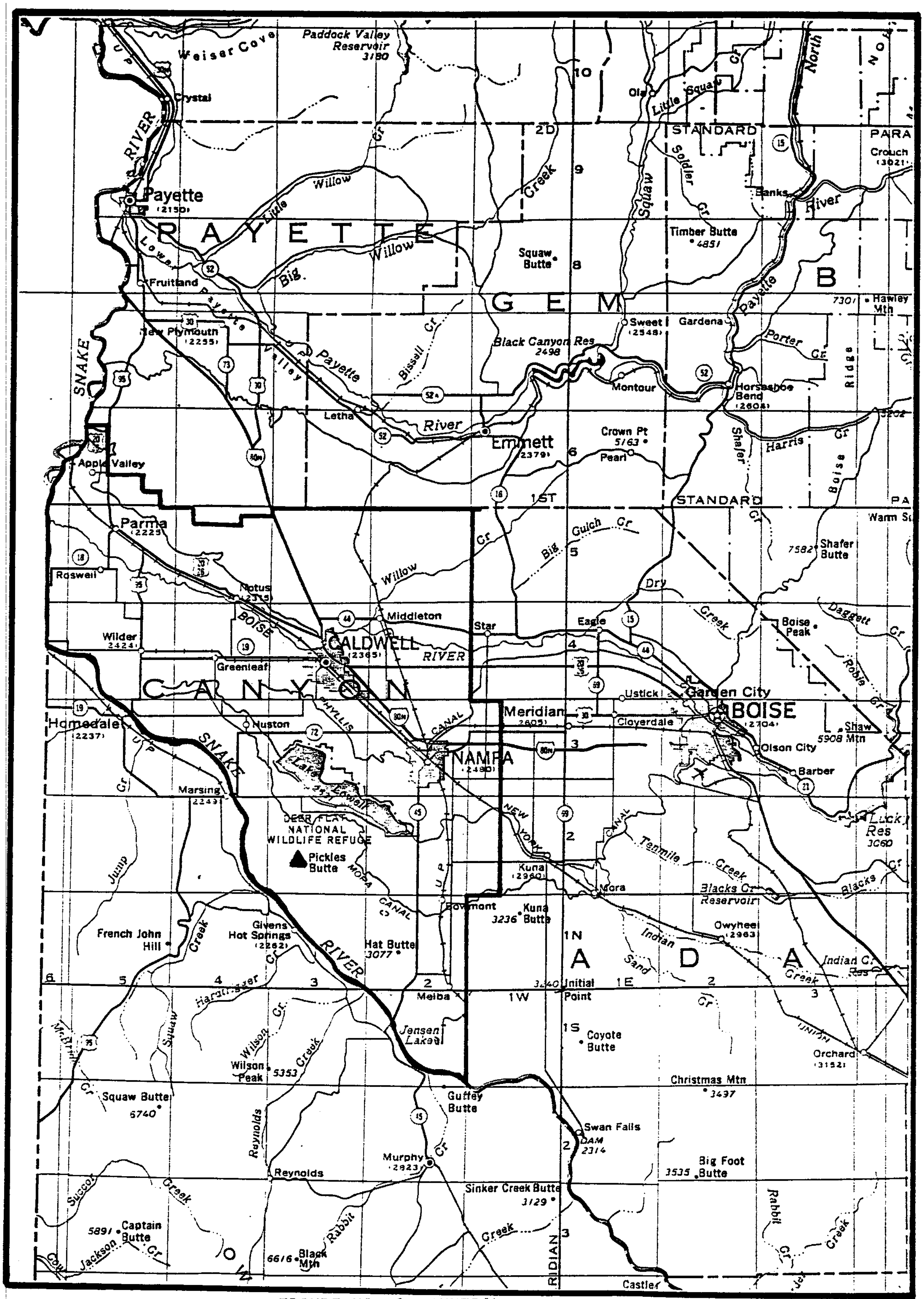



FIGURE NO. 1 GENERAL LOCATION MAP

# II. GEOLOGIC ANALYSIS

## A. REGIONAL GEOLOGY

The Pickles Butte Landfill is located within the Western Snake River Plain which is an arcuate basin more than 400 miles long spanning most of the southern portion of the Idaho. This section of the plain trends towards the northwest and is approximately 40 miles wide. The western plain is generally considered to be a graben-like depression bounded by northwest-trending normal faults. Deep drilling in the western portion of the plain indicates that basin-fill sediments and volcanic flows extend more than 14,000 feet below the plain (Wood and Anderson, 1981) and the total thickness of basin fill may be in excess of 23,000 feet (Mabey, 1982). The upper 2,300 to 5,700 feet of fill in the western plain is mostly clastic sediments (Wood and Anderson 1981).

Discussion of the various tectonic theories explaining the formation of the Snake River Plain is beyond the scope of this report. However, most researchers who have worked in the western plain agree that it first developed into a prominent structural feature during the lower to middle Miocene. Faulting and subsidence continued during the deposition of the sediments and volcanics in the basin but tectonic activity appears to have ceased before upper Pleistocene Snake River Basalt deposition (Wood and Anderson, 1981).

The middle Miocene to middle Pleistocene sediments of the Western Snake River Plain are included in the Idaho Group which has been divided (from oldest to youngest) into the Poison Creek Formation, unnamed basalts, Chalk Hills Formation, Banbury Basalt, Glenns Ferry Formation, Tuana Gravel, Bruneau Formation, and Black Mesa Gravel (Malde, 1962; Kimmel, 1982; Swirydezuk et al, 1982; Middleton et al, 1985).

The sediments exposed in canyon walls in the vicinity of the landfill are upper Pliocene strata (Neville et al, 1979) locally capped with a thin veneer of mid-Pleistocene basalts (see Figure 2, Regional Geologic Map). The majority of the sediments exposed in Deadhorse Canyon are part of the upper Glenns Ferry Formation which are capped with Bruneau Formation basalts. The Idaho Group in the area of the landfill may be up to

4,000 feet thick, of which the Glenns Ferry Formation comprises most of the upper 2,300 feet (Wood and Anderson, 1981).

The Glenns Ferry is principally shallow-water facies, delta-plain sands and silts underlain by deeper water lacustrine pro-deltaic mud and clay (Wood, 1994). The depositional environment of this formation involved the formation of a large lake, known as ancient Lake Idaho, by presumed basalt flow damming of the ancestral Snake River in the northwest margin of the plain. Much of the lake sediments were deposited by a northwesterly prograding delta within the lake and lateral drainage alluvium.

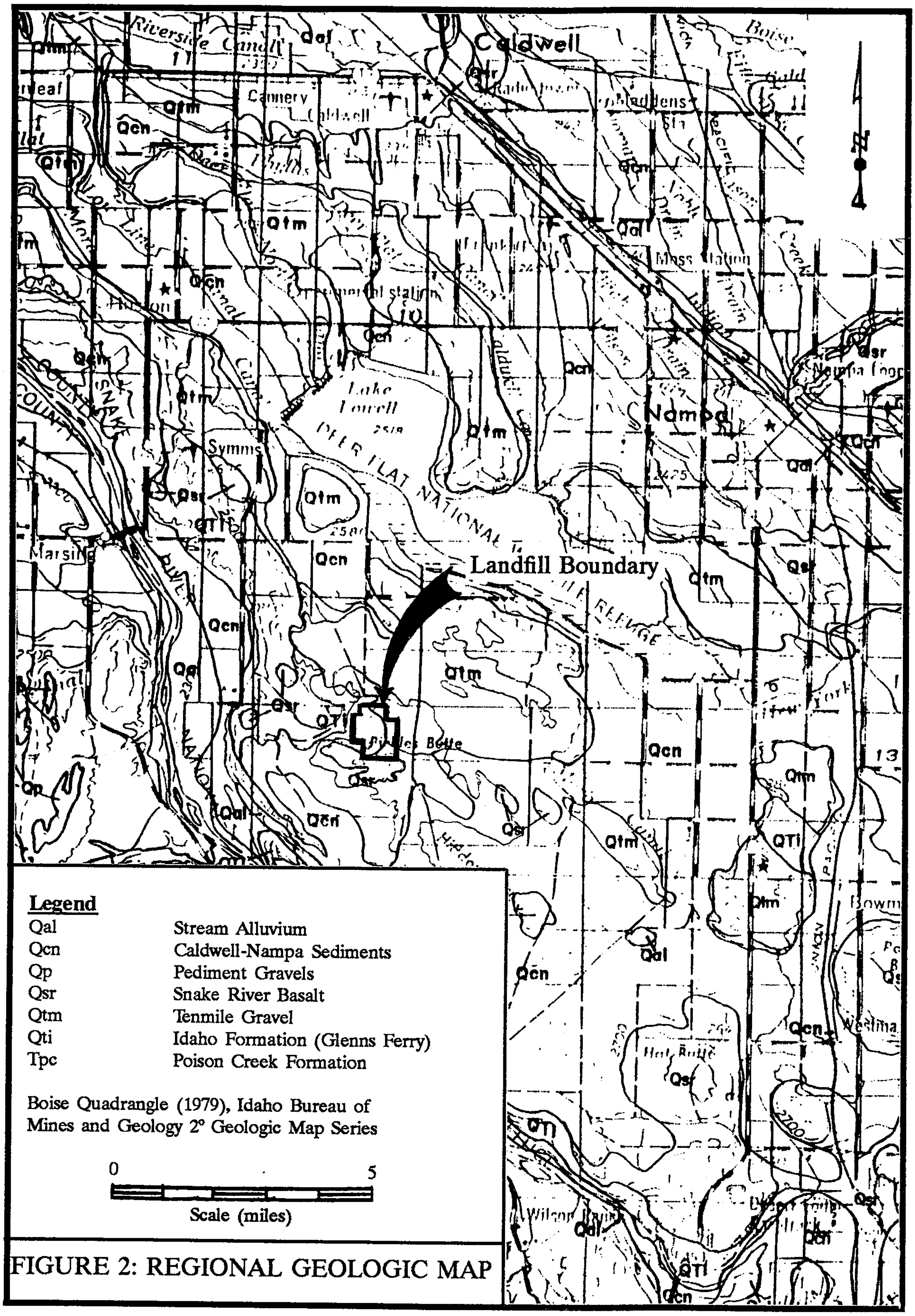



FIGURE 2: REGIONAL GEOLOGIC MAP

## B. LOCAL GEOLOGY

There is almost 500 feet of topographic relief and stratigraphy exposed between the mouth of Deadhorse Canyon and the top of Pickles Butte. The bluffs comprising the canyon walls provide useful exposure of this upper stratigraphy and surficial geology. Detailed mapping of the local geology was conducted by Holladay Engineering Company in 1991 which is depicted on the Geologic Map (Plate 2).

Subsurface geology was exposed in backhoe test pits and trenches excavated in critical areas of poor exposure such as along the suspected trace of concealed faults or checking formation material for suitable landfill cover. However, the principal tool for subsurface investigation was continuous diamond core and reverse circulation rotary drilling. The subsurface geologic investigation is described under section **III. HYDROGEOLOGIC CHARACTERIZATION** of this report.

A generalized stratigraphic section advanced by Wood and Anderson (1981) of the strata exposed in Deadhorse Canyon consists of fluvial and lacustrine beds of the upper Glenns Ferry Formation unconformably overlain by Tuana gravel and capped by Bruneau Formation fluvial and lacustrine sediments and basalt. The gravel commonly defines the top of the northeastern canyon rim. The eastward slope of the plateau immediately east of the rim is a modified dip-slope generally mimicking the local bedding attitude. The Tuana gravel is unconformably overlain by a thin mantel of fluvial or lacustrine sand and silt which correlate with Bruneau Formation. A thin basalt veneer, which caps Pickles Butte generally overlies the lacustrine silt but in places appears to rest directly on the gravel. The basalt is mapped as lower to middle Pleistocene Bruneau Formation by Wood and Anderson (1981).

The stratigraphic succession proposed by Wood and Anderson (1981), as briefly outlined above, matches the lithology found at the landfill site and the established nomenclature has not been modified in this report.

## Glenns Ferry Formation

The Glenns Ferry Formation is comprised of buff-colored fine, medium, and coarse grained sand layers of fluvial origin interbedded with lacustrine silt beds. The sands in individual beds vary from moderately well sorted to poorly sorted. The time of earliest deposition has not been defined by investigators but most agree that Glenns Ferry deposition ceased approximately 2.2 to 2.4 million years ago.

Most of the sand beds are only weakly to moderately consolidated except for some lithified sandstone outcrops located in the lower central portion of the canyon. These outcrops are composed of a well consolidated, poorly sorted, tuffaceous, fine-grained sandstone. The bedding planes of the sand layers are generally parallel, laterally uniform in thickness but vertically adjacent beds may vary to each other in respective thickness. The sedimentary structures present within individual beds include: symmetrical, asymmetrical, and climbing ripples, large dune foreset beds, flute casts, graded and laminar beds. Other sedimentary features associated with the sand layers are: channel scour and fill, rip-up clasts commonly composed of mud, and large scale soft-sediment deformations developed in underlying silts. Most of the sand layers appear to be sheets that are laterally continuous but others such as the channel scour sands are elongate or lenticular.

The lacustrine sediments are comprised of buff-colored, very fine-grained sands and silts with a clay-size constituent of mostly non-mineral clays except possible devitrified volcanic ash. Sediments of this character are commonly described in driller's logs as buff, green, brown, red and blue clays. The blue color (often gray) is due to disseminated sulfides indicating the sediments were deposited and preserved in a reducing environment. When the blue sediments are exposed to the air the sulfide quickly oxidizes and turns the sediments buff or tan in color. The lacustrine sediments appear to be laterally extensive planar beds or series of beds which only occasionally show distinguishable horizontal bedding planes.

Consolidation (lithifaction) varies significantly throughout the vertical section and appears to vary between drillholes within correlatable beds. In general, the upper buff-colored sands and silts are less consolidated than the deeper unoxidized clay(stone) units. The span of consolidation ranges from virtually loose material to quite hard and brittle sedimentary rock (unconfined compressive strength greater than 200 psi, Wood, 1994). In this case, lithifaction appears mostly to be a product of calcareous cementation and, to a lesser degree, load compaction.

Commonly the bedding contact between the medium and fine fluvial sands and the lacustrine silts is very abrupt. The abrupt change can significantly affect the movement of water in both the saturated and vadose zones. Changes in hydraulic conductivity across these contacts may vary by a factor of 100 to 10,000.

## Tuana Gravel

The Tuana Gravel unconformably overlies lacustrine facies of the Glenns Ferry Formation which is truncated by the gravel. The gravel immediately adjacent to the contact dips gently to the northeast at approximately $3^{o}$ and the underlying Glenns Ferry Formation strata dip from between $4^{o}$ to $25^{o}$ to the northeast. The steeper dips reflect minor localized drag from Pliocene and lower Pleistocene faulting. The Tuana gravel post-dates the Glenns Ferry Formation and has been dated by Amini to be approximately 2 million years old (reference cited in Othberg, 1986).

The gravel varies from six feet thick at the northern end of the northeastern canyon wall to 30 feet thick at the southern end. The gravel exposed along the northern portion of the northeastern canyon rim is moderately well cemented with calcium carbonate. The gravel is poorly sorted and where it is not cemented constitutes an acceptable material for use in road construction and drainage applications at the landfill. The formation commonly contains sand lenses which can locally comprise a significant percentage of the formation.

## Bruneau Formation

The Bruneau Formation consists of fine-grained sandy silt and silty sand of probable lacustrine origin. No sedimentary structures were observed in outcrops, trenches or testholes. In the absence of sedimentary structures it is unknown what type of contact exists with the underlying Tuana Gravel. Wood and Anderson (1981) suggest that the

Bruneau Formation lies unconformably on the Tuana Gravel. The testholes and trenching indicates the formation grades from a silty sand above the gravel to a sandy silt at the ground surface (see Figure 8 and Table 20 in Section **VI. A. COVER MATERIAL EVALUATION**).

The formation is only a few feet thick where exposed along the northeastern rim of the canyon but drilling indicates the silts are up to 45-feet thick near the facility lease boundary. See section on **VI. A. COVER MATERIAL EVALUATION** for a discussion regarding the application of this formation in the facility design.

Included in the Bruneau Formation is a thin basalt flow which caps Pickles Butte. This basalt shows some minor offset (a few tens of feet) resulting from a northwest-trending fault 2,000 feet west of the landfill. Potassium-Argon dating conducted by Amini suggest the basalts of the Bruneau Formation range in age from 1 to 2 million years old (reference contained in Malde, 1987). The basalt is geographically limited and found at the highest elevations above the southwestern-most portion of the canyon. As a result, the basalt does not have any direct role in the site's hydrogeologic setting.

Cinder deposits located in an old Nampa Highway District gravel pit located along the southern boundary of the site are included in the Bruneau Formation but may correlate with the later Snake River Group basalts. The cinders overlie the Tuana Gravel, the sedimentary facies of the Bruneau Formation, and are found topographically above adjacent Bruneau Formation basalt at the Nampa Highway District gravel pit. The contact relationship between the cinders and the basalt is not exposed. The cinders comprise only a minor portion of the rocks in the southern extremity of the area.

## Sand Dunes

Some minor sand dunes are located along the top of the northeastern rim of the canyon and along a low ridge located in the west center of the valley. The dunes are the most recent deposit in the area and appear to be substantially stabilized by grasses.

## C. GEOLOGIC STRUCTURE

Tectonic activity has probably structurally controlled the evolution of the plain and the accumulation of clastic sediments since the Miocene (Mabey, 1976). Rocks of Pliocene and younger age appear to be displaced downward along northwest-trending faults toward the center of the basin in progressively diminishing amounts (Swirydezuk et al, 1982; Malde et al, 1963). Wood and Anderson (1981) and Wood (1994) describe the region during late Pliocene and early Pleistocene as a northwest-trending and plunging tectonic sedimentary basin with the basin axis located beneath Lake Lowell and the City of Caldwell.

The faults found in the area of the landfill generally reflect the structural character of the overall basin described above. The local faults shown on the geologic map are mostly northwest-striking, high-angle, normal faults. A few small faults that strike north, northeast, and east-west have offsets of a few inches to 18 feet. The small faults are possibly shallow, minor settlement features without roots or consequence to the structural setting of the canyon.

The northwesterly faults tend to occur in localized zones as a set of parallel to sub-parallel, high-angle, normal displacements. A northwest-trending, high-angle, normal fault zone located in the canyon wall to the immediate east of the facility is the only structure found with sufficient size and proximity which could potentially have any influence on the site's hydrogeologic setting. The offset relationship along this fault suggest about 35 feet of apparent displacement. This fracture system, on close inspection in the field, appears sealed; being limonite filled and cemented.

The surrounding sediments appear too unconsolidated to sustain open fractures for a protracted period. In any case, an early concern for this structure providing a preferential pathway for leachate was negated when it was realized that the upper sands hosting the fault most likely have a higher relative permeability than the structure itself. It is obvious that the unconsolidated upper clays and silts cannot support wet open fractures either; only the more lithified claystone unit at depth is a candidate for fracture flow. Yet the claystone below the site was found to have positive artesian head when penetrated. This condition indicates that direct hydraulic communication to ground water by downward fracture flow along the fault system is not feasible.

Three backhoe trenches were excavated in areas of possible concealed faults based on topography or linears features (see Geologic Map, Plate 2). The trenches were dug through overburden to approximate depths of six to ten feet and between 150 to 200 feet long. In each case no evidence of fault occurrence was found below the overburden.

Overall local bedding strikes north-northwest with dips usually less than ten degrees east-northeast. Bedding attitude along the northwest-trending fault zone indicates some fault drag. The sediments nearer the fault tend to have steeper dips than bedding further from the structure. This dip variation is probably attributable to frictional drag deformation created along the fault during movement. Near the contact, the dip of Glenns Ferry Formation strata is commonly steeper than the dip of the overlying Tuana Gravel which indicates that most of the movement along the fault probably occurred before deposition of the gravel. But the gravel is also offset by the fault zone indicating that movement spanned the period of time during which the gravel was deposited. No evidence of active faulting during the Holocene Epoch was found at the site.

The orientation of strata, other than across the northwest fault, do not seem to be significantly affected by faulting and apparent offsets are generally in the range of a few inches to a few feet. Despite localized fault-drag effects on bedding dips, observed fault influence on overall structural attitudes at the site is relatively small. Furthermore, the agreement of subsurface attitudes of sedimentary contacts with that of primary surface sedimentary features (described in section **III. D. BOREHOLE HYDROGEOLOGY**) tends to validate the absence of large-scale differential fault-block rotation within the drilled area.

# III. HYDROGEOLOGIC CHARACTERIZATION

## A. REGIONAL HYDROGEOLOGY

The facility is located in an area where the regional hydrogeologic system is complex and the availability of reliable and correlatable well log information is unevenly distributed spatially. Table 1 presents data on 72 wells in the general area of the facility. There are many more wells in the area for which well log information is not available. The two well types common in the area, are for domestic utilization and irrigation. Generally, the domestic wells are looking for "good" potable water, completed at relatively shallow depths and probably produce small yields of 10 to 20 gallons per minute (gpm) or less. The irrigation wells are completed to greater depths and greater screened intervals in attempts to access high-yield aquifers or cumulative aquifers capable of yielding more than 200 gpm with little concern about potability of the water.

The landfill is not located above a designated sole source aquifer nor in an aquifer recharge area. Isopiestic and isolithic maps were constructed from information contained on the well logs and many of the conclusions presented in the following sections are predicated from associations revealed on the maps. The well logs indicate that three different water-bearing horizons (two of which are aquifers) are located in the region but only the deepest aquifer appears to be continuous beneath the entire area.

The convention used for this report recognizes the aquifer located above the "blue clay" layer described on well drillers logs as the Uppermost Aquifer or UA. The water-bearing zone located within the blue clay is referred to as the Middle Aquifer or MA. The MA is not always a beneficial use water-bearing zone in the region, is discontinuous and, at best is, a low-yield producer outside of the landfill area. The aquifer located below the blue clay is regarded as the Bottom Aquifer or BA. This blue clay controls the behavior of all three aquifers and its characteristics will be discussed in connection with how it affects each aquifer. It should be noted that this clay unit is not ubiquitously blue in color but, in fact, was found to have a gray coloration during the hydrogeologic characterization.

TABLE 1: WELL LOG DATA OF PICKLES BUTTE AREA
Township 2 North, Range 3 West, Boise Meridian

| Location | | Owner of Record | Collar Elev. | Static Level | Static Elev. | First Interval | Blue Clay |
|---|---|---|---|---|---|---|---|
| BBB | 8 | Smith | 2625 | 284 | 2341 | 2445 A | 2295 |
| DB | 8 | Lyons/Rutherford | 2660 | 138 | 2522 | --- | 2372 |
| DA | 8 | Knapp | 2703 | 158 | 2545 | --- | <2419? |
| CDD | 8 | Rawlings | 2670 | 220 | 2450 | 2475 A | 2394 |
| DA | 9 | Hennis | 2650 | 100 | 2550 | 2551 | <2495? |
| W1/2 | 9 | Knapp | 2680 | 120 | 2560 | 2580 A | 2430 |
| ABC | 9 | Drumheller | 2590 | 126 | 2464 | 2501 | <2398? |
| BAB | 9 | Hennis | 2600 | 28 | 2572 | 2580 | <2511? |
| CC | 9 | Walker | 2665 | 120 | 2545 | --- | 2420 |
| CDC | 14 | Russell | 2745 | 306 | 2439 | 2519 A | 2299 |
| BBC | 14 | Millar | 2840 | 128 | 2712 | 2722 A | 2477 |
| ACC | 14 | Millar | 2790 | 303 | 2487 | 2450 A | 2393 |
| CD | 14 | Millar | 2735 | 295 | 2440 | 2425 A | 2383 |
| ADB | 14 | Millar | 2730 | 340 | 2390 | 2350 W | 2350 |
| AAD | 15 | Millar | 2830 | 804 | 2026 | 2026 B | 2549 |
| DA(1) | 15 | Millar | 2760 | 335 | 2425 | 2400 A | 2331 |
| DCD | 15 | Millar | 2730 | 360 | 2370 | 2365 W | 2408 |
| DA(2) | 15 | Millar | 2760 | 300 | 2460 | 2455 A | 2420 |
| CDD | 15 | Russell | 2710 | 313 | 2397 | 2383 | <2026? |
| DD | 15 | Russell | 2760 | ? | ? | --- | 2284 |
| BAD | 16 | Johnson | 2670 | 125 | 2545 | 2552 A | <2497 |
| DAA | 16 | Johnson | 2685 | 220 | 2465 | 2435 A | 2425 |
| CW/2 | 16 | Johnson | 2790 | 235 | 2555 | 2522 A | 2426 |
| DA | 16 | Johnson | 2700 | ? | ? | --- | 2301 |
| CC | 16 | Johnson | 2800 | 290 | 2510 | 2415 A | 2340 |
| CNN/2 | 16 | Johnson | 2740 | 250 | 2490 | 2480 A | 2415 |
| BAA | 16 | Johnson | 2660 | 112 | 2548 | 2538 A | 2420 |
| BD | 17 | Johnson | 2700 | 161 | 2539 | --- | 2464 |
| DCC | 17 | Penrod | 2590 | 190 | 2400 | 2290 B | 2380 |
| BDD | 18 | Lindholm | 2460 | 30 | 2430 | 2430 A | <2398? |
| ACB | 18 | Waters | 2440 | 94 | 2346 | 2335 A | 2290 |
| DDC | 19 | Brant | 2745 | 500 | 2245 | 2110 B | 2360 |

## TABLE 1: WELL LOG DATA OF PICKLES BUTTE AREA
Township 2 North, Range 3 West, Boise Meridian
(Continued)

| Location | Owner of Record | Collar Elev. | Static Level | Static Elev. | First Interval | Blue Clay |
|---|---|---|---|---|---|---|
| AA 20 | Kraft | 2730 | 200 | 2530 | 2553 | <2206? |
| BCC 21 | County | 2692 | 339 | 2353 | 2097 W | 2441 |
| BDC 22 | Russell | 2770 | 360 | 2410 | 2410 A | 2292 |
| CDC 22 | Russell | 2810 | 395 | 2415 | 2405 A | 2232 |
| AC 22 | Barlow | 2740 | 332 | 2408 | 2388 A | 2370 |
| CD 22 | Barlow | 2790 | 345 | 2445 | 2450 A | 2395 |
| DCC 23 | Can.Farms | 2700 | 290 | 2410 | --- | 2397 |
| BA 23 | Can.Farms | 2720 | 316 | 2404 | 2407 A | 2365 |
| AC 23 | Russell | 2760 | 285 | 2475 | 2420 | <2005? |
| CD 23 | Balley | 2725 | 260 | 2465 | 2460 A | 2445 |
| AAD 24 | Kanz | 2675 | 216 | 2459 | 2464 | ? |
| AAC 24 | Moldenhaue | 2675 | 183 | 2492 | 2537 A | <2420 |
| AAA 24 | Poulton | 2640 | 170 | 2470 | 2545 A | <2400 |
| AAC 24 | Hanson | 2680 | 159 | 2521 | 2587 A | <2430? |
| ABC 24 | Stapp | 2700 | 200 | 2500 | 2515 A | 2450 |
| BBD 24 | Breach | 2800 | 272 | 2528 | 2325 W | 2340 |
| DDB 24 | Farmer | 2600 | 72 | 2528 | 2373 W | 2393 |
| CA 24 | Breach | 2700 | 340 | 2360 | 2362 W | 2429 |
| DA 24 | Martan | 2625 | 10 | 2615 | 2613 A | <2547? |
| CC 24 | Taggart | 2685 | 200 | 2485 | 2490 A | 2387 |
| BDA 24 | Schober | 2740 | 200 | 2540 | --- | 2440 |
| BBD 24 | Breach | 2785 | 283 | 2502 | 2495 A | 2435 |
| CA 24 | Breach | 2700 | 220 | 2480 | 2481 A | 2399 |
| BB 25 | Eells | 2685 | 80 | 2605 | 2485 B | 2615 |
| AA 25 | Nanoolas | 2610 | 300 | 2310 | 2145 A | 2140 |
| DAD 25 | Anderson | 2655 | 39 | 2616 | 2616 A | <2587 |
| DD 25 | Boise Proj | 2660 | 125 | 2535 | 2477 A | 2360 |
| BDA 25 | Naito Bro. | 2660 | 80 | 2580 | 2580 A | 2350 |
| BAA 25 | Keith | 2640 | 115 | 2525 | 2479 A | <2474 |
| DA 25 | Keith | 2625 | 71 | 2554 | 2537 A | <2490 |
| AA 26 | Schuster | 2690 | 66 | 2624 | --- A | <2548 |
| ADC 26 | Davis | 2710 | 116 | 2594 | 2605 A | <2505 |
| A 26 | Natio Bros. | 2710 | 244 | 2446 | 2440 A | 2270 |
| AA 26 | Hastriter | 2690 | 56 | 2634 | 2638 A | <2605 |

TABLE 1: WELL LOG DATA OF PICKLES BUTTE AREA
Township 2 North, Range 3 West, Boise Meridian
(Continued)

| Location | | Owner of Record | Collar Elev. | Static Level | Static Elev. | First Interval | Blue Clay |
|---|---|---|---|---|---|---|---|
| BA | 27 | Barlow | 2841 | 421 | 2420 | 2416 A | 2367 |
| DA | 30 | Cope | 2680 | 123 | 2557 | 2550 A | <2475 |
| CAA | 35 | Pintler | 2762 | 431 | 2331 | 2262 B | 2402 |
| BCA | 35 | Salove | 2840 | 115 | 2725 | 2692 A | 2691 |
| CB | 35 | Hasfnagle | 2744 | 328 | 2416 | 2413 A | 2413 |
| DA | 36 | Clements | 2740 | 320 | 2420 | 2315 W | 2440 |

NOTES:

The coordinate system used for well locations is the numbering system used by the Idaho Department of Water Resources and the U.S. Geological Survey in Idaho. The system divides and labels a section by quarters (down to 10 acre tracts) commencing from the NE quarter section with "A" and labeling counter-clockwise to "D" in the SE quarter section.

All elevations are stated as relative to Mean Sea Level and Collar Elevations were determined from the 7.5 minute USGS topographic quadrangles. All data was compiled from well logs on file with Idaho Department of Water Resources.

Static Level and Static Elevation are those measurements given on the wells logs for the distance below the ground surface and the correlatable mean sea level elevation respectively.

First Interval - is the interval on the well log which first denotes the presence of water. The elevation given in the table is the top of the interval recorded on the well log.

A = the first water level is located above the Blue Clay;
W = the first water level was encounter within the Blue Clay;
B = the first water level is below the Blue Clay;
- = means the interval was not recorded on the well log; and
? = means the interval recorded on the well log is very thick and it is probable that the first water level is not at the top of the interval but at some unknown elevation within the interval.

The Blue Clay elevation given is the top of the interval described on the well log. The "<" symbol preceding an elevation means that no Blue Clay was intersected in the well and the clay is presumed to be located at greater depth. The "?" symbol following an elevation indicates that the well log did not record the color of any of the material.

## Uppermost Aquifer - UA

The UA is located in silts, sands, gravel, basalt and cinder deposits above the unit referred to on well logs as "blue clay". The UA is locally and regionally discontinuous and yields highly variable volumes of water from one well to another. The UA is represented on well logs at numerous elevations and intervals above the blue clay and is identified on 45 of the logs. The UA is bounded on the bottom by the blue clay, unbounded on the top, and contains small discontinuous aquitards. The UA varies in thickness from 70 feet to as much as 578 feet, but usually averages between 250 and 400 feet. Near the site the UA was found to be just a few tens of feet thick or less. Laterally, northwest-trending faults appear to subject a control on the horizontal extent of the UA and water level depths and yields may dramatically differ across these structures.

The package of sediments above the blue clay may contain numerous interconnected and contiguous aquifers rather than one distinct water-bearing horizon but all water-bearing units above the blue clay are considered to be UA aquifers for the purposes of this report. Some well logs indicate three or four water-bearing intervals located in the UA. Many of the wells that are completed either through or within the blue clay either have water-bearing layers in the UA or have a water-bearing strata located directly above the blue clay.

Of the ten UA wells completed above the blue clay, five have negative static water levels, two approximate the first water-bearing unit elevation, and three have slight artesian heads. On those UA completed wells whose logs indicate negative static water levels, the depth of the first water interval is stratigraphically above the static water level measured at the time of well completion. This first water may be a small perched aquifer located above a larger unconfined aquifer. When the well penetrates the aquitard between the two, the water may drain from the upper into the lower aquifer. Alternatively, the measurement may have been taken prior to the water level stabilizing from purging due to slow recovery in a low yield section of the UA

The UA is the most important water-bearing formation east of the northwest fault which trends along the northeastern bluff of the canyon. See section **II. C. GEOLOGIC**

**STRUCTURE** of this report for a more comprehensive discussion of this and other faults.

The probable major recharge sources for the UA are surface irrigation, Lake Lowell, and irrigation and return ditches, particularly the Mora Canal. Of lesser importance is recharge by infiltration of precipitation which averages approximately eight inches a year. Those areas where the soils are fine grained will inhibit infiltration and hold most or all the precipitation near the ground surface which is subsequently evaporated. Those areas which have coarse-grained sand, gravel, cinder or basalt flows at or near the surface will have higher precipitation recharge rates.

## Middle Aquifer - MA

The next deepest aquifer, or middle aquifer (MA), is located in fine to medium sand or silt layers or lenses within the blue clay. Ground water was also discovered to reside in small localized fractures in the more consolidated clays (claystone) below the site. regionally the top of the blue clay, which is the bottom of the UA, ranges from a shallow depth of 70 feet below the ground surface to as much as 578 feet. The descriptions of the MA on the well logs is commonly incomplete but may locally be tens to hundreds of feet thick. Generally, the unit appears to be on the order of 200 to 300 feet thick. The MA (water-bearing layers) are not identified in all the wells that penetrate the blue clay and it is probable that it is discontinuous and frequently provides very low yields.

Seventeen of the wells which are completed in the MA seem to exhibit, at least initially, artesian pressure above the first water interval even if the first water level is located in the UA. Another eight logs indicate that the wells completed in the MA have a negative static head in relationship to the first recorded water interval. It is not known whether these MA wells actually have negative heads or are combined MA and UA heads which are masked by UA declining heads. It is also probable that the recorded levels have not fully recovered due to low yields and protracted recovery times. Of the six wells indicating first water in the MA and completed in the MA, five have positive artesian pressures which range from five to 256 feet while the other well indicated a negative two-foot static level.

Presumably most of the yielding layers in the MA are bounded on all sides by clay and the recharge rate is consequently very slow. Some of the lower layers may be more or less directly connected to the underlying aquifer discussed below. The recharge source for the MA is probably circulating geothermal waters which will be discussed in greater detail later. If the recharge is from confined water being forced through overlying clay beds it is expected that heads will decline by pumping the formation faster than recharge is possible.

## Bottom Aquifer - BA

The third aquifer (BA) is located below the blue clay and appears to be an important water source in all the wells which penetrate the blue clay. The formation is usually described as sands or rock commonly grey or black in color. It is difficult to determine where the MA - BA boundary occurs from the information on the well logs. The boundary is arbitrarily set at that depth which the driller stopped describing the strata as blue even if the material is labeled clay. The reason the BA is considered a separate aquifer is that non-water bearing clay units are usually noted on the logs between the water-bearing layers in the MA and the underlying more productive layers.

Logs for five of the wells included in Table 1 indicate that the first water encountered in the well was in the BA. Four of these well logs recorded a positive artesian head ranging from 69 to 135 feet. All but four of the eighteen wells completed in the BA have recorded artesian pressure regardless of the first water elevation and two of the four have static water levels equal to the first water elevation.

The major source of recharge for the BA is probably circulating geothermal waters which are confined by the overlying blue clay. In a study conducted by Wood and Anderson (1981) temperature measurements taken of wells in the Nampa-Caldwell area indicate the waters in the BA and MA (Wood and Anderson do not differentiate between the BA and MA) were $5^{o}C$ to $15^{o}C$ higher in temperature than water in the overlying UA aquifer. Faults and manmade connections between the aquifers may allow the waters to regionally mix and obscure the thermal gradient between the aquifers.

## Regional Correlation to Site

The drill log of the PB-1 well (BBC 21) located adjacent to the shop at the landfill indicates that the first water is found within the MA unit and the well is completed within the MA. The top of the MA is recorded as being 251 feet below the ground surface or at an elevation of 2441 mean sea level (MSL). The first water noted on the well log is found in the interval 595 to 640 feet below the surface or at 2097 to 2052 MSL (see Table 2).

Three other wells (See Table 2) in the vicinity of the landfill are the Penrod well (DCC 17), the Waters well (ACB 18), and the Brant well (DDC 19); which are all domestic wells. DCC 17 is located approximately 1/2 mile northwest and below the landfill along the toe of the northeastern rim of the canyon. This well first intercepts the MA at a depth of 210 feet (2380 MSL) and the first water is noted in the interval 300 to 305 (2290 to 2285 MSL). ACB 18 is located approximately 1.75 miles northwest of the landfill adjacent to a volcanic plug near the middle of the canyon although no volcanic material was intercepted in the well. This well intercepts the MA at a depth of 150 feet (2290 MSL). The first water interval is seven feet thick and is located at a depth of 105 to 112 feet between yellow clay units. The second water level is intercepted at 190 to 240 feet (2250 - 2200 MSL). The first water level may have yielded small quantities of water insufficient for domestic utilization and for purposes of correlation between the wells the second water level is used. DDC 19 is located approximately 1.5 miles southwest of the landfill on the southeastern rim of the canyon. This well first intercepts the MA unit at a depth of 385 feet (2360 MSL) and the first water interval is from 635 to 640 (2110 - 2005 MSL).

These four wells have some characteristics in common. They are all located southwest of the northwest trending fault structure located along the northeastern rim of the canyon. The first water level intercepted in three of the four wells is located in the MA and the fourth has a correlatable unit in the MA. All four wells have artesian heads ranging from 11 to 256 feet and if the ACB 18 head is derived from the second water interval the range narrows to 96 to 256 feet. All four wells are completed within the MA. The head may be decreasing in BBC 21 (PB-1) since the pump has been lowered twice since the well was constructed and the water level continues to decrease (2353 in 1978, 2272 in 1992, and 2230 in 1993).

TABLE 2: CORRELATIVE WELLS LOCAL TO PICKLES BUTTE

| WELL LOCATION | TOP OF BLUE CLAY | 1st WATER INTERVAL | ARTESIAN HEAD |
|---|---|---|---|
| DCC 17 | 2380 | 2290 - 2285 | 110 |
| ACB 18 | 2290 | 2250 - 2200 * | 96 |
| DDC 19 | 2360 | 2110 - 2005 | 135 |
| BBC 21 | 2441 | 2097 - 2052 | 256 |

* This interval is actually the second water interval recorded on the well log but is the first water unit in the Blue Clay.

The DCC 17, ACB 18 and BBC 21 wells are probably located within the same geologic structural domain and correlations between the wells appear meaningful. DDC 19 is located across at least two northwest-trending faults from the three previously listed wells. DDC 19 is important, in relation to the other three, in that a UA also is not present similar to the other wells (except ACB 18 as previously discussed). The absence of a UA in the above three domestic wells also matches the conditions found below the site during the subsurface investigation. The hydrogeologic domain beneath the landfill, which appears partitioned along the northeastern rim of the canyon, indicates that the major UA recharge sources (ie. Lake Lowell and the irrigation ditches) northeast of the fault do not effect the areas southwest of the structure.

Three point solutions were calculated using the data for wells DCC 17, ACB 18 and BBC 21. Three point solutions assume that the points all lie within the same plane. Following this assumption, calculating the plane of the top of the first water interval recorded in the MA unit results in a dip of 7.6$^{\circ}$ towards South 27$^{\circ}$ West. The bottom of the first water bearing interval dips 12.0$^{\circ}$ towards South 29$^{\circ}$ West. Nevertheless, the aquifers within the blue clay may be laterally discontinuous and non-correlatable over long distances.

Based on these domestic wells, the top of the blue clay dips 1.5$^{o}$ towards N03$^{o}$E. The 1.5$^{o}$ dip of the top of the blue clay is not an aquifer gradient but is the dip of a stratigraphic horizon. The dip of the stratigraphy exposed at the surface and the probable blue clay dip calculated between the site investigation boreholes (see Plate 2 Geologic Map and Plate 3 Geologic Cross Sections) is somewhat steeper and more easterly than the dip calculated from these three domestic wells, but this amount of divergence is slight over such a larger area.

## B. SITE CHARACTERIZATION SUMMARY

Hydrogeologic characterization consisted of drilling one continuous core hole and six rotary holes, geophysical logging three of these holes and the existing shop well, and unifying the surface geology and regional hydrogeology with the local subsurface hydrogeology. All drilling was performed by one drill contractor licensed in Idaho. Core drilling began on April 15, 1992 at Pickles Butte with 2.4-inch diameter core to establish the subsurface lithologic section under the site and to acquire intact samples for laboratory analysis. This hole (PB-2) reached a total depth of 557 feet and the hole has been left as a temporary piezometer for further water level measurements and will be abandoned during completion of the ground water monitoring system.

Rotary drilling began on PB-3 August 29, 1992 for further subsurface hydrogeologic definition, periodic spot core sample acquisition, and well construction. PB-4 drilling and well construction completed the first phase of the subsurface investigation on October 27, 1992. On July 7, 1993 the subsurface investigation recommenced for its next phase with drilling to the north and east of the landfill. This consisted of four reverse circulation rotary holes PB-5, 6, 7 and 8. Well construction of PB-8 concluded on November 18, 1993. Initial sampling for baseline information will be performed by bailing, however dedicated sampling pumps may be required for routine ground water monitoring.

The uppermost occurrence of ground water below the landfill exceeds a minimum depth of 400 feet. To the immediate north, west, and south of the landfill this uppermost water occurs in a low-yield (less than 1 gpm), gray and bluish-gray massive clay or claystone unit. This unoxidized lower clay unit below the site clearly correlates to the "blue clay" or "blue shale" of driller's logs previously described in section **III. A. REGIONAL HYDROGEOLOGY** of this report. As noted earlier, the blue clay on a regional scale is the principle strata separating and defining the upper, middle and lower aquifers where one or more aquifers are present. Water from this unit represents the MA. The blue clay or blue shale of regional context is henceforth called the "lower clay" or "gray claystone unit" within the context of the site investigation. This is because the blue color was usually either missing in the clay or subordinate to a gray coloration. The clay versus claystone terminology used here is based on varying degrees of consolidation found below the site. Although somewhat subjective, the determining field criteria was whether or not the rotary drill cuttings were conveyed to the surface as discrete chips (fragments) or as plastically deformable balls or aggregates. Core samples were tested by finger pressure to determine whether hard and brittle or plastically deformable.

The MA ground water in wells PB-2, PB-3, and PB-8 rise 70 to 80 feet and in PB-4, 13 feet above the producing zones in response to a positive head within the confining clays. Laboratory analysis of the core samples retrieved beneath the site indicates the confining clay generally has very low saturated hydraulic conductivity. Consequently, yields are extremely low. Full recovery of PB-1, 2, 3 and 8 from pumping or bailing takes months. Shop well PB-1 has had a continuous history of problems with meeting the facility's small demand which has necessitated lowering the well pump on several occasions.

The bottom of testhole PB-3 intercepted a 27-foot thick, greenish gray aquifer sand that produced approximately 10 gpm by airlifting with the drill. This water is from the BA of the regional hydrogeologic setting. Water temperatures are somewhat elevated in all the wells (greater than $20^{\circ}C$) and the domestic well's water (PB-1) is limited and not potable. Published isotopic and hydrogeochemical studies on the character of MA and BA ground water from other wells indicate it is derived from deep circulating geothermal waters confined below the claystone (Wood and Anderson, 1981.

Ground water conditions to the east of the landfill differ from the conditions described above. Ground water occurs at even greater depths than further west but under unconfined water table condition in PB-5, PB-6 and PB-7. Depth to ground water is on the order of 500 feet and occurs in clayey silts and silty fine sands immediately above the lower clay unit. Yields are higher than that found to the north, west, and south of the landfill; being on the order of 1 to 5 gpm in the undeveloped testholes. Recovery is on the order of hours to days as opposed to weeks or months. The hydraulic gradient of this water table dips to the east, opposite to that of the stratigraphically lower confined water's westward dipping potentiometric surface. More detailed hydrogeologic results from this drilling will be discussed in section **III. F. SITE HYDROGEOLOGY**.

## C. CONDUCT OF HYDROGEOLOGIC INVESTIGATION

### Procedures of Subsurface Investigation

The hydrogeologic investigation employed two different drilling techniques; core rotary and reverse circulation (RC) air rotary. Drilling operations were conducted by Boyles Brothers Drilling Company of Salt Lake City, Utah. Equipment and drillrods were steam cleaned prior to drilling each well to minimize introduction of contaminants. All six rotary characterization holes were completed as monitoring wells in conformance with Idaho Department of Water Resources monitoring well construction standards for collection of baseline data and for eventual routine detection monitoring. Each well's design is shown in the well construction diagrams in Appendix B of APPENDIXES OF PRIMARY DATA (HECO, 1994) and each well was developed by surge blocking and purged by wireline bailing.

Eight core samples from the first three drillholes (PB-2, PB-3 and PB-4) were sent for testing of the subsurface material's physical and hydrologic properties. The results of this testing was summarized in two reports from a recognized soils lab, Daniel B. Stephens and Associates, which are on file at Holladay Engineering Company. Analyzed core samples were selected on the basis of spaced vertical intervals and sample representativeness. The latter criteria was implemented by selecting cores possessing the least drill disturbance and displaying a physical appearance most closely matching that of the overall zone of neighboring core.

Continuous core was collected downhole within Lexan plastic tubes in PB-2 and samples of rotary drill cuttings were collected in hermetically sealable plastic bags at five-foot intervals from the RC air rotary holes. Occasional spot core samples were also taken with the rotary drill where feasible. This last procedure was found to be expensive and technically difficult in the loose formation; unfortunately this limited core acquisition in the rotary holes. All samples are stored in a locked storage shed at the facility which serves as a permanent stratigraphic record.

The primary objective of core drilling PB-2 was to establish an unequivocal lithologic section below the facility and to acquire a complete and uncompromised sample sequence as possible. Secondary objectives of core drilling were to provide ground water information and geophysical data. Four-inch steel casing was installed through the coarser sandy formation from the surface to a depth of 297 feet in PB-2. The casing was cemented at the surface and the casing bottom cemented within the claystone. The upper 100 feet of annulus outside of the casing has a bentonite seal to prevent ingress of surface water into the hole since it has been retained as a temporary piezometer.

The well liner materials had been sanitized by the manufacturer (Houston Well Screen) and wrapped in plastic which were opened at the time of installation. Non-petroleum based lubricants (Threadsafe or corn oil) were used for drillrod joints. The use of drilling agents downhole was kept to a minimum to avoid potential contamination; these being limited to air, water, bentonite, Clear Mud (a polymer), and a foaming agent Air Quick (MSDS of the last two are on file). The rotary drill rig had environmental filters installed on the compressor. The injected water used during drilling was exclusively from an irrigation well approximately one mile east of the landfill, from a domestic well less than a mile north of the landfill, and a limited amount from the shop well PB-1. Water from each of these wells was analyzed for constituents listed in Appendix I, 40 CFR Part 258 as a precaution against drill water possibly compromising baseline information. Analytical results indicated non-detect on all constituents and are included in Appendix F of APPENDIXES OF PRIMARY DATA (HECO, 1994). Well drilling permits were secured from Idaho Water Resources for each well and the drill contractor was a certified well driller in the State of Idaho.

Eight-inch diameter, steel surface casing was installed through the upper sandy strata to maintain hole stability during drilling and to assist in the protection of the wells from surface water infiltration. Bentonite pellets (Volclay) or chips (Holeplug) were used to provide downhole well seals to isolate the 10/20 silica sand pack filters. Four-inch diameter, 0.020-inch slot size, stainless steel wire wrap screens, and threaded schedule 10, 304 stainless steel casing liners below water levels were employed in each well. Carbon steel threaded well casing was employed above water levels in PB-5, 6, 7, and 8; the others employing stainless steel throughout. Wells PB-5 and PB-6 utilized factory prepacked silica sand filter screens, whereas the other wells had tremmie delivered sand.

A geologist remained on-site during drilling and recorded visually estimated permeabilities (using the Unified Soil Classification and characteristics pertinent to landfills) and initial moisture of drill samples. Later comparison with laboratory results indicate the visual estimates are generally accurate or conservative (estimated permeabilities and moisture were commonly higher than measured). An exception to this was in estimating the native moisture of very moist clays where a generic "greater than 35%" was assigned due to difficulty in visually gauging higher moisture level clays in the field. The geologist also lithologically logged the samples at the time of collection, acquired pertinent hydrogeologic information available during drilling, maintained drilling quality control and sample integrity, monitored methane gas at the borehole collar, to determine appropriate drill depths, supervised appropriate well design and construction, and controlled costs and performed general drill program administration.

Downhole geophysics was conducted in the first three boreholes (PB-2, 3 and 4) and also in the existing shop well (PB-1). The purpose of the geophysics was to supplement information that may prove useful for stratigraphic correlation between drillholes and to assist defining subsurface hydrologic properties. Geophysics was performed by Strata Data of Casper, Wyoming. A description of these results is devoted to a separate geophysics section (see section **III. E. GEOPHYSICS**).

Because methane gas is a specified monitoring parameter at MSL's and because Pickles Butte has been accepting municipal solid waste since April of 1983, the investigation included monitoring for the presence of methane during drilling. Methane concentrations were checked at the borehole collars in the course of drilling. These tests were conducted with a portable AIM Logic 2000 combustible hydrocarbon detector in the mornings before drilling to allow sufficient time for the accumulation of potential methane in the covered borehole. The instrument was calibrated by the manufacturer to the reference standard for methane and instrumental self-diagnostics were performed in the field before each monitoring event. Instrument operation was further field confirmed by an occasional test of a known combustible hydrocarbon source (gasoline tank).

Methane was not detected (0% lower explosive limit or LEL) in any of the boreholes during repeated checks while drilling with the exception of PB-5. PB-5 showed 21% LEL on one occasion while the borehole had been advanced into the unoxidized blue clay of the Glenns Ferry formation at a depth of 620 feet. However, only PB-3 has subsequently indicted any significant concentration (greater than 3% LEL) of methane after well construction. PB-3 has shown transient concentrations of up to 44% LEL on one occasion and 11% on another after being capped for extended periods (months). These levels fall to zero within seconds after the well cover has been removed. Since this well's highest screen level is almost 300 feet lower than the bottom of the landfill and located 130 feet into the claystone unit, it is evident that natural formation methane is present below the site (methane normally rises within the vadose zone). A high sporadic methane background at Pickles Butte and the large well screen depths below the site renders future methane detection monitoring within the wells meaningless.

## Core Rotary Drilling

One HX-size core hole (2.4-inch core diameter and 4-inch outside diameter) was drilled employing a truck-mounted Longyear 44 diamond rotary drill to a depth of 557 feet at the site specifically for hydrogeologic information and sample acquisition. Due to poor sample recovery and caving conditions using dry air core drilling methods, the hole was aborted at 98 feet and offset west 60 feet where core drilling was initiated using injected mud (water and bentonite). Several attempts were again made to drill PB-2 without water but each time without successful sample recovery. The hole was purged of drill water by air compressor at the end of each day in order to check for ground water the following morning. Once ground water was detected by this method at a depth at 557 feet, the water level was monitored for recovery for several hours. The borehole was then purged and compressor dried again to rule out the possibility of return fluids introduced during drilling. Due to very slow recovery, water levels were monitored over the next 40 hours. This recovery will be discussed further within section **III. D. PB-2 Description** of this report.

Core was lithologically logged by the geologist (logs contained in Appendix C of APPENDIXES OF PRIMARY DATA - HECO, 1994) and core samples were collected and sent for independent analysis. Chain of custody protocol was used in sample handling and shipping. Core samples were rigidly held, logged, and transported in transparent Lexan liner tubes. The five-foot Lexan liners were installed in the split tube of the core barrel so that core samples were collected in situ and downhole within the liners at the time of drilling. As a result, sample contamination, mechanical disruption from drilling, and secondary disturbance from handling was minimized.

Sample analysis of physical and hydrologic characteristics was performed by Daniel B. Stephens and Associates, Inc. of Albuquerque, New Mexico. Three core samples submitted from PB-2 were from the claystone unit, which represent the unit below the sand-silt-clay beds that comprise the upper 150 to 300 feet of the lithologic section (see borehole schematics in Appendix A of APPENDIXES OF PRIMARY DATA (HECO 1994). Samples were laboratory tested for initial moisture, dry bulk density, calculated porosity, saturated and unsaturated hydraulic conductivity, moisture characteristics, and particle size characteristics.

## Conventional Rotary Drilling

A truck-mounted Schramm T685-DDH reverse circulation air rotary drill was employed to drill wells PB-3, 4, 5, 6, 7 and 8. These wells were drilled into and below the uppermost water-bearing horizon in order to determine the depth to ground water, potentiometric conditions, and to further define the subsurface geology of the site. Cuttings from rotary drilling were collected from the cyclone sampler at five-foot intervals, lithologically logged by the geologist, and stored in hermetically sealed plastic bags. Rotary drilling was interrupted at intervals during penetration of the claystone unit to obtain spot core samples for testing. These core samples consisted of one-foot long, 3-inch diameter, steel Shelby tubes or 2.4-inch Lexan-lined dry rotary core within a stratapack. Shelby tubes were employed where consolidation of formational material was found to be low and rotary air core was employed in the harder zones. The core samples were acquired and retained in Lexan liners or metal Shelby tubes similar to that described for core drilling.

Drilling was occasionally suspended at times to check for the presence of small volumes of ground water. A determination for water was also made each morning for potential accumulation overnight. Ground water sample analysis from wells are being deferred until the completed and approved monitoring system and plan are in place. Dedicated pumps or bailer systems compatable will be employed for routine detection monitoring. Sampling system will be compatable with VOC sampling as much as practicable considering water depth and recharge rate.

## D. BOREHOLE HYDROGEOLOGY

### PB-1 Description

The PB-1 well (Shop Well, BBC) is located approximately 100 feet southeast of the landfill shop with a collar elevation of 2692 MSL and was completed on 2-11-78 by Witt Drilling using a cable tool drill. The following lithologic description for PB-1 is based on the well driller's log (see Appendix B of APPENDIXES OF PRIMARY DATA - HECO 1994) which was found to be generally consistent with results of the characterization drilling. The uppermost 48 feet is described as clayey sand, sandy clay from 48 to 152 feet, yellow clay from 152 to 205, gray sticky clay from 205 to 251, blue or gray clay and shale from 251 to 595, sandy shale from 595 to 640, and blue clay from 640 to the hole bottom at 658 feet. The driller's log reported ground water production from the sandy shale unit of 595 to 640 feet and placed the well screen from 577 to 637 feet. The resulting static water level (SWL) after completion was recorded at 339 feet below land surface (2353 feet MSL). With our current knowledge of the newly constructed monitoring well's protracted recovery times and static levels, it is probable that the driller's log SWL of 339 feet is not accurate and the true SWL would have been substantially higher given sufficient time to recover.

Even the low demand on the well for the landfill's equipment cleaner and two restrooms has resulted in substantial drawdown. This use has required the pump to be lowered twice in the well to date. Knowledge of the well's performance is unclear since water levels were not taken in the intervening years. However, the water depth on 10-23-92 at 420 feet (2272 feet MSL) is 81 feet lower than recorded at the time of well construction in 1978. The water level found on 10-23-92 may be lower than usual from heavy use the day prior since personnel knew they were to be without water due to geophysical logging the following day. However, a water depth of 461.2 feet on 9-21-93 followed four days of no use which was more than 40 feet lower than on 10-23-92. In any case, the well recovers slowly and has probably sustained a long term drawdown from only moderate use over the intervening 14 years. A videocamera survey of the well on 10-24-92 indicated no problems with the casing or screen.

The temperature in the bottom of the well's water column is 29.7$^{\circ}$C (see Table 3). The water is described by landfill personnel as unfit to drink due to iron or mineral taste

TABLE 3: MAXIMUM WATER TEMPERATURES ($^{o}C$)

| WELL | DATE | WATER LEVEL | MAX. TEMP. |
|---|---|---|---|
| PB-1 | 10-23-92 | 2271.94 | 29.7 |
| PB-2 | 1-28-94 | 2412.42 | 27.4 |
| PB-3 | 1-28-94 | 2388.48 | 32.1 |
| PB-4 | 1-28-94 | 2385.29 | 27.6 |
| PB-5 | 1-28-94 | 2333.68 | 28.3 |
| PB-6 | 1-28-94 | 2393.25 | 26.1 |
| PB-7 | 1-28-94 | 2401.24 | 26.1 |
| PB-8 | 1-28-94 | 2414.77 | 23.3 |

Notes:

PB-1 through 4 maximum temperatures taken from downhole thermal logs (accuracy: plus/minus 0.1$^{o}$C). PB-5 through 8 temperatures taken with a highest reading thermometer (accuracy: plus/minus 1.0$^{o}$C) suspended at lowest portion of screen. PB-1 water level is probably dynamic from slow recovery.

(they use bottled water). Yet analysis for the Appendix I 40 CFR Part 258 suite on a sample taken from this well on 4-8-92 resulted in non-detect for all listed constituents (see Appendix F of APPENDIXES OF PRIMARY DATA - HECO, 1994). Tested field parameters of water at the shop tap indicate a temperature of 21.1$^{o}$C (70$^{o}$F), a pH of 8.4 and a conductivity of 1.10 mS/cm (see Table 4). The fact that the productive zone occurs at least 256 feet below the static level at the time of drilling (175 feet below its measured level on 10-23-92) and the aquifer is at an elevated temperature indicates both a confined and geothermally heated condition. These conditions agree with those in the neighboring characterization holes and indicates the ground water not only is under positive confining pressure but also suggests the water's origin is either remote or possibly ascends from an environment of higher heat flow.

TABLE 4: GROUND WATER FIELD PARAMETERS

| WELL NAME | DATE | WATERLEVEL (MSL) | TEMP °C | pH | CONDUCTIVITY |
|---|---|---|---|---|---|
| PB-1 | 10-23-92 | 2271.94 | 21.1* | 8.4 | 1.10 mS/s |
| | 4-7-93 | | 20.9* | 8.1 | 1.11 mS/s |
| PB-2 | 5-19-92 | 2365.00** | 23.0 | 10.7 | 0.46 mS/s |
| | 10-26-92 | 2411.65 | | | |
| | 2-1-93 | 2412.35 | 23.0 | 10.6 | 0.43 mS/s |
| | 4-7-93 | 2412.84 | | | |
| PB-3 | 9-25-92 | 2397.02 | 24.5 | 8.5 | 0.84 mS/s |
| | 2-1-93 | 2394.56 | | | |
| | 4-7-93 | 2394.90 | 27.1 | 7.3 | 1.00 mS/s |
| PB-4 | 10-26-92 | 2384.54 | | | |
| | 2-1-93 | 2385.93 | | | |
| | 4-7-93 | 2386.14 | 22.2 | 7.2 | 0.78 mS/s |

Note: Temperature and other parameters were measured from bailed water taken from near the surface of the water column except as noted. For temperature gradient within the water column see thermal geophysics logs in Appendix D of APPENDIXES OF PRIMARY DATA (HECO, 1994). PB-2, 3 and 4 were not developed before these measurements were taken and the values shown may not accurately represent ground water conditions.

* Measurements taken at the landfill shop tap after running 10 minutes.

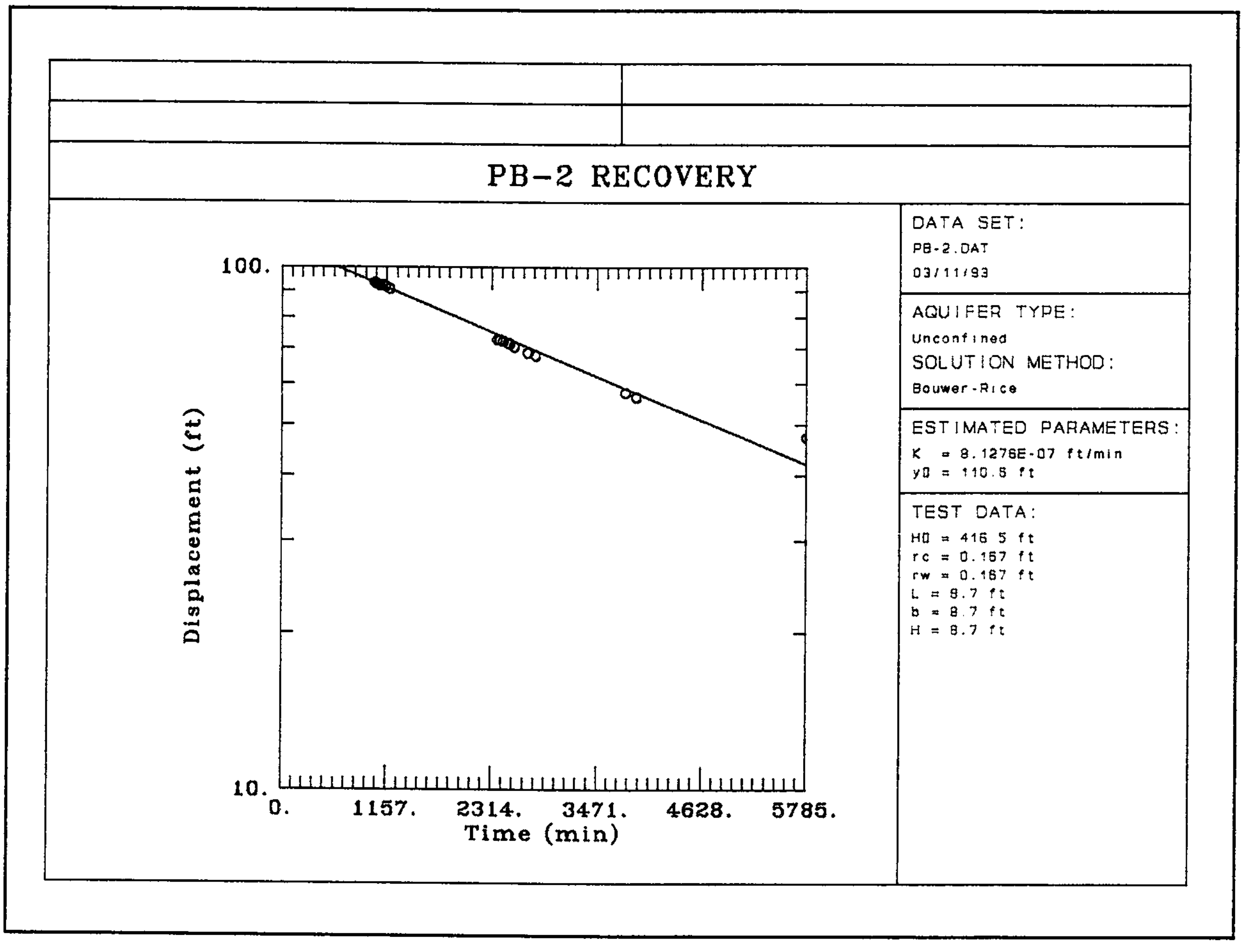
** Water level was still recovering from drilling.

## PB-2 Description

Corehole PB-2 is located immediately east of the landfill's active area as shown on the site and geology maps (Plates 1 and 2). The lithology encountered in this hole consist of a varied sequence of weak to moderately consolidated tan to light brown silty sand, clayey silt, and sandy silt from the surface down to 294 feet. This assemblage constitutes the coarser material of which an analog was identified in the upper levels of all seven characterization holes drilled at the landfill. The same package also appears in the driller's log of the domestic well PB-1 which may correspond to its sand (0 - 48 feet) and sandy clay (48 - 152 feet). A moderately consolidated silty claystone occurs from 294 to 396 feet depth; this unit contains a redox boundary at 353 feet, below which occasional plant carbon and fine pyrite occurs. A well indurated, dark gray, mostly massive claystone was found in the interval below 396 feet to the hole bottom at 557 feet. The claystone generally corresponds to the lithology found in the lower reaches of all the subsequent holes, PB-3 through PB-8 and almost certainly correlates to the blue and gray shale and clay of the PB-1 driller's log (see Geologic Cross Sections, Plate 3).

A small amount (less than three gallons per hour) of ground water was encountered in several fracture zones within the claystone between 490 feet and 530 feet. This zone of weak production is confirmed by both a downhole camera survey after bailing the hole dry on 5-27-92 and by weak thermal spikes in the water column's thermal gradient identified by downhole geophysical logging (see Appendix D of APPENDIXES OF PRIMARY DATA, HECO 1994). The fractures identified in the core and visible in the video record are small, generally less than a few millimeters in width, extend over several feet vertically and scattered over a range of a few tens of vertical feet, possess vertical, oblique, and subhorizontal attitudes, and visibly supply very low volumes of water to the borehole. It appears that many of the fractures are drill induced and others probably enlarged by the drilling process. The subhorizontal fractures are likely related to bedding planes. Ground water ingress viewed by the camera can be described as a drop-by-drop process from fractures which accumulates into small rivulets that slowly weep down the wall of the purged borehole. The measured rate of partial recovery over a four day period after purging was analyzed using AQTESOLV aquifer modeling software (Geraghty & Miller, 1991). The recovery curve is shown on Figure 3 having a resulting Bouwer-Rice curve matching solution which indicates a conductivity of $1.28 \times 10^{-7}$ cm/sec and a transmissivity of $1.56 \times 10^{-4}$ $cm^2$/sec averaged over the 40-foot zone of production (490-530 feet). This agrees very well with the nearest laboratory determined hydraulic conductivity in the claystone of $7.9 \times 10^{-8}$ cm/sec (see Tables 5 and 7). After several months the water level in PB-2 stabilized at a depth of 415.4 feet (2412.4 feet MSL), approximately 80 feet above the uppermost zone of production.

FIGURE 3: PB-2 RECOVERY CURVE




Field parameters of PB-2 water are shown in Table 4. Temperature of sample water from the top of the water column had cooled slightly from bailing as confirmed by the downhole temperature log indicating 25° C at the top of the column. Both pH and conductivity may have been effected by residual drill fluids in the undeveloped borehole since the pH appears too high and the conductivity too low in comparison to the other locations. PB-2 was the only characterization hole drilled with routine injection of drill fluids.

Bedding features exhibited in the core were consistently horizontal and subhorizontal throughout the extent of the drillhole with the predominant beds generally being on the order of several feet thick or more within the massive claystone. Bedding thickness on the order of inches does occur, and thin laminated bedding is occasionally present in the clay and silt facies. No persuasive evidence of faulting within the PB-2 sequence was found, although as mentioned earlier, fracture intensity does appear to increase in several zones within the more lithified claystone. Fault associated tectonic gouge, slickensides, veining, preferential oxidation, brecciation or other features accompanying faults were absent.

## PB-3 Description

Rotary drilled well PB-3 is located approximately 250 feet from the landfill's current footprint as shown on Plate 1. The lithologies encountered consist of a sequence of weakly consolidated tan to light brown silty sand with occasional gravel lenses and sandy silt from the surface down to a depth of about 135 feet. This sequence constitutes the coarser material corresponding with the upper levels encountered in the other wells (geologic Cross Sections, Plate 3). A weakly to moderately consolidated, tan-brown clayey silt and silty clay occurs from 135 to 190 feet depth. From 190 to 263 feet is a moderately consolidated, tan claystone; below which is unoxidized, gray, moderately consolidated massive claystone to a depth of 823 feet. The claystone unit from 263 feet to 823 feet corresponds to the lithology found in the lower reaches of PB-2, the other wells, and the blue and gray shale and clay of the driller's PB-1 log. The redox boundary in PB-3 is located at 263 feet within the claystone unit. Below this depth traces of plant fossils, carbonaceous material and fine pyrite are occasionally present indicating the muds were deposited in an eutrophic lake or paludal environment (ancient Lake Idaho, see section **III. A. REGIONAL GEOLOGY**).

Because the claystone unit proved to be a very weak producer, well screens were placed at three different intervals in PB-3 to assure acquiring ground water from the uppermost practical producing zone. As detailed later, the screen locations were based on a combination of lithologic characteristics, drill sample moisture, drilling conditions, and borehole geophysics. The screens were placed at 340-350, 410-420, and 520-530 with a resultant static water level at 397.4 feet (2394.6 MSL) below ground surface. The upper screen at 340-350 was based on a small zone of increased moisture which later proved to be above static water level.

Although sample moisture content increased below 320 feet to near saturation free water did not accumulate in the drillhole overnight. The upper screen was installed between 340 and 350 feet based on the increased moisture content of the clays and to assure that the uppermost water bearing layer would be monitored. Definitive water-bearing conditions occurred only after drilling advanced to 488 feet and a 35-foot column of water had accumulated in 13 hours overnight (approximate average of 4 gph). The water level was found to be still rising at 0.8 feet per hour (about 1 gph) in the morning. Saturated conditions may have been encountered in the claystone at and below 400 feet but extremely low existing permeabilities prevented determining any precise source level while drilling. Native moisture in drill samples seemed to have been decreasing between 445 feet to 488 feet, where water accumulation was first noted, so overnight water ingress was presumably from above 445 feet. This possible uppermost zone of production appeared in the form of excessive moisture in the clays recovered below 400 feet and particularly below 410 feet. The 410 to 420-foot zone, therefore, was selected for installation of the second well screen. No evidence of fractures was found in this zone or elsewhere in PB-3, yet small fractures could easily go undetected in rotary drilling. Although ground water of such trivial yield has no beneficial use and does not constitute an aquifer, as the potential uppermost available water it is the logical monitoring horizon.

The zone between 515 and 540 feet was sandpacked and a third screen installed between 520 and 530 feet. This zone was selected as it was below the level where water was first detected (488 feet), due to a down-hole thermal anomaly at 522 - 524 feet, and the caliper log indicated a borehole enlargement at 517 - 528 feet. This lower screen provided a measure of insurance that above-aquifer ground water would be accessible had both the upper two screens failed to yield water. This last case later proved to be true.

PB-3 drilling intersected an aquifer below the claystone unit at a depth of 823 feet. The aquifer consist of poorly-sorted, greenish-gray, silty, fine to medium sand and produced water at a rate of about 10 gpm by air lifting with the drill compressor. A somewhat higher yield could be expected using a more efficient pumping method. The hole was terminated at 860 feet with the clay component increasing with depth below the aquifer sand. Aquifer thickness at PB-3 appears to be about 30 to 35 feet depending on where the gradational sand/clay contact is placed below the aquifer.

Bailed water from PB-3 borehole on the day following drill completion, had a temperature of 24.5$^{o}$C, a pH of 8.5, and a conductivity of 0.84 mS/s (see Table 4). These initial parameters may change now that development and purging has occurred. A downhole geophysical survey of the borehole was conducted on 9-26-92, initially to a depth of 745 feet and then to 615 feet; the lower depths lost to repeated caving in the open hole below the surface casing (see section **III. E. GEOPHYSICS**). The borehole again collapsed to a depth of 566 feet and was backfilled from there with bentonite to 540 feet and completed as a monitoring well as described in this section and depicted on well construction diagrams in Appendix B oF APPENDIXES OF PRIMARY DATA (HECO, 1994).

The upper screen between 340 and 350 feet, later proved to be above the static water level. The two submerged lower screens were later separated by a rubber packer (sterile butyl with silica core) at 461.3 feet and the water above the packer purged by bailing to establish whether the middle screen was contributing ground water. After purging, water was found not to be entering PB-3 at the middle screen after monitoring for two days. The packer was pushed to the well bottom at 542 feet to allow the lower screen to provide for characterization. Although not an ideal method of establishing a well in uppermost water, the precaution was necessary in the low-yield claystone and the method proved effective.

There was no visual evidence of faulting in the sample cuttings nor indication of the presence of faults from downhole geophysical data. Although rotary drilling is not conducive to ready visual recognition of bedding orientation or fault rotation, encountered elevations of major facies and lithologic contacts correlatable between holes are reasonably consistent with bedding dips found both in PB-2 and those exposed at the surface (dips generally less than 10 degrees). This matching straight-line projection of subsurface bedding attitude among holes diminishes the likelihood of large-scale fault offsets below the site.

## PB-4 Description

Rotary drilled well PB-4 is located above the bluffs immediately southeast of the landfill approximately 400 feet from the current active area and 200 feet from the ultimate design (see General Site Map, Plate 1). The lithology encountered in this hole consist of weak to moderately consolidated, tan, clayey and silty sand with occasional gravel lenses from the surface down to a depth of about 265 feet. This sequence constitutes the coarser material correlating with the upper levels of the other borehole locations at the landfill (see geologic borehole schematics in Appendixes A of APPENDIXES OF PRIMARY DATA - HECO 1994 and Geologic Cross Sections Plate 3). A moderately consolidated, tan claystone occurs from 265 to 305 feet depth and a weakly consolidated tan silty clay from 305 to 385 feet. From 385 to 440 feet occurs a moderately consolidated, greenish-brown claystone. The redox boundary occurs within this unit at 422 feet, below which the claystone is an unoxidized gray-brown or gray color. PB-4 below 440 to 500 feet is a weakly consolidated, brown-gray clayey silt and from 500 to 550 feet is a weakly consolidated, gray silty clay. Moderately consolidated gray claystone occurs from 550 feet to the hole bottom at 640 feet.

Despite local facies changes the silt-claystone units from 265 feet to 640 feet closely matches the claystone lithology found in the lower portions of PB-2 (294-557) and PB-3 (215-823) and probably correlates to the blue and gray shale and clay described in PB-1.

Estimated moisture contents within the formation increased markedly below 300 feet and, thereafter for assurance, repeated delays in drilling were incurred to check for the presence of ground water. A check at 505 feet indicated no ground water accumulation at this depth. Although water-bearing conditions became suspected due to higher moisture levels in samples from about 565 to 580 feet, no free water was lifted during drilling. Based on drilling behavior the operator noted there may be weak water production at and below 615 feet. Below 630 feet the sample cuttings started containing less native moisture than from above, so another water check was performed at 640 feet. Ground water was confirmed in the hole with the knowledge that water ingress was from above 630 feet and probably at or below 565 feet. The water level initially rose 35 feet the first hour but had slowed to an 11-foot rise the second hour and to one foot the third hour. The water level the next morning after 19 hours of recovery was at 545 feet for a 95-foot water column in the borehole.

Well screens were placed at 560-575 feet based on the observed higher moisture content and thermal gradient (see section **III. E. GEOPHYSICS**) and at 605-620 feet based on the suspected weak water production inferred from drilling. No distinct textural variation marks the formation at these nor other intervals which would suggest higher relative permeabilities than neighboring zones. Consequently, it is assumed they are small fracture-flow zones similar to those noted in PB-2. These small features are subtle and would be virtually undetectable in rotary cuttings.

Formation consolidation increased from weak to weakly moderate in the zone from 535 to 590 feet and from weakly moderate to moderate from 590 to 640 feet. Increased consolidation may influence the occurrence and preservation of water-bearing fractures in the claystone unit. The water-producing fractures in the corehole are also in the more consolidated claystone. Consolidation was consistently moderate in the massive claystone in PB-3 where the upper water-bearing zones occur. Sediment consolidation could play a role if fracture preservation and fracture-flow in the claystone has a bearing on the uppermost storage and movement of ground water below the site.

As would be expected, consolidation in each hole usually increases with depth and generally favors finer-grained materials. The depth/consolidation relationship is casual and each borehole displays exceptions, however the trend appears conclusive. Possible causes include increasing load compaction with depth and, to a lessor degree, increasing age and time for cementation.

The static water level after screening these two zones was 545.7 feet below surface (2385.9 feet MSL) after stabilization on February 1, 1993. Similar to PB-3, the two screened intervals in PB-4 were separated by a packer (at 590 feet) and the upper water column bailed to test for upper screen water contribution. After surge blocking and bailing recovery was relatively fast in the upper screen with bailing incapable of lowering the water level to the screen. The packer has been left at 590 feet to permanently isolate the upper screen from any lower screen contribution.

## PB-5 Description

Drilling subsequent to PB-4 proved more straight forward as to interpreting downhole hydrologic conditions and due to increasing familiarity with the lithologic section. Also, geophysics was not employed due to its high cost with little potential for obtaining significant new information. For these reasons, the following accounts of each borehole are comparatively abbreviated.

Rotary drilled well PB-5 is located approximately 950 feet from the landfill's designed northeast perimeter. A coarse-grained facies was encountered in the upper section of the hole consisting of a sequence of weakly consolidated tan to light brown sandy silt from 0 to 45 feet, a one-foot gravel lens, a tan silty clay from 46 to 140 feet, and fine to medium sands with occasional clayey silts from 140 to 590 feet. Materials are unoxidized below 485 feet; changing from tan, brown, and orange colorations above to gray, blue-gray, or green-gray below. Saturation occurs below a depth of 517 feet within fine silty sands. Below the coarser sequence is a clayey silt from 590 feet to 630 feet; below which there is a more indurated gray claystone corresponding to the claystone found in the lower portions of PB-2, 3, and 4 and the shale noted in the PB-1 driller's log.

The uppermost zone of production appears as a phreatic surface within the fine silty sands and was screened from 512.5 to 522.5 feet. The borehole was advanced to a depth of 660 feet for verification of stratigraphic continuity of the lower claystone. The established depth of this unit indicates the bedding dip found in the previous holes continues easterly without change to PB-5 (see Geologic Cross Section B-B', Plate 3).

Saturation in PB-5 occurs above the claystone unit which hosts ground water in the wells further west. Airlift testing at 635 feet in the open hole yielded about one to two gpm, however, a developed well and efficient pump may yield five to ten gpm. Maximum water temperature measured within the well at the screen is 28.3$^{\circ}$C.

## PB-6 Description

Rotary drilled well PB-6 is located approximately 850 feet from the current active area and about 450 feet from the northeast perimeter of the ultimate design. Drilling penetrated 17 feet of a tan silty sand, a one-foot bed of gravel and a tan silty clay from 17 to 60 feet, a medium sand from 60 to 95 feet, tan silt and clay from 95 to 160 feet, a poorly sorted gray-brown sand from 160 to 195 feet, a tan to brown silty clay from 195 to 220 feet, and a poorly sorted gray-tan sand from 220 to 435 feet with some interbedded clayey silt. Clayey silt from 435 to 620 feet rest on gray claystone and silty clay at the hole bottom. Below 465 feet the formation is moderately consolidated and below 490 feet the sediments are unoxidized and saturated.

The uppermost level of saturation occurs within clayey silt which was screened from 487.5 to 497.5 feet with a resulting static level at 492.5 feet. The borehole was terminated at a depth of 700 feet after confirming the presence of the lower claystone unit. Airlifting at 700 feet produced about a sustained two gpm. Maximum water temperature measured within the well at the screen is 26.1$^{o}$C.

## PB-7 Description

PB-7 is located approximately 700 feet from the current active area and about 200 feet west of the ultimate design. Lithologies encountered were tan clayey sand from 0 to 25 feet, gravel from 25 to 35 feet, fine to medium sand from 35 to 130 feet, a tan clay from 130 to 185 feet, interbedded sand, silt, and clay from 185 to 280 feet, mostly gray-tan fine sand from 280 to 455, tan silt from 455 to 515 feet, light gray clayey silt from 515 to 540 feet, and green-gray clay and silty clay from 540 to the hole bottom at 610 feet. The borehole was terminated at a depth of 610 feet upon confirming the presence of the lower claystone unit. Materials are unconsolidated above 135 feet, weakly to moderately consolidated from 135 to 525 feet, and mostly moderately consolidated below 525 feet. Again, consolidation appears to increase with depth and coarser-grained sediments generally appear less consolidated.

The upper level of saturation occurs within clayey silt just above the contact of the lower clay and this zone was screened from 535 to 555 feet. This resulted in a static level depth of 536.8 feet (2401.2 feet MSL). Yield was too small to be estimated during drilling by air-lift testing; however, recovery was found to be about 3.4 feet per hour with 25 feet of drawdown (open hole to 560 feet). This rate declined to 2.6 feet per hour with 13 feet of drawdown. Maximum temperature measured within the well at 555 feet is 26.1$^{o}$C (79$^{o}$F).

## PB-8 Description

Rotary drilled well PB-8 is located approximately 350 feet from the landfill's northwest designed boundary and 1100 feet from the current waste cell as shown on Plate 1. The hole penetrated an interbedded sequence of weakly consolidated, tan, silty fine sand and clayey silt from the surface down to a depth of about 155 feet. This material correlates to the coarser facies found in the upper sequence of the other wells (Geologic Cross Sections A-A' and D-D', Plate 3). A weak to moderately consolidated, tan silty clay occurs from 155 to 240 feet depth. Below 240 feet the clay is an unoxidized gray, moderately consolidated, mostly massive clay to the hole bottom at 420 feet.

Moisture content did not measurably increase with depth once the hole was in the clays and ground water production from the upper zone of saturation was found to be extremely low as in the other wells placed in the lower clay unit. No water was found when the hole was checked in the morning with a depth of 320 feet but water was detected after drilling advanced to 420 feet when 8.7 feet of water accumulated in 20 hours. Screen was placed at the most probable production level based on observed recharge rates over time; from 377 to 407 feet. After well completion and developing, the water level rose to 294.8 feet over a period of two months. Again, the yield is very low as would be expected from the lower clay unit. Maximum water temperature measured within the well at the screen is 23.3$^{o}$C (see Table 4).

## Bedding Attitudes

Borehole evidence indicates that calculated bedding attitudes at depth dip gently to the northeast conformable to measured surface bedding. Three-point solutions of the claystone's upper contact with the overlying sand-silt sequence in PB-2, PB-3, PB-4 and PB-8 match the shallow, northeast dipping beds observed at the surface. The resultant average strike and dip for this subsurface contact is N54$^{o}$W07$^{o}$NE. This orientation agrees well with the surface mapped N30$^{o}$W to N70$^{o}$W strikes and shallow 5 to 25 degree northeasterly dips (see Geologic Map, Plate 2). Two solutions for the upper claystone contact using the PB-1 driller's log along with PB-2 and PB-3, and PB-1 with 2 and 4, results in similar strike and dips (N30$^{o}$W07$^{o}$NE and N46$^{o}$W09$^{o}$NE). Other lithologic contacts higher in the section than the lower claystone contact also have similar downhole calculated strike and dips.

To the east of the landfill, three-point solutions for the top of the lower claystone found in PB-5, 6 and 7 yields a bedding strike and dip of N38°W09°NE, again in close agreement with other observed and calculated attitudes. The importance of the stratigraphic dip direction and its bearing on the facility will be discussed under sections **III. F. SITE HYDROGEOLOGY** and **VI. B. PRINCIPLES OF MONITORING DESIGN.**

## E. GEOPHYSICS

Downhole geophysical surveys were performed by Strata Data Inc. of Casper, Wyoming on the shop well PB-1, the corehole PB-2, and rotary holes PB-3 and PB-4 before well construction. Pre-existing well PB-1 geophysical logs reflect the influence of the well casing and screen and the others were open holes below their 200 to 300-foot surface casing (geophysical logs are in Appendix D OF APPENDIXES OF PRIMARY DATA - HECO, 1994).

The caliper log was run on each hole to assist in interpreting other geophysical logs and proved useful in defining potential producing zones from fractures or washouts. The natural gamma log in PB-1 showed some variable highs in the upper sandy sequence above 150 feet (especially between 30-75 feet) and a distinctly higher response from the aquifer sand below 585 feet as opposed to the clayey shale. High natural gamma usually correlate to clays or silts; whereas these spikes may be a lithologic response from increased radiogenic potassium within the feldspathic sands. The upper sandy sequence in PB-3 and 4 are less defined by natural gamma than in PB-1 and the aquifer sand was not accessible in these holes. An interesting feature present in all the holes tested is a natural gamma spike at or near the redox boundary, possibly a result of natural supergene effects of uranyl salts or other natural geochemically mobile radioactive minerals at this interface. No clearly defined lithostatigraphic marker beds were identified from natural gamma or from other geophysical methods employed. In fact, the signatures of these sediments are unusual for their lack of variability and contrast with electric logs as well; a characteristic that in several instances caused the technician to double check his instruments to see if they were working properly (the tools were calibrated prior to each trip downhole). The weak response generally confirms the lithologic homogeneity of the lower clay stratigraphic section.

Below the water level (420 feet bgl) in the shop well, the temperature log shows probable water sources (weak thermal highs) in the area of the screen at 550-575 feet (see the well driller's report in Appendix B of APPENDIXES OF PRIMARY DATA - HECO 1994) and several smaller zones around and below 600 feet. Bottom hole temperature is above 85$^{\circ}$F (29.7$^{\circ}$C) around 650 feet, which is in general agreement with the other wells. Thermal waters (water above 20$^{\circ}$C) were found in all the drillholes at Pickles Butte. The other bottom hole temperatures are as follows: PB-2 at 551 feet, 27.4$^{\circ}$C; PB-3 at 740 feet, 32.2$^{\circ}$C; and PB-4 at 650 feet, 27.6$^{\circ}$C (see Table 4). The water in the bottoms of PB-1 and PB-3 would be classified as geothermal as it is greater than 85°F.

Small thermal anomalies at 490 and 515 feet in PB-2 tend to confirm that there are weak fracture-controlled producing zones inferred from the core and TV survey (see PB-2 description). Other than temperature, both neutron and gamma-gamma density-porosity logs suggest possible weak water production from 510 to 514 feet. Spontaneous potential and electric logs, both dual and single point resistivity, proved of limited value in all holes other than confirming or registering general sand versus shale effects.

Differential thermal response in PB-3 suggest possible weak ground water contribution around 470 feet and several small zones between 600 and 650 feet. The caliper suggests possible weak, washed-out producing zones from 500 to 530 feet and another at 580 to the hole's accessible bottom at 610 feet. The gamma-gamma log reflects these washed out zones but the density-porosity curves are suspect in the areas influenced by these voids. The neutron and electric logs were not particularly helpful in defining hydrogeologic conditions in PB-3.

The temperature survey was performed twice in PB-4, after stabilizing overnight between runs, to allow for further recovery of the water column. The differential temperature curve indicates a potential ground water source near 580 feet; occurring within the interval of the later installed filter pack from 550 to 584 feet. The caliper tends to confirm this depth as a washout or fractured zone at around 578 feet (and another at 636 feet). The screen was set above 580 feet due to high moisture in sample returns at 565 to 575 feet but the filter pack brackets the thermal and caliper indicators. The density-porosity curve reflects these cavities but it nor the neutron porosity log indicate much else in the way of potential producing zones. The point resistivity shows an anomalous high around 636 feet, possibly indicating extended hole size (poor electrode contact) or open fractures. This zone was later included within the lower sand pack of PB-4 between 601 and 645 feet. The other geophysical methods employed at PB-4 offer little additional hydrogeologic information. Neither drilling nor geophysical logging revealed evidence of faulting within any of the four holes although such features could easily be masked in the sediments.

The temperature and depth to the thermal waters below the confining claystone unit at Pickles Butte are typical of the intermediate hydrologic unit of the Nampa-Caldwell area (Wood and Anderson, 1981). This unit is described as containing thermal waters capped by a confining or partially confining "blue clay" of local driller's description which encompasses a broad regional area of the western Snake Plain. Based on published information involving the regional geology, age dates, water chemistry and isotopic studies, these waters appear to be ultimately derived from either recharge areas remote to the site during the wet climatic Pleistocene Epoch or from mixing with deeper, geothermal waters (Wood and Anderson, 1981). The implications of this origin and the nature of the ground water in relation to the site is discussed further under the sections **III. F. SITE HYDROGEOLOGY** and **III. I. CONCLUSIONS: HYDROGEOLOGIC SETTING.**

Perhaps the temperature logs provided the most useful direct hydrologic information of all the employed geophysical methods. The caliper log added important supporting data and the gamma-gamma log contributed useful data in specific circumstances. The natural gamma log provided some interesting, if not particularly useful, data. However, neutron and electrical response to downhole lithologic changes, density, and pore saturation in most cases were weak. Characteristic signatures identifying potentially useful marker beds or other clearly defined correlative horizons are absent. The particular zones within the claystone formation that are yielding such small volumes of water are typically too small and subtle to be contrasted and easily detected.

In summary, the caliper, temperature, gamma-gamma and perhaps natural gamma logs provided some helpful supporting hydrogeologic information but the neutron, spontaneous potential, point resistivity and dual normal electric methods do not appear especially useful in this environment. The latter instruments indicated a marked lack of lithologic and physical variation and at most reflected the very weak water-producing capability within the claystone unit. In general, the most important utility was simply that all the instruments verified the downhole lithologic and hydrologic conditions determined through other means.

## F. SITE HYDROGEOLOGY

The subsurface hydrology at Pickles Butte is not simple. The confined conditions and thick clay protection found under the landfill is different than the conditions found down stratigraphic dip to the east of the facility. This eastern domain is characterized by water table conditions, yet it is protected by equally thick layers of desiccated, water retentive, poorly sorted, fine-grained clastic sediments (See tables on Physical Properties and report sections on Travel Times, Moisture Retention Capacity, and Infiltration Modeling).

Wells PB-3, PB-4, and PB-8 (see Geologic Map, Plate 2 and Well Construction Diagrams, Appendix B of APPENDIXES OF PRIMARY DATA - HECO, 1994) are screened in uppermost water which show varying degrees of positive head. These zones of saturation occur in a thick clay or claystone member of the Glenns Ferry Formation and yield insufficient volumes of water (less than 0.02 gpm) to be considered an aquifer (beneficial use). PB-1, PB-2, PB-3, and PB-8 take several months to recover from use or bailing. PB-4 yields more water than PB-2, PB-3, and PB-8 and has little head since it's water-bearing zone occurs near the top of the lower clay member (but protected below 300 feet of upper clay and clayey silt of intermediate depth and an additional 240 feet of fine sands and silts).

Water located within the "blue clay" unit is denoted as the "middle aquifer" (MA) in a regional sense which is described in more detail in section **III. A. REGIONAL HYDROGEOLOGY**. Pumping can readily deplete available storage and outstrip recovery rates based on performance of other MA wells within the region. Recharge of this "aquifer" is believed to be supplied from underflow of geothermal water underlying the confining blue clay (Wood and Anderson, 1981). This lower or bottom aquifer (BA) is generally a high-yield system and known to be regionally continuous in extent. This is in contrast to the low-yield MA which is characteristically regionally discontinuous but has been found to be locally continuous under the site. By definition and character the facility's shop well PB-1, the corehole PB-2, and PB-3, PB-4, and PB-8 monitoring wells represent MA ground water.

Elevated water temperatures within the monitoring wells indicate the water is at least partially supplied from the lower geothermal system. Water of the BA is suspected to be derived from ancient origin and remote recharge (see section **III. E. GEOPHYSICS**).

This circumstance suggests the locality is not a recharge area having direct hydraulic communication to the surface.

The confined aquifer exceeds 800 feet in depth at the site, of which over 600 feet is clay and silty clay. Due to the large depth, PB-3 was the only borehole to penetrate this confined system below the site. Potentiometric levels of this aquifer were inferred from higher-level water-bearing zones within the confining clay. It is probable the BA system was not encountered fully in PB-3 since the aquifer sand at 823 feet appeared to be ending in clay again below 850 feet (27 feet thick).

In summary, the ground water under the site does not appear to be derived from the local area nor recharged by modern surface waters, it is under positive head, the uppermost water possesses very low yields, and an extremely low hydraulic conductivity of overlying confining clays indicate there is a high level of natural aquifer protection below the landfill.

The potentiometric surface of the uppermost ground water under the landfill (see Plate 4, Potentiometric Surface Contour Map and Plate 5, Oblique Geologic Cross Section) rises to the northeast placing PB-4 down potentiometric gradient but up stratigraphic dip from the landfill. Well PB-8 and piezometer PB-2 are up potentiometric gradient and along stratigraphic strike with the landfill. PB-3 has a down-gradient intermediate potentiometric level but is also located up stratigraphic dip from the landfill. However, due to the thick confining clay unit, the potentiometric surface has little bearing on contaminant plume direction. More important to effective monitoring is that the stratigraphic dip direction is inclined toward an unconfined aquifer.

Wells PB-5, PB-6, and PB-7 are located northeast and east of the site, down stratigraphic dip, and are also screened in the uppermost water-bearing zone. Ground water production is substantially greater (more than 5 gpm) in this zone than from the wells to the west and do not possess artesian head. Yield is higher because the water occurs above the clay member in more permeable sand and silts. This aquifer belongs to the upper aquifer (UA) described under the regional hydrogeology. Based on other wells in the region the UA is laterally discontinuous, rests upon the "blue clay" unit, and characteristically expresses weak or no artesian heads. This typifies the conditions found in PB-5, PB-6, and PB-7.

Based on static water levels within PB-5, 6, and 7, the hydraulic gradient in this area is $3.6^{o}$ toward the northeast. This gradient has possibly been steepened or even diverted in this direction due to substantial demand from high capacity irrigation wells located approximately a mile and more to the north, northeast, and east.

Ground water perched on top of the claystone unit was considered a strong possibility early in the program and, therefore, was actively sought while drilling PB-2, PB-3, PB-4, and PB-8. However, such a perched zone was not detected while drilling these more westerly holes. Either excess moisture retention with high net evaporation (no deep percolation) in the vadose zone is responsible for its absence or the regional tilt of the beds are draining vadose waters toward the eastern water table environment (the HELP model predicts the former). A graphic depiction of the hydrogeologic setting of the site employing an oblique perspective is shown on Plate 5. This simplified representation shows the potentiometric surface above the clay confined ground water. To the east (left in the diagram) where the confining clay dips below the potentiometric surface, an eastward-dipping water table condition occurs. Although not shown in the diagram for the sake of clarity, the potentiometric surface of the MA may rise unaffected further to the east and possibly continues above the perched water table of the UA.

The water table's western margin may be defined by the occurrence of the mapped northwest-trending fault, although the proximity may only be coincidental since the perched zone in any case thins toward zero in this vicinity. The lower clay unit to the east of the fault is down-dropped relative to the western area along this structure. This places the lower clay relatively higher to the west of the fault and drops the coarser, more permeable facies down to the east of the fault. Such a condition, although a matter of only a few tens of vertical feet throw, would serve to abut the permeable upper sand/silt regime of the east against the adjacent tight lower clay regime to the west. This arrangement constitutes a vertically limited but well defined ground water boundary condition, a setting that explains the UA water table margin's proximity to the fault. Strong northwest-trending structural influences on the UA is also typical of this aquifer on a regional extent (see section **III. A. REGIONAL HYDROGEOLOGY**).

The water table defined by wells PB-5, PB-6, and PB-7 indicate a hydraulic gradient of $3.6^{o}$ N$52^{o}$E. Applying this gradient to the geometric mean of the estimated hydraulic conductivities and porosities (Tables 10, 11, and 12) of the upper zone of saturation within the three wells yields an average linear velocity of ground water 345 cm/yr (11.3 ft/yr) with a possible range of from 20 cm/yr to 680 cm/yr. The range of variation dependent on the range of estimated hydraulic conductivity and porosity found within each borehole at the upper zone of saturation.

The northwesterly fault observed at the site potentially providing a preferential pathway from surface to ground water was an early consideration in the investigation. However, since the sand, silt and much of upper clays possess little internal strength, soft sediment deformation responding from lithostatic load rapidly close open faults or fractures within the less indurated overlying sediments. Furthermore, the overlying poorly consolidated sandy sediments possess relatively high permeabilities anyway; negating the effect of preferential conduits. Open fracture systems are manifested in the more indurated clay or claystone at depth where ground water is found under positive head from the confining aquitard. Therefore, the issue of faults controlling descending fluids becomes less important in view of the more permeable nature of the enclosing vadose zone materials.

## G. HYDROLOGIC PROPERTIES

Eleven core samples from the three Phase I drillholes were sent to Daniel B. Stephens and Associates for laboratory analysis of the hydrologic behavior and other physical properties of the claystone material above the uppermost water-bearing zone. These lab reports are on file as supporting documentation at Holladay Engineering Company. The more pertinent laboratory results of the core samples are listed in Table 5. The laboratory measured saturated hydraulic conductivities are shown on the borehole schematics located in Appendix A contained in APPENDIXES OF PRIMARY DATA (HECO, 1994).

### Saturated Travel Time

Time of travel calculations were performed using hydraulic conductivity rates of infiltration which require the sediments to be completely saturated with excess water available sufficient to maintain a 30 centimeter positive head on the system. The formulas used to calculate saturated travel times are shown on Table 6. Calculated conductivities resulting from unsaturated conditions, the actual situation at the site, would yield markedly lower hydraulic conductivities (absolute hydraulic conductivity). This would yield more representative travel times that are orders of magnitude longer (see Table, 14 UNSATURATED TRAVEL TIME CALCULATIONS section of this report).

The divisions on Tables 7 through 13 bounding each layer were determined by placing the boundary at observed lithologic contacts or at facies changes that possess a distinct variation in visually estimated permeability. Where results of core samples occur in vertical succession within a formational unit without any noted lithologic variation, the assigned boundary is simply the equidistant vertical division between each sample. Intervals for which laboratory determination of saturated hydraulic conductivity were not conducted were assigned values. The values were determined using comparative lithologies with core samples. Those lithologic intervals for which representative core sample values were not available, the values were determined by calculation of the geometric mean of the field assigned hydraulic conductivities. This procedure of assignment allows gauging the total material thickness having laboratory quantified

## TABLE 5: LABORATORY DETERMINED PROPERTIES OF CORE SAMPLES

| DRILLHOLE NUMBER | INTERVAL (FEET) | LITHOLOGIC UNIT DESCRIPTION | INITIAL MOISTURE (%, $cm^3/cm^3$) | DRY BULK DENSITY ($g/cm^3$) | WILTING POINT (%, $cm^3/cm^3$) | SPECIFIC RETENTION (%, $cm^3/cm^3$) | CALCULATED POROSITY (%, $cm^3/cm^3$) | SAT HY CON K-sat (cm/sec) | ABS HY CON K-unsat# (cm/sec) |
|---|---|---|---|---|---|---|---|---|---|
| PB-2 | 320-321 | SILTY CLAYSTONE | 43.08 | 1.23 | 15.73 | 34.65 | 53.53 | $1.0 \times 10^{-4}$ | $5.8 \times 10^{-6}$ |
| | 395-396 | SILTY CLAYSTONE | 45.19 | 1.51 | 32.31 | 44.48 | 43.18 | $1.5 \times 10^{-7}$ | $1.5 \times 10^{-8}$ |
| | 479-480 | CLAYSTONE | 42.72 | 1.55 | 32.19 | 45.94 | 41.48 | $7.9 \times 10^{-8}$ | $1.5 \times 10^{-9}$ |
| PB-3 | 206-207 | SILTY CLAY | 29.55 | 1.65 | 28.12 | 40.56 | 37.82 | $1.1 \times 10^{-7}$ | $2.7 \times 10^{-9}$ |
| | 249-250 | CLAYSTONE | 34.29 | 1.71 | 34.44 | 41.65 | 35.46 | $1.8 \times 10^{-9}$ | $3.0 \times 10^{-14}$ |
| | 285-286 | CLAYSTONE | 35.10 | 1.50 | 30.77 | 45.31 | 43.32 | $1.3 \times 10^{-6}$ | $3.5 \times 10^{-8}$ |
| | 325-326 | CLAYSTONE | 37.54 | 1.65 | 34.96 | 42.79 | 37.86 | $1.1 \times 10^{-8}$ | $8.1 \times 10^{-13}$ |
| | 389-390 | CLAYSTONE | 43.14 | 1.50 | 39.12 | 47.01 | 43.48 | $7.0 \times 10^{-8}$ | $1.4 \times 10^{-10}$ |
| PB-4 | 312-313 | SILTY CLAYSTONE | 39.53 | 1.58 | 33.62 | 40.86 | 40.51 | $8.4 \times 10^{-8}$ | $1.1 \times 10^{-9}$ |
| | 404-405 | CLAYSTONE | 36.83 | 1.64 | 35.45 | 43.19 | 37.97 | $7.7 \times 10^{-8}$ | $1.5 \times 10^{-14}$ |
| | 444-445 | CLAYEY SILT | 37.62 | 1.49 | 32.90 | 42.61 | 43.88 | $2.1 \times 10^{-7}$ | $5.1 \times 10^{-11}$ |

* PB-2 was drilled as a continuous recovery core hole in which water and drill fluid were used. Therefore, laboratory measured initial moisture content may not be accurate.

# Absolute Hydraulic Conductivity is the hydraulic conductivity of the material at initial moisture content. For those samples which may have absorbed water during drilling (PB-2 samples) the Absolute Hydraulic Conductivity may be expected to be slower than the value given in this table.

TABLE 6: SATURATED TRAVEL TIME FORMULA

| | |
|---|---|
| sum of $d_m/K_{vm}$ | (yrs/layers) |
| $K_{vavg} = d/\text{sum}[d_m/K_{vm}]$ | (cm/yr) |
| $V_x = (d_h * K_{vavg}/d * n_e)$ | (cm/yr) |
| Travel Time $= d/V_x$ | (yrs) |

where:

$d_m$ = individual layer thickness
d = total thickness of all layers above ground water
$d_h = d + 30$ cm
$K_{vm}$ = Saturated hydraulic conductivity of a layer
$K_{vavg}$ = the average saturated hydraulic conductivity through all the layers of sediments.
$n_e$ = mean average porosity
$V_x$ = average linear velocity

Formula from Fetter (1988) and Freeze and Cherry (1979).

parameters and assigned values based on professional experience, for realistically estimating the potential saturated vertical time of travel.

The laboratory determined K-sat hydraulic conductivities, as shown on the Schematics and denoted with an asterisk on Tables 7, 8, and 9, range from $1.0 \times 10^{-4}$ to $1.8 \times 10^{-9}$ cm/sec, most of which are in the $10^{-7}$ and $10^{-8}$ cm/sec range. It should be noted that the measured saturated hydraulic conductivity ($1.0 \times 10^{-4}$ cm/sec) in the silty claystone of sample PB-2 320-321 is questionable due to noted sample disruption from drill induced fractures. Such sample disturbance, in most cases, will bias laboratory tests toward markedly higher hydraulic conductivities. The strata for which laboratory data is available constitutes about 40% of the actual thickness for PB-2, 67% for PB-3, and 35% for PB-4.

The travel times calculated for water moving only through the layers were they saturated, an unlikely worst-case scenario, are shown in Tables 7 through 13. These saturated travel times are 495 years for PB-2, 12,376 years for PB-3, 753 years for PB-4 30 years for PB-5, 31 years for PB-6, 184 years for PB-7, and 505 years for PB-8. Travel times based on saturated conditions are longest directly beneath the landfill and Results of calculations for each borehole are included on Tables 7 through 13.

## Specific Moisture Capacity

The specific retention of a geologic formation is that amount of water which will be retained in the pore spaces of the formation against the force of gravity. Specific moisture capacity is the specific retention minus the initial moisture of the formation. Specific retention varies in geologic formations as a function of grain size, grading, degree of lithification, cementation, and grain packing. Fine-grained, poorly-graded sediments generally have very large specific retention whereas coarse-grained, poorly-graded sediments have lower specific retention. For any predominate grain size sediment, specific retention tends to decrease with better grading. The specific retention values included on Physical Properties Tables (Tables 7 through 13) for each borehole were either directly measured by the soils laboratory or estimated using tables derived by the Buckman and Brady (1969) and Birkland (1976).

Specific moisture capacities were calculated for each sedimentary layer identified on the geologic schematics of the boreholes. The specific moisture capacity was quantified into feet of water. The feet of water was divided by the infiltration rate predicted by the HELP Model (See section **III. H. HELP MODEL INFILTRATION SIMULATION** for discussion). The resultant is the estimated years needed to increase the moisture content of the sediments to the point that water will flow down through the entire sedimentary package by the force of gravity. The estimates range from a period of 936 years in Borehole PB-3 to 2149 in Borehole PB-7.

These results obviously understate the actual time necessary to induce conditions where gravity alone would control the downward movement of water. If the infiltration rate predicted by the HELP model were valid, the current moisture content of the sediments would be at their respective specific retention.

# Table 7: PB-2 Physical Properties and Saturated Travel Time Calculations

| Unit Description | Interval (feet) | Unit Thickness (cm) | Porosity (% vol.) calculated estimate | Dry Bulk Density (gm/cc) estimate | Initial Moisture (% wt.) | Specific Retention (% vol) | Specific Moisture Capacity (% vol) | Specific Moisture Capacity (cm) | Ksat (cm/sec) estimated average | Travel Time Saturated (years) |
|---|---|---|---|---|---|---|---|---|---|---|
| Silty Sand | 0-24 | 731.5 | 24.53 | 2.00 | | | | | 4.7E-04 | 0.05 |
| Clayey Silt | 24-63 | 1188.7 | 36.60 | 1.68 | | | | | 3.6E-05 | 1.05 |
| Silty Sand | 63-73 | 304.8 | 24.53 | 2.00 | | | | | 1.8E-04 | 0.05 |
| Silty Clay | 73-83 | 304.8 | 39.62 | 1.60 | | | | | 1.3E-05 | 0.74 |
| Silty Sand | 83-133 | 1524.0 | 24.53 | 2.00 | | | | | 7.7E-05 | 0.63 |
| Sand & Silt | 133-167 | 1036.3 | 33.58 | 1.76 | | | | | 8.1E-05 | 0.41 |
| Silty Sand | 167-220 | 1615.4 | 24.53 | 2.00 | | | | | 7.6E-05 | 0.67 |
| Sandy Silt | 220-249 | 883.9 | 33.58 | 1.76 | | | | | 3.8E-05 | 0.74 |
| Silty Sand | 249-268 | 579.1 | 24.53 | 2.00 | | | | | 9.8E-05 | 0.19 |
| Clayey Siltstone | 268-294 | 792.5 | 35.84 | 1.70 | | | | | 5.7E-06 | 4.41 |
| Silty Claystone * | 294-358 | 1950.7 | 53.53 | 1.23 | | | | | 1.0E-04 | 0.62 |
| Silty Claystone * | 358-396 | 1158.2 | 43.18 | 1.51 | | | | | 1.5E-07 | 244.84 |
| Claystone * | 396-495 | 3017.5 | 41.48 | 1.55 | | | | | 7.9E-08 | 1211.19 |
| Claystone | 495-557 | | Top of Upper Water Bearing Zone @ 495 feet, Potentiometric Surface @ 417 feet and TD @ 557 feet | | | | | | | |
| Totals / Averages | | 15087.4 (d) | 33.85 ($n_e$) | 1.75 | | | | | | 1465.59 |

sum of $d_m/K_{vm}$

| | | |
|---|---|---|
| Average vertical hydraulic conductivity (cm/year) | $K_{vavg}$ | 10.29 |
| Average linear velocity (cm/year) | $V_x$ | 30.47 |
| Saturated Travel Time (years) | | 495.13 |

* Porosity, Bulk Dry Density and Ksat determined by laboratory analysis of Core samples.

This borehole was drilled using rotary core methods with collection of continous core. Fluids were injected during drilling therefore Initial Moisture determinations and subsequent conclusions developed from the data would be inaccurate.

# Table 8: PB-3 Physical Properties, Saturated Travel Time and Moisture Retention Calculations

| Unit Description | Interval (feet) | Unit Thickness (cm) | Porosity (% vol.) calculated estimate | Dry Bulk Density (gm/cc) estimate | Initial Moisture (% wt.) | Specific Retention (% vol) | Specific Moisture Capacity (% vol) | Specific Moisture Capacity (cm) | Ksat (cm/sec) estimated average | Travel Time Saturated (years) |
|---|---|---|---|---|---|---|---|---|---|---|
| Fine Sand | 0-35 | 1066.8 | 33.58 | 1.76 | 1.55 | 12.00 | 9.27 | 98.9 | 1.0E-03 | 0.03 |
| Silty Fine Sand | 35-100 | 1981.2 | 24.53 | 2.00 | 1.89 | 14.00 | 10.22 | 202.5 | 1.9E-03 | 0.03 |
| Clayey Silt | 100-135 | 1066.8 | 36.60 | 1.68 | 2.72 | 35.00 | 30.43 | 324.6 | 5.5E-05 | 0.62 |
| Silty Clay * | 135-215 | 2438.4 | 37.82 | 1.65 | 17.93 | 40.56 | 10.98 | 267.6 | 1.1E-07 | 702.92 |
| Claystone * | 215-267 | 1585.0 | 35.46 | 1.71 | 20.05 | 41.65 | 7.36 | 116.7 | 1.8E-09 | 27922.23 |
| Claystone * | 267-306 | 1188.7 | 43.32 | 1.50 | 23.37 | 45.31 | 10.26 | 121.9 | 1.3E-06 | 28.99 |
| Claystone * | 306-358 | 1585.0 | 37.86 | 1.65 | 22.79 | 42.79 | 5.19 | 82.2 | 1.1E-08 | 4569.09 |
| Claystone * | 358-408 | 1524.0 | 43.48 | 1.50 | 28.80 | 47.01 | 3.81 | 58.1 | 7.0E-08 | 690.37 |
| Claystone | 408-860 | | Top of Upper Water Bearing Zone @ 480 feet, Potentiometric Surface @ 408 feet and TD @ 860 feet | | | | | | | |
| Totals / Averages | | 12435.9 (d) | 36.58 ($n_e$) | 1.68 | | | | 1272.5 | cm | 33914.29 |

sum of $d_m/K_{vm}$

| | | | |
|---|---|---|---|
| Average vertical hydraulic conductivity (cm/year) | $K_{vavg}$ | 0.37 |
| Average linear velocity (cm/year) | $V_x$ | 1.00 |
| Saturated Travel Time (years) | | 12376.41 |

| | |
|---|---|
| Specific Moisture Capacity (feet) | 41.75 |
| Years of Accumulation @ 0.535 per year (as predicted by the HELP Model) | 936 |

* Porosity, Bulk Dry Density, Initial Moisture, and Ksat determined by laboratory analysis of core samples.

## Table 9: PB-4 Physical Properties, Saturated Travel Time and Moisture Retention Calculations

| Unit Description | Interval (feet) | Unit Thickness (cm) | Porosity (% vol.) calculated estimate | Dry Bulk Density (gm/cc) estimate | Initial Moisture (% wt.) | Specific Retention (% vol) | Specific Moisture Capacity (% vol) | Specific Moisture Capacity (cm) | Ksat (cm/sec) estimated average | Travel Time Saturated (years) |
|---|---|---|---|---|---|---|---|---|---|---|
| Fine Sand | 0-20 | 609.6 | 33.58 | 1.76 | 2.29 | 12.00 | 7.97 | 48.6 | 6.3E-03 | 0.00 |
| Clayey Silt | 20-40 | 609.6 | 36.60 | 1.68 | 10.75 | 35.00 | 16.94 | 103.3 | 2.8E-04 | 0.07 |
| Gravelly Clay | 40-70 | 914.4 | 27.55 | 1.92 | 17.41 | 34.00 | 0.57 | 5.2 | 2.4E-05 | 1.21 |
| Silty Fine Sand | 70-240 | 5181.6 | 24.53 | 2.00 | 1.18 | 14.00 | 11.64 | 603.1 | 6.6E-04 | 0.25 |
| Fine Sandy Silt | 240-265 | 762.0 | 33.58 | 1.76 | 1.27 | 20.00 | 17.76 | 135.4 | 1.8E-04 | 0.13 |
| Claystone | 265-305 | 1219.2 | 39.62 | 1.60 | 9.90 | 42.00 | 26.16 | 318.9 | 2.6E-07 | 148.69 |
| Silty Clay * | 305-385 | 2438.4 | 40.51 | 1.58 | 25.08 | 40.86 | 1.23 | 30.1 | 8.4E-08 | 920.49 |
| Claystone * | 385-440 | 1676.4 | 37.97 | 1.64 | 22.41 | 43.19 | 6.44 | 107.9 | 7.7E-08 | 690.37 |
| Clayey Silt * | 440-500 | 1828.8 | 43.88 | 1.49 | 25.30 | 42.61 | 4.91 | 89.8 | 2.1E-07 | 276.15 |
| Silty Clay | 500-547 | 1432.6 | 39.62 | 1.60 | 20.68 | 40.00 | 6.91 | 99.0 | 6.2E-07 | 73.27 |
| Claystone | 547-640 | | Top of Upper Water Bearing Zone @ 560 feet, Potentiometric surface @ 547 feet and TD @ 640 feet | | | | | | | |
| Totals / Averages | | 16672.6 (d) | 35.74 ($n_e$) | 1.70 | | | | 1541.41 | | 2110.63 |

sum of $d_m/K_{vm}$

| | | |
|---|---|---|
| Average vertical hydraulic conductivity (cm/year) | $K_{vavg}$ | 7.90 |
| Average linear velocity (cm/year) | $V_x$ | 22.14 |
| Saturated Travel Time (years) | | 753.07 |

| | |
|---|---|
| Specific Moisture Capacity (feet) | 50.57 |
| Years of Accumulation @ 0.535 per year (as predicted by the HELP Model) | 1134 |

* Porosity, Bulk Dry Density, Initial Moisture, and Ksat determined by laboratory analysis of core samples.

# Table 10: PB-5 Physical Properties, Saturated Travel Time and Moisture Retention Calculations

| Unit Description | Interval (feet) | Unit Thickness (cm) | Porosity (% vol.) calculated estimate | Dry Bulk Density (gm/cc) estimate | Initial Moisture (% wt.) | Specific Retention (% vol) | Specific Moisture Capacity (% vol) | Specific Moisture Capacity (cm) | Ksat (cm/sec) estimated average | Travel Time Saturated (years) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sandy Silt | 0-45 | 1371.6 | 33.58 | 1.76 | 3.77 | 20.00 | 13.36 | 183.3 | 3.6E-04 | 0.12 |
| Sandy Gravel | 45-46 | 30.5 | 18.49 | 2.16 | 1.28 | 6.00 | 3.24 | 1.0 | 1.0E-03 | 0.00 |
| Silty Clay | 46-140 | 2895.6 | 39.62 | 1.60 | 6.12 | 40.00 | 30.21 | 874.7 | 3.0E-06 | 30.61 |
| Fine Sand | 140-225 | 2590.8 | 33.58 | 1.76 | 1.14 | 12.00 | 9.99 | 258.9 | 5.0E-04 | 0.16 |
| Clayey Silt | 225-240 | 457.2 | 36.60 | 1.68 | 2.16 | 35.00 | 31.37 | 143.4 | 3.7E-05 | 0.39 |
| Sand | 240-250 | 304.8 | 27.55 | 1.92 | 0.98 | 10.00 | 8.12 | 24.7 | 1.0E-03 | 0.01 |
| Clayey Silt | 250-275 | 762.0 | 36.60 | 1.68 | 12.64 | 35.00 | 13.76 | 104.9 | 4.6E-07 | 52.53 |
| Sand | 275-367 | 2804.2 | 27.55 | 1.92 | 1.71 | 10.00 | 6.72 | 188.4 | 3.9E-04 | 0.23 |
| Clayey Silt | 367-374 | 213.4 | 36.60 | 1.68 | 2.91 | 35.00 | 30.11 | 64.3 | 1.0E-05 | 0.68 |
| Sand | 374-460 | 2621.3 | 27.55 | 1.92 | 2.14 | 10.00 | 5.89 | 154.4 | 6.1E-04 | 0.14 |
| Silty Clay | 460-485 | 762.0 | 39.62 | 1.60 | 13.32 | 40.00 | 18.69 | 142.4 | 2.7E-06 | 8.95 |
| Silty Sand | 485-517 | 975.4 | 24.53 | 2.00 | 1.90 | 14.00 | 10.20 | 99.5 | 8.5E-05 | 0.36 |
| Silty Sand | 517-590 | | Static Water Level @ 517 feet and TD @ 660 feet | | | | | | | |
| Clayey Silt | 590-630 | | | | | | | | | |
| Gray Claystone | 630-660 | | | | | | | | | |
| Totals / Averages | | 15788.8 (d) | 31.82 ($n_e$) | 1.81 | | | | 2239.9 cm | | 94.18 |

sum of $d_m/K_{vm}$

| | | |
|---|---|---|
| Average vertical hydraulic conductivity (cm/year) | $K_{vavg}$ | 167.65 |
| Average linear velocity (cm/year) | $V_x$ | 527.84 |
| Saturated Travel Time (years) | | 29.91 |

| | |
|---|---|
| Specific Moisture Capacity (feet) | 73.49 |
| Years of Accumulation @ 0.535 per year (as predicted by the HELP Model) | 1648 |

Table 11: PB-6 Physical Properties, Saturated Travel Time and Moisture Retention Calculations

| Unit Description | Interval (feet) | Unit Thickness (cm) | Porosity (% vol.) calculated estimate | Dry Bulk Density (gm/cc) estimate | Initial Moisture (% wt.) | Specific Retention (% vol) | Specific Moisture Capacity (% vol) | Specific Moisture Capacity (cm) | Ksat (cm/sec) estimated average | Travel Time Saturated (years) |
|---|---|---|---|---|---|---|---|---|---|---|
| Silty Sand | 0-17 | 518.2 | 24.53 | 2.00 | 4.30 | 14.00 | 5.40 | 28.0 | 2.5E-03 | 0.01 |
| Sandy Gravel | 17-18 | 61.0 | 18.49 | 2.16 | 4.15 | 10.00 | 1.04 | 0.6 | 1.0E-02 | 0.00 |
| Silty Clay | 18-60 | 1280.2 | 39.62 | 1.60 | 3.15 | 40.00 | 34.96 | 447.6 | 2.6E-04 | 0.16 |
| Medium Sand | 60-95 | 1066.8 | 27.55 | 1.92 | 1.01 | 10.00 | 8.06 | 86.0 | 1.6E-03 | 0.02 |
| Clayey Silt | 95-125 | 914.4 | 36.60 | 1.68 | 10.09 | 35.00 | 18.05 | 165.0 | 2.0E-05 | 1.45 |
| Clay | 125-160 | 1066.8 | 39.62 | 1.60 | 26.66 | 43.00 | 0.34 | 3.7 | 3.6E-07 | 93.97 |
| Sand | 160-195 | 1066.8 | 27.55 | 1.92 | 1.10 | 10.00 | 7.89 | 84.1 | 7.3E-04 | 0.05 |
| Silty Clay | 195-220 | 762.0 | 39.62 | 1.60 | 18.87 | 40.00 | 9.81 | 74.7 | 2.1E-04 | 0.12 |
| Sand | 220-360 | 4267.2 | 27.55 | 1.92 | 1.54 | 10.00 | 7.04 | 300.5 | 6.8E-04 | 0.20 |
| Clayey Silt | 360-380 | 609.6 | 36.60 | 1.68 | 1.54 | 35.00 | 32.41 | 197.6 | 3.1E-05 | 0.62 |
| Sand | 380-435 | 1676.4 | 27.55 | 1.92 | 1.54 | 10.00 | 7.04 | 118.1 | 3.3E-04 | 0.16 |
| Clayey Silt | 435-492 | 1737.4 | 36.60 | 1.68 | 11.34 | 35.00 | 15.95 | 277.1 | 6.2E-05 | 0.89 |
| Clayey Silt | 492-510 | | Static Water Level @ 492 feet and TD @ 700 feet | | | | | | | |
| Silty Clay | 510-620 | | | | | | | | | |
| Gray Claystone | 620-690 | | | | | | | | | |
| Gray Silty Clay | 690-700 | | | | | | | | | |
| Totals / Averages | | 15026.8 (d) | 31.82 ($n_e$) | 1.81 | | | | 1783.06 | | 97.63 |

sum of $d_m/K_{vm}$

| | | |
|---|---|---|
| Average vertical hydraulic conductivity (cm/year) | $K_{vavg}$ | 153.91 |
| Average linear velocity (cm/year) | $V_x$ | 484.60 |
| Saturated Travel Time (years) | | 31.01 |

| | |
|---|---|
| Specific Moisture Capacity (feet) | 58.50 |
| Years of Accumulation @ 0.535 per year (as predicted by the HELP Model) | 1312 |

# Table 12: PB-7 Physical Properties, Saturated Travel Time and Moisture Retention Calculations

| Unit Description | Interval (feet) | Unit Thickness (cm) | Porosity (% vol.) calculated estimate | Dry Bulk Density (gm/cc) estimate | Initial Moisture (% wt.) | Specific Retention (% vol) | Specific Moisture Capacity (% vol) | Specific Moisture Capacity (cm) | Ksat (cm/sec) estimated average | Travel Time Saturated (years) |
|---|---|---|---|---|---|---|---|---|---|---|
| Clayey Sand | 0-25 | 762.0 | 27.55 | 1.92 | 9.52 | 30.00 | 11.72 | 89.3 | 2.4E-04 | 0.10 |
| Silty Gravel | 25-35 | 304.8 | 21.51 | 2.08 | 3.44 | 17.00 | 9.84 | 30.0 | 3.0E-04 | 0.03 |
| Fine Sand | 35-55 | 609.8 | 33.58 | 1.76 | 1.21 | 12.00 | 9.87 | 60.2 | 1.0E-03 | 0.02 |
| Clayey Silt | 55-65 | 304.8 | 36.60 | 1.68 | 5.65 | 35.00 | 25.51 | 77.7 | 5.5E-07 | 17.57 |
| Sand | 65-130 | 1981.2 | 27.55 | 1.92 | 2.72 | 10.00 | 4.78 | 94.7 | 6.8E-04 | 0.09 |
| Clay | 130-185 | 1676.4 | 39.62 | 1.60 | 6.17 | 42.00 | 32.13 | 538.6 | 1.0E-07 | 531.58 |
| Clayey Sand | 185-210 | 762.0 | 27.55 | 1.92 | 1.15 | 30.00 | 27.79 | 211.8 | 3.1E-04 | 0.08 |
| Silty Clay | 210-250 | 1219.2 | 39.62 | 1.60 | 6.38 | 40.00 | 29.79 | 363.2 | 7.7E-06 | 5.02 |
| Fine sand | 250-260 | 304.8 | 33.58 | 1.76 | 0.74 | 12.00 | 10.70 | 32.6 | 5.5E-04 | 0.02 |
| Clayey Silt | 260-280 | 609.6 | 36.60 | 1.68 | 5.13 | 35.00 | 26.38 | 160.8 | 7.5E-06 | 2.58 |
| Fine Sand | 280-370 | 2743.2 | 33.58 | 1.76 | 0.95 | 12.00 | 10.33 | 283.3 | 6.4E-04 | 0.14 |
| Clayey Sand | 370-390 | 609.6 | 27.55 | 1.92 | 0.68 | 30.00 | 28.69 | 174.9 | 3.8E-04 | 0.05 |
| Fine Sand | 390-455 | 1981.2 | 33.58 | 1.76 | 0.87 | 12.00 | 10.47 | 207.4 | 4.3E-04 | 0.15 |
| Silt | 455-515 | 1828.8 | 33.58 | 1.76 | 1.67 | 25.00 | 22.06 | 403.4 | 2.5E-05 | 2.32 |
| Clayey Silt | 515-540 | 762.0 | 36.60 | 1.68 | 5.86 | 35.00 | 25.16 | 191.7 | 4.3E-06 | 5.62 |
| Clay | 540-570 | | Top of Upper Water Bearing Zone at 540 feet, Static Water Level @ 537 feet and TD @ 610 feet | | | | | | | |
| Silty Clay | 570-600 | | | | | | | | | |
| Gray Clay | 600-610 | | | | | | | | | |
| Totals / Averages | | 16459.4 (d) | 32.58 ($n_e$) | 1.79 | | | | 2919.72 | | 565.37 sum of $d_m/K_{vm}$ |

| | | |
|---|---|---|
| Average vertical hydraulic conductivity (cm/year) | $K_{vavg}$ | 29.11 |
| Average linear velocity (cm/year) | $V_x$ | 89.53 |
| Saturated Travel Time (years) | | 183.84 |

| | |
|---|---|
| Specific Moisture Capacity (feet) | 95.79 |
| Years of Accumulation @ 0.535 per year (as predicted by the HELP Model) | 2149 |

## Table 13: PB-8 Physical Properties, Saturated Travel Time and Moisture Retention Calculations

| Unit Description | Interval (feet) | Unit Thickness (cm) | Porosity (% vol.) calculated estimate | Dry Bulk Density (gm/cc) estimate | Initial Moisture (% wt.) | Specific Retention (% vol) | Specific Moisture Capacity (% vol) | Specific Moisture Capacity (cm) | Ksat (cm/sec) estimated average | Travel Time Saturated (years) |
|---|---|---|---|---|---|---|---|---|---|---|
| Silty Sand | 0-10 | 304.8 | 24.53 | 2.00 | 3.06 | 15.00 | 8.88 | 27.1 | 1.0E-04 | 0.10 |
| Clayey Silt | 10-25 | 457.2 | 36.60 | 1.68 | 5.20 | 35.00 | 26.26 | 120.1 | 4.0E-05 | 0.36 |
| Fine Sand | 25-35 | 304.8 | 33.58 | 1.76 | 5.39 | 12.00 | 2.51 | 7.7 | 3.0E-04 | 0.03 |
| Clayey Silt | 35-50 | 457.2 | 36.60 | 1.68 | 7.35 | 35.00 | 22.65 | 103.6 | 3.5E-05 | 0.41 |
| Clay | 50-70 | 609.6 | 39.62 | 1.60 | 5.64 | 42.00 | 32.98 | 201.0 | 8.8E-07 | 21.97 |
| Silty Sand | 70-100 | 914.4 | 24.53 | 2.00 | 2.09 | 15.00 | 10.82 | 98.9 | 2.3E-04 | 0.13 |
| Clay & Sand | 100-155 | 1676.4 | 30.57 | 1.84 | 4.20 | 30.00 | 22.27 | 373.4 | 1.8E-04 | 0.30 |
| Silty Clay | 155-240 | 2590.8 | 39.62 | 1.60 | 8.10 | 40.00 | 27.04 | 700.6 | 1.2E-06 | 68.46 |
| Gray Clay | 240-385 | 4419.6 | 39.62 | 1.60 | 14.81 | 42.00 | 18.30 | 809.0 | 1.0E-07 | 1401.45 |
| Gray Clay | 385-424 | | Top of Upper Water Bearing Zone @ 385 feet, Potentiometric Surface @ 296 feet, and TD @ 424 feet | | | | | | | |
| Totals / Averages | | 11734.8 (d) | 33.92 ($n_e$) | 1.75 | | | | 2441.2 | cm | 1493.20 |

sum of $d_m/K_{vm}$

| | | |
|---|---|---|
| Average vertical hydraulic conductivity (cm/year) | $K_{vavg}$ | 7.86 |
| Average linear velocity (cm/year) | $V_x$ | 23.23 |
| Saturated Travel Time (years) | | 505.19 |

| | |
|---|---|
| Specific Moisture Capacity (feet) | 80.09 |
| Years of Accumulation @ 0.535 per year (as predicted by the HELP Model) | 1796 |

## Unsaturated Travel Time

Laboratory calculation of absolute hydraulic conductivity (K-unsat) is determined as the hydraulic conductivity of the material at initial moisture. The K-unsat values as shown in the Table 14 (right-hand column) range in the clay and claystone facies under the silt-sand sequence from 5.8 x $10^{-6}$ to 1.5 x $10^{-9}$ in PB-2, 3.5 x $10^{-8}$ to 3.0 x $10^{-14}$ in PB-3, and 1.1 x $10^{-9}$ to 1.5 x $10^{-14}$ cm/sec in PB-4. Presumably the initial moistures of the PB-2 core is lower in-situ, since water was injected during drilling, these lower moistures content would increase the K-unsat travel time. Comparing these K-unsat values with their respective K-sat values (column second from right) indicate that K-unsats are from one order to five orders of magnitude longer than K-sat. The travel times through the measured unsaturated sediment as they occur at the site are shown in Table 14. The travel times given in both tables are calculated only for the sampled and laboratory measured layers; this excludes accumulative travel time of other layers for which laboratory analyses were not available.

Based on the sampled and measured physical properties of part of the existing clay media above the water-bearing zone, and excluding the influence of the overlying sand-silt sequence, estimated K-unsat travel times are 26,200 years for PB-2, 617,000,000 years for PB-3, and 1,300,000,000 years for PB-4. These estimates are many times slower than the rate of infiltration predicted by the HELP Model (see section **III. H. HELP MODEL INFILTRATION SIMULATION**). All of these layers are below the geologic formations modeled and their presence increases the natural protection beneath the landfill.

## TABLE 14: UNSATURATED TRAVEL TIME CALCULATIONS

| Unit Interval | Unit Description | Unit Thickness cm | Moisture Initial vol/vol | Kunsat cm/sec | Travel Time in Years |
|---|---|---|---|---|---|
| Pickles Butte Drillhole PB-2 | | | | | |
| 294-358 | Silty Claystone | 1950.7 | 0.4308 | 5.8e-06 | 4.59e+00 |
| 358-396 | Silty Claystone | 1158.2 | 0.4318 | 1.5e-08 | 1.06e+03 |
| 396-490 | Claystone | 2865.1 | 0.4148 | 1.5e-09 | 2.51e+04 |
| | | | Total Travel Time in Years | | 2.62e+04 |
| Pickles Butte Drillhole PB-3 | | | | | |
| 135-215 | Silty Clay | 2438.4 | 0.3782 | 2.7e-09 | 1.08e+04 |
| 215-267 | Claystone | 1585.0 | 0.3546 | 3.0e-14 | 5.94e+08 |
| 267-306 | Claystone | 1188.7 | 0.4363 | 3.5e-08 | 4.70e+02 |
| 306-358 | Claystone | 1585.0 | 0.3786 | 8.1e-13 | 2.35e+07 |
| 358-410 | Claystone | 1585.0 | 0.4348 | 1.4e-10 | 1.56e+05 |
| | | | Total Travel Time in Years | | 6.17e+08 |
| Pickles Butte Drillhole PB-4 | | | | | |
| 305-385 | Silty Clay | 2438.4 | 0.3953 | 1.1e-09 | 2.78e+04 |
| 385-440 | Claystone | 1676.4 | 0.3683 | 1.5e-14 | 1.30e+09 |
| 440-500 | Clayey Silt | 1828.8 | 0.3762 | 5.1e-11 | 4.27e+05 |
| | | | Total Travel Time in Years | | 1.30e+09 |

Formula+ for calculation of unsaturated time of travel:

$$\text{Time of Travel} = \frac{\text{Unit Thickness} * \text{Initial Moisture}}{\text{Unsaturated Hydraulic Conductivity}}$$

+ Personal communication Daniel B. Stephens and Associates.

## H. HELP MODEL INFILTRATION SIMULATION

The HELP Model version 2.05 was utilized to simulate the movement of water through layers of solid waste, interim soil cover layers and underlying geologic formations. The geologic materials used in the simulation were extrapolated from the Plate 3 Geologic Cross Section B - B' between PB-2 and PB-3 from underneath the landfill. Since the model limits the number of available layers to twelve, only two geologic layers were included in the simulation. The simulation was constructed by modeling a 12-foot thick solid waste layer covered by one foot of interim soil material over the two lithologic layers and running the model for a five year simulation. After five years another set of waste and cover layers were added and the model was run for an additional five year simulation. This procedure was used until the end of 25 years of simulation when all the available model layers were filled. The simulation was continued for an additional 75 years without changing the configuration of the layers. After each five-year simulation the resultant moisture contents of each layer were entered into the model before the next five-year simulation was run. See Tables 15 through 18 for initial, 25-year, 80-year, and 100-year moisture contents.

The default precipitation values for the Boise area were used. The model inputs that the average annual precipitation of 11.87 inches, and predicts evapotranspiration of 11.315 inches and infiltration of 0.535 inches for modeler specified bare ground conditions. The United States Soil Conservation Service estimates that the average annual precipitation in the area of the landfill is between six and eight inches (SCS, 1972). Using the Boise precipitation data overstates the amount of annual precipitation by 48 to 98 percent. Based on data from the University of Idaho Agricultural Research Station located near Parma Idaho the excess evaporative potential exceeds precipitation by approximately 50 inches annually (see Table 21 in section **VI. B. EVAPORATION AND PRECIPITATION**).

Initial water content of the waste layers was set at 21.10 % (vol/vol). During a telephone conversation with Dr. Paul Schroeder, the originator of the HELP model, stated that "municipal solid waste has an excess specific retention capacity of at least one inch of water per foot of waste" (personal communication, December 1, 1992). This translates into an excess specific retention capacity of 8.3%. The HELP model default moisture content for solid waste is 29.4% (vol/vol) and the solid waste modeled in the simulation was assumed to have a moisture content of 21.10% (vol/vol) but it is expected that the actual average water content of solid waste deposited at the site is closer to 15% (vol/vol). Dr. Schroeder bases his estimate of excess specific retention capacity on his experience with solid waste moisture contents from his area of residence within the state of Mississippi. It is appropriate to assume that wastes are drier in the deserts of the west than in Mississippi. Regardless of the initial moisture content, solid waste generally is not saturated when delivered at the landfill and the model predicts that the increase of moisture content after burial will be less than the excess specific retention capacity of the waste estimated by Dr. Schroeder.

The following model parameters were used during each five year simulation: SCS runoff curve number 88.00, total area 1,176,120 sq. ft., evaporative zone depth 48.00 inches, potential runoff fraction 0.35, default rainfall with synthetic daily temperatures and solar radiation for Boise Idaho, maximum leaf index 0.35, start of growing season (Julian date) 123, end of growing season (Julian date) 284, initial moisture content as shown for layers in Table 15; $K_{sat}$, porosity, field capacity, and wilting point for layers 1, 3, 5, 7, 9 and 11 are $1 \times 10^{-4}$, 0.2453, 0.1400, and 0.0200 respectively; $K_{sat}$, porosity, field capacity, and wilting point for layers 2, 4, 6, 8, 10 are $2 \times 10^{-4}$, 0.5200, 0.2940, and 0.1400 (model defaults for MSW) respectively; and $K_{sat}$, porosity, field capacity, and wilting point for layer 12 of $5.7 \times 10^{-6}$, 0.3660, 0.2200 and 0.0400 respectively.

TABLE 15: INITIAL WATER STORAGE AT BEGINNING OF YEAR ONE

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 |
| 3 | 0.00 | 0.00 |
| 4 | 0.00 | 0.00 |
| 5 | 0.00 | 0.00 |
| 6 | 0.00 | 0.00 |
| 7 | 0.00 | 0.00 |
| 8 | 0.00 | 0.00 |
| 9 | 0.36 | 0.0300 |
| 10 | 30.38 | 0.2110 |
| 11 | 44.64 | 0.0310 |
| 12 | 19.20 | 0.0457 |

Layer 12 is a 20-foot thick Clayey Silt bed, Layer 11 is a 120-foot thick Silty Sand bed, Layer 10 is a 12-foot thick layer of solid waste, and Layer 9 is a one-foot thick layer of silty sand cover material.

TABLE 16: FINAL WATER STORAGE AT END OF YEAR 25

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 0.65 | 0.0541 |
| 2 | 32.60 | 0.2264 |
| 3 | 0.52 | 0.0436 |
| 4 | 32.53 | 0.2259 |
| 5 | 0.55 | 0.0458 |
| 6 | 32.52 | 0.2258 |
| 7 | 0.55 | 0.0457 |
| 8 | 32.52 | 0.2258 |
| 9 | 0.55 | 0.0457 |
| 10 | 30.85 | 0.2142 |
| 11 | 45.23 | 0.0314 |
| 12 | 19.20 | 0.0457 |

Layers 9 through 12 are as described above and layers 1 through 8 are couplets of solid waste and cover soil like layers 9 and 10. A couplet is added every five years. It takes 25 years to construct the simulation of alternating waste and cover soil layers. Cumulative solid waste depth after 25 years is 60 feet.

TABLE 17: FINAL WATER STORAGE AT END OF YEAR 80

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 0.65 | 0.0541 |
| 2 | 36.82 | 0.2557 |
| 3 | 0.76 | 0.0629 |
| 4 | 36.97 | 0.2567 |
| 5 | 0.69 | 0.0577 |
| 6 | 36.70 | 0.2548 |
| 7 | 0.68 | 0.0570 |
| 8 | 35.71 | 0.2480 |
| 9 | 0.65 | 0.0540 |
| 10 | 36.32 | 0.2522 |
| 11 | 49.21 | 0.0342 |
| 12 | 19.22 | 0.0458 |

The layers are as described above. The model simulation was continued even though the model does not allow additional layers of waste to be added; in effect, allowing infiltration to continue into the solid waste without placement of additional waste layers or installation of final cover. A one hundredth percent change in the water volume content in the clayey silt layer (12) is predicted to occur at the end of the eightieth year.

TABLE 18: FINAL WATER STORAGE AT END OF YEAR 100

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 0.65 | 0.0541 |
| 2 | 36.82 | 0.2557 |
| 3 | 0.76 | 0.0629 |
| 4 | 37.13 | 0.2578 |
| 5 | 0.70 | 0.0582 |
| 6 | 37.37 | 0.2595 |
| 7 | 0.71 | 0.0591 |
| 8 | 37.61 | 0.2612 |
| 9 | 0.72 | 0.0599 |
| 10 | 37.56 | 0.2608 |
| 11 | 56.73 | 0.0394 |
| 12 | 19.45 | 0.0463 |

In 100 years the moisture content of the clayey silt bed is predicted to increase in moisture content by 0.06%. The base of Layer 12 is approximately 240 feet above the upper water-bearing zone within the confining Claystone. See report section Unsaturated Travel Time for estimations of travel times derived from laboratory measured physical characteristics of this lower section. The HELP Model defaults result in conservatively over estimating the amount of water available for infiltration. During most years it is likely that all precipitation is lost to the atmosphere and net infiltration of water does not occur. The ubiquitous presence of calcareous hardpan at a depth of four to six feet bears out this conclusion.

In summary, the HELP model predicts that the landfill will neither generate significant leachate during its active life nor during the total active life plus the post-closure care period in a quantity sufficient to threaten ground water quality. Any infiltration which occurs during operation will only marginally increase moisture contents of soil and waste/soil layers and any additional increases will be totally arrested by a non-infiltration final cover or cap (see section **VI. FINAL COVER DESIGN** of this report).

## I. CONCLUSIONS: HYDROGEOLOGIC SETTING

In conclusion, the hydrogeologic setting at Pickles butte has proved to be well suited for landfilling municipal solid waste from the perspective of aquifer protection in conformance with arid design criteria of Title 39, Chapter 74 Idaho Code. Some of the naturally occurring attributes of the site are listed below:

1. Extensive depth to the uppermost ground water potentiometric surface occurs more than 400 feet beneath the design footprint (see section **V. DESIGN**) and the aquifer is at a depth of more than 800 feet.

2. The aquifer directly beneath the footprint is under a confined condition.

3. The aquifer is supplied, at least in part, by deeper-seated geothermally heated water of probable ancient and remote origin.

4. The uppermost water-bearing horizon under the footprint is low yield (less than one gpm), has no beneficial use and is not an aquifer.

5. Based on the facility well, the uppermost water-bearing zone below the landfill has a diminishing yield and produces water that is not potable without treatment.

6. There is no indication that the site's surface has direct hydraulic connection to the aquifer and strong evidence that there is no connection.

7. Evidence indicates there is lateral and vertical stratigraphic continuity of the confining bed below the site.

8. The lower clay unit beneath the current footprint has exceedingly low saturated hydraulic conductivity and a large vertical thickness which result in conservatively estimated potential leachate travel times well in excess of regulatory compliance criteria. This is an extremely conservative estimate since the underlying sediments are not saturated.

9. A thick vadose zone separates the base of the landfill from the uppermost water-bearing horizon. Unsaturated hydraulic conductivities indicate that travel times are

actually from one to five orders of magnitude greater than estimates based on saturated hydraulic conductivity. Unsaturated travel times are measured in 10's to 100's of thousands of years.

10. Specific retention capacities for water within the vadose zone render time of appreciable mass transport by percolation or wetting fronts substantially longer than the landfill's active life and post-closure care period.

11. HELP model simulation over a one-hundred year period conservatively predicts that moisture content of underlying sediments will not significantly increase.

These conditions, in combination with an arid climate of six to eight inches precipitation per year with a mean annual excess pan evaporation of 50 inches and a high probability of leachate attenuation within the stratigraphic column, all contribute to the high level of natural protection. The exceptional level of naturally occurring protection to the confined aquifer below the site, in addition to the ground water monitoring system, precludes future need of an artificial liner. The benefit of an artificial liner is rendered superfluous and exceeded many fold by the thick natural liner existing below the design footprint of Pickles Butte Solid Waste Landfill.

# VI. MONITORING SYSTEM

The hydrogeologic setting is not simple, being complicated by a northwest-trending fault and a prevailing bedding dip towards a differing hydrogeologic domain to the east of the landfill. The proposed monitoring well system has been designed specifically for these conditions so as to intercept and detect potential pollutants in the remote case of leachate generation and migration to such extraordinary depths. But in a more practical sense, the monitoring system has been designed for the benefit of the County to assure the public that the landfill does not degrade a ground water resource. Monitoring the uppermost level of ground water down gradient of the site shall maintain direct assurance to the public that resource contamination is not occurring.

## A. WELL CONSTRUCTION

Six wells have been completed (PB-3 through PB-8 shown on Plates 1 and 2) for the purpose of baseline information and routine ground water monitoring. PB-1 is a pre-existing domestic well not designed for monitoring and PB-2 is a continuous core hole not suitable for monitoring well construction. PB-2 is now used as a piezometer for characterization but will eventually be abandoned.

All monitoring wells are constructed as stipulated by Title 34 of Idaho Code (39-7410). See Well Construction Diagrams in Appendix B of APPENDIXES OF PRIMARY DATA (HECO, 1994) for details of each monitoring well. Wells PB-3 and PB-4 consist of stainless steel liners from top to bottom whereas PB-5, PB-6, PB-7, and PB-8 have stainless construction only below each wells' water column. All-stainless construction, although expensive, was deemed necessary as a comparative control with the carbon steel wells for determining the influence, if any, they may have on baseline water quality. This was because the early Subtitle D, Appendix I constituents included iron as a monitoring parameter but subsequently was dropped. Wells are 4-inch diameter, schedule 10, 304 stainless steel or 1/4-inch wall carbon steel, 0.020-inch stainless steel wire wrap screen with tremmie-placed 10/20 silica sandpacks (sand prepack screens were used in PB-5, PB-6 and PB-8), 8-inch steel locked covers, and concrete surface pads with steel bumper posts. Well seal depths and sandpack levels were determined with tagline as they were constructed. All wells were developed by surging with a 20-ft bailer and winchline until effluent was clear or turbidity stabilized.

## B. PRINCIPLES OF MONITORING DESIGN

The design of the ground water monitoring system has been optimized for the existing hydrogeologic environment in order to intercept and detect, within the compliance boundary, a potential contaminant plume from the landfill that could threaten the ground water resource. Plates 1 and 2 show the well locations in relation to the waste cell footprint and surface geology. The Geologic Cross Sections on Plate 3 depict the well locations in respect to the subsurface geology and hydrology. Monitoring wells were screened at the uppermost water-bearing zones to minimize contaminant dilution within the saturated zone and to ensure its' earliest possible detection. The large depth to groundwater and its positive artesian head both combine to make monitoring wells difficult and expensive to construct. Yet it is maintained that such wells are ultimately necessary to validate public assurance of protection.

The distribution of wells has been designed to reflect the locality's two differing hydrogeologic domains. The well array accessing the ground water under confined conditions below the landfill was constructed for characterization and subsequent perimeter monitoring. The perimeter wells meeting this objective are PB-8 to the northwest, PB-3 to the southwest, and PB-4 to the south. These are essentially baseline control wells since it is reasonable to conclude that ground water contamination will not be found under the prevailing confined conditions below the landfill.

The well array accessing uppermost ground water from the eastern, down stratigraphic dip, unconfined aquifer is comprised of PB-6 to the north, PB-5 to the northeast, and PB-7 to the east. The spacing of these wells are approximately 1200 and 1500 feet apart at an approximate distance of 200 to 900 feet from the boundary of the designed footprint. Despite the arid conditions and the high level of natural protection, public assurance of aquifer protection justifies installing a monitoring system at Pickles Butte. Since the down-dip wells monitor a ground water resource without benefit of confinement, current well spacings could arguably exceed the interval required for total confidence of plausible contaminant plume interception. For this reason, two additional wells are proposed (see Plates 1, 2, and section B-B' on Plate 3) to establish an approximate 650-foot spacing between down-dip wells with PB-5 acting as a more distant, down-gradient, backup well. This concentrated, two-tier, five-well array eliminates doubt concerning down-gradient well distribution and achieves the high level of protection the resource deserves.

## C. MONITORING PLAN

Monitoring Schedule

Ground water monitoring will begin prior to October 9, 1994 for the currently constructed wells and additional wells will be added to the monitoringg schedule consequent to construction. Ground water monitoring will be performed in accordance with Title 39, Chapter 74, Section 10 of Idaho Code. Background characterization sampling and analysis for 40 CFR 258, Appendix I constituents and temperature will be performed on groundwater by one independent sample from each monitoring well taken quarterly for the first full sampling year (four sample sets per well). Prior to sample collection static water level will be determined for each well and static water elevations will be used to determine flow direction and rate. Thereafter, detection monitoring will commence and continue on a semiannual basis. Detection monitoring will consist of collecting one sample from each well for analysis of Appendix I constituents, determination of static water level prior to sampling and temperature.

A comprehensive review of the monitoring program will be performed during a meeting between the landfill owners (Canyon County Commissioners) and the authorized regulatory agencies (DEQ and SWDHD), as required by Title 39 Chapter 7419, Idaho Code. If no statistically significant change in Appendix I constituent concentrations occur in any monitoring well during the period prior to the meeting the monitoring results will be evaluated to determine whether there is a basis for a less rigorous monitoring schedule during the remaining active life and post-closure care period of the landfill.

Should a statistically significant change in constituent concentration occur in any well during detection monitoring, a notice of such detection will be placed in the operating record and the state director will be notified within 14 days. In addition to the detection monitoring regimen, assessment monitoring will begin within 90 days of constituent variance detection and continue thereafter on an annual basis. Assessment monitoring will consist of collecting one sample annually from all downgradient well and analyzed for Appendix II listed constituents or those constituents in Appendix II determined necessary by the state director. Thereafter, the ground water monitoring procedures or actions to be taken will depend on the results of assessment monitoring and followed as prescribed necessary by the director in accordance with Subtitle D, 40 CFR, Parts 258.55(c-j) and Parts 258.56 through 258.58 as required by 39-7414 Idaho Code.

## Quality Assurance/Quality Control

Background characterization and detection monitoring will be performed with a QA/QC protocol which assures uncompromised representative samples, valid laboratory analysis, and accurate and complete data recordation. Sample acquisition at the wells will be conducted in a manner which prevents contamination from personnel, equipment, the surrounding environment or other ground water sources. Well sampling will be done in a manner appropriate to each well's performance characteristics and in a manner which is consistent between sampling cycles. Purging multiple well volumes before sampling will not be possible for the slow recovering wells nor even desirable since drawdown would induce sample turbidity from the water-bearing clays. Therefore, purging will be performed following sampling in order to induct new formation water for the following sampling event. This will allow for well recovery and settlement of suspended solids. Sample water will be collected in laboratory provided sterilized bottles by a certified ground water specialist (Idaho licensed Geologist or Engineer).

It should be noted that under these very low yield, deep water-bearing conditions, there is a high likelihood of non-intrusive but interpretive error by the very nature of sampling and statistical methods. Before any significant change can be announced, the methodology and procedure should be reviewed and confirmed. A significant question on the validity of "statistically significant" analysis exists for arid, deep, slow recharge sites in the scientific literature (Siegel, 1994).

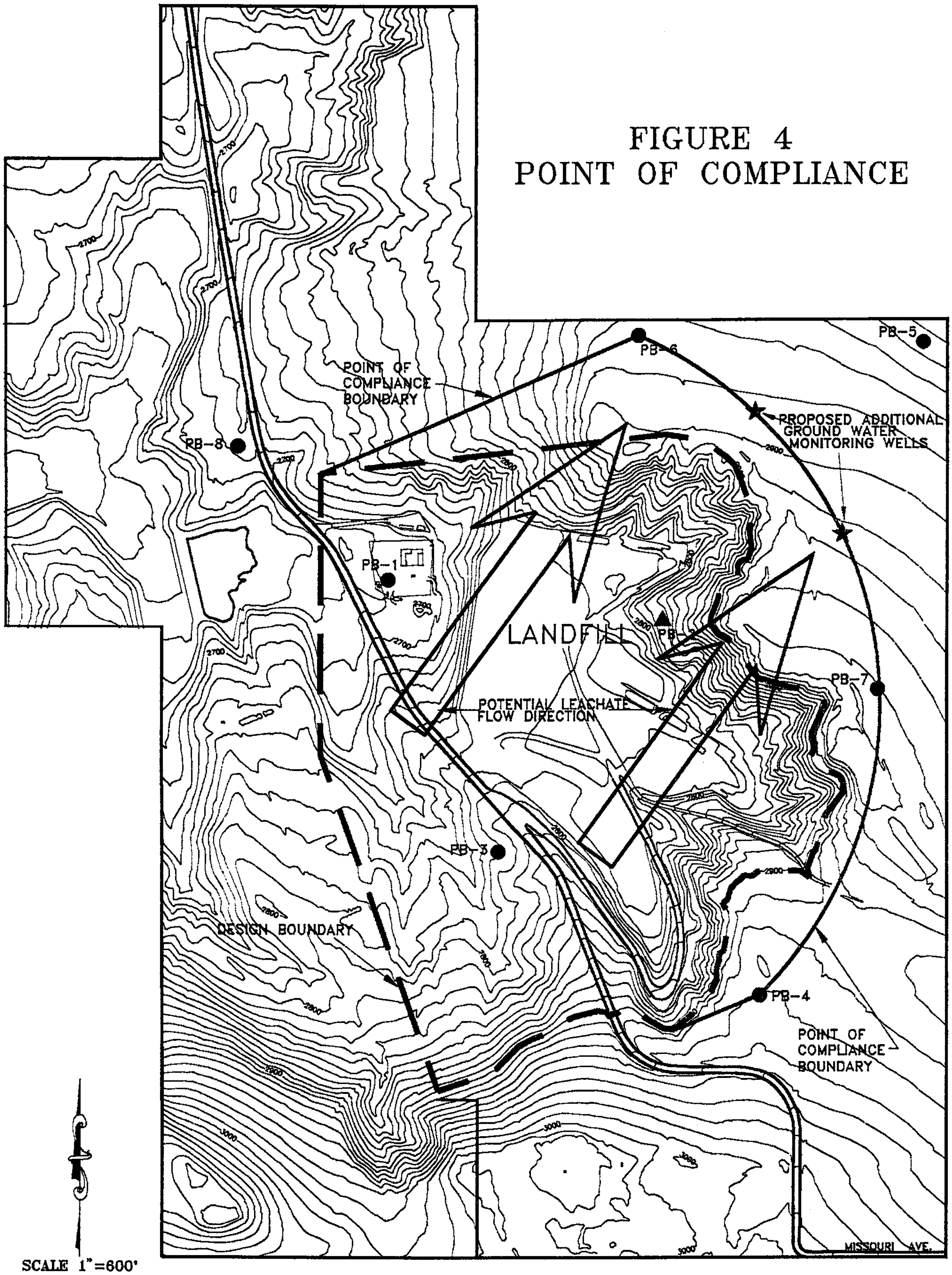
Ground water samples will be transported in cooled, insulated containers protected by custody seals and chain of custody record. Overnight shipping will be utilized so as to assure 48-hour sample arrival to an EPA-certified laboratory. Laboratory analytical reports will be duplicated and placed in two separate notebooks along with compiled tables of data for convenient comparative review. After sufficient analytical data has been accumulated, an accepted computer software statistical evaluation for ANOVA will be conducted following results from each monitoring event.

## D. POINT OF COMPLIANCE

The point of compliance (POC) has been determined in consideration of the criteria of Title 39 Chapter 74 Section 10(3), Idaho Code. Figure 4 shows the boundary of the POC. The POC encompasses the design boundary, an arc through the four down hydraulic gradient monitoring well locations (PB-6, PB-7 and two proposed wells), one well located normal to the potentiometric gradient (PB-4), and one well within the design boundary (PB-3). PB-5 is located further down-gradient from the POC and is considered as a POC check well located near the property boundary. PB-8 is located normal to the potentiometric gradient. None of the wells which define the POC are greater than 150 meters distant from the design boundary and all wells and portions of the POC are located on contiguous property owned by the County.

The nearest down-gradient drinking water well is located at a residence more than 10,000 feet from the POC. The nearest drinking water well to the POC is located at a residence north-northwest of the POC (normal to the hydraulic gradient) at a distance of more than 3000 feet. See Part **III.** Chapters **A.** through **I.** of this report for detailed discussion regarding leachate generation, quantity, quality and direction of ground water flow, existing ground water quality, and complete description of the hydrogeologic characteristics of the facility and the surrounding land. The landfill with the monitoring well network and POC, as described, should allow the County a high degree of confidence that all appropriate measures are being taken to protect the public health, safety, and welfare of the citizens of Canyon County within the practicable capabilities of the County.

# FIGURE 4
# POINT OF COMPLIANCE



# V. DESIGN

## A. DESIGN INVESTIGATION

### General Objectives

The principal objective of landfill design is to optimize permanent solid waste containment, within the constraints of applicable laws and regulations, in a manner which controls or prevents environmental impacts from landfill operation during the operating life of the landfill, and minimizes environmental impacts subsequent to closure. The environmental concern most strongly addressed by 40 CFR 258 is the protection of ground water from leachable waste constituents, because concern for the need for such protection has evolved recently. Other environmental concerns addressed in design, as listed in the following, are treated in less detail in 40 CFR 258 because they are the familiar objectives of sanitary landfill design that have been widely known and routinely dealt with by the disposal industry for decades.

Environmental impacts from landfill operation can include communicable disease transmission, air pollution, explosion and asphyxiation hazards from gases produced by anaerobic degradation of wastes, odor nuisance, "aesthetic pollution" (ugliness), excessive noise, littering of surrounding areas by refuse dropped from conveyances, borne by wind or carried by animals, contamination of surface water by landfill run-off and contamination of ground water by leachate from the landfill, or any combination of the listed effects.

Uncontrolled waste disposal can lead to communicable disease transmission by two general routes: either (1) through incidental contact with contaminated objects in the waste or (2) through transmission of disease by a vector organism (most commonly Norway rats; secondarily flies) that finds either its habitat or its food source in the waste. Control of communicable disease transmission is achieved by (1) requiring covering of conveyances bringing waste to the landfill, (2) requiring a daily soil cover on the waste to prevent communicable disease vectors (especially Norway rats) from supporting viable populations by feeding on food scraps in the waste, (3) prohibiting or controlling salvage efforts, (4) controlling public access and (5) installing debris fences to minimize paper and other wind-borne lightweight objects from leaving the landfill. Control of air pollution is achieved by prevention of open burning and, where appropriate, by flaring of vented methane. Control of hazards from methane generated in the waste is achieved by venting and, where appropriate, flaring accumulated gases from the waste or, in cases where it is economically feasible and physically practicable, by collecting the methane and utilizing it as fuel. Control of odor nuisance is achieved primarily by covering the waste daily with soil. Since waste may have strong odors when received, this nuisance is a major consideration in site selection as well as a concern in operation. Aesthetic pollution is greatly reduced by daily cover, but remains a motive for selecting remote locations as landfill sites. Noise pollution control is achieved more by site selection than by noise reduction measures, as there is a limit to the degree to which noise can be reduced with today's technology, particularly during the compacting operation. Littering is controlled by conveyance covering, drift fences and daily cover. Contamination of surface water by landfill run-off is controlled during the life of the landfill by run-on and run-off control channels and by treatment for contaminant removal if necessary. Contamination of ground water is controlled by taking steps necessary to prevent contaminant-bearing leachate from mixing with ground water beyond the boundaries of the landfill property. In new landfills where leachate is expected to form, this normally consists of removing leachate from the base of the landfill and treating it to remove contaminants before discharging it in accordance with NPDES requirements.

## Effects of Local Conditions

Local conditions at the Pickles Butte Landfill have specific effects on the implications of many of the stated general objectives of landfill design and operation.

The site is remote from human dwellings, and Canyon County owns enough land surrounding the design boundary to constitute a buffer zone not less than 1/8-mile wide on the north, west, south and most of the east sides of the landfill and 1/12-mile wide on a portion of the east side canyon rim of the landfill (see Plate I General Site Map). There are currently no dwellings within 3/8 miles of the landfill design boundary and this dwelling is located outside of the canyon. This remoteness greatly reduces the potential for noise nuisance. The landfill is in a deep canyon which hides it visually from all but two existing dwellings, therefore it is not a visual nuisance. The canyon walls also greatly reduce noise transmission.

The climate of the site is arid, to such a degree that samples of soils recovered from considerable depths had moisture contents markedly below the range of wilting points of respective soil types. This shows that local soil water conditions are dominated by evaporation, and that objects left in the open for years become desiccated, rather than becoming moist or wet. Therefore, a completed landfill will tend to be slowly dried by evaporation over time if no impervious membrane layer is included in the cap, and percolation of infiltrated precipitation will be minimal through the completed landfill and into the soil layers below. This prediction is borne out by HELP model simulations (discussed in section **III. H. HELP MODEL INFILTRATION SIMULATION** of this report), hence it is possible to base ground water protection design on preventing leachate from forming, rather than on collecting and treating leachate at this site. In addition, treatment of landfill run-off to prevent contamination of surface water can be achieved by an evaporative lagoon, eliminating the need for a discharging wastewater treatment system.

Disease transmission concerns are also mitigated by the aridity and relative remoteness of the site. In particular, the site is poor habitat for Norway rats due to its hot, dry summers. The usual minimum operational precautions for disease transmission control (daily cover, debris fencing, limited access) can be expected to show high effectiveness as enhanced by the supporting effects of the aridity of the site.

## B. HISTORIC VOLUME OF WASTE

A topographic map was constructed of the site from aerial photographic data collected on October 30, 1990 and converted into a two-foot contour interval base map. This base map was compared with the original map generated during the initial permitting procedure before the facility began accepting solid waste. Volume estimates were calculated using the average end area method. The facility began accepting waste on April 1, 1983. During this seven-year, eight-month period approximately 733,000 cubic yards of the site has been utilized. This volume includes solid waste, daily and interim soil cover material. The percentage of daily and interim cover material to the total volume is unknown. The total volume of solid waste should be approximately equal to the total volume calculated since the minor difference in compaction of in-situ soil versus re-compacted soil will only minimally affect the volume calculations. During this period, the average annual compacted in-place volume is approximately 95,000 cubic yards. The population of Canyon County has increase since 1990 at an annual rate of approximately 2.4% (Ned Kerr, Canyon County Clerk, personal communication March, 1994). At this rate of population increase it is estimated that the annual volume of compacted in-place waste is currently 100,000 cubic yards.

## C. ORIGINAL DESIGN

Operation of the facility during the last eleven years has principally followed the original 1973 Plan of Operation (Blakley, 1980) as modified in 1975, 1976, 1980, 1983, and 1986. Generally, the Plan of Operation entailed a three phase operation which began with Phase I - filling three of the deeper ravines to a common elevation. Two of the three ravines were located northeast of the access road and the third southeast of the road. Phase II continued to fill the area over the three ravines to a depth of approximately 175 feet and a crown elevation of 2900 feet standard mean sea level (MSL) with 30% side slopes. Phase III operation would consist of filling small miscellaneous higher-elevation ravines and deposition of a final lift over Phase II.

The 1980 plan of operation was modified by county landfill management to allow motorcycle access for the longest period of time to the largest possible portion. To maximize motorcycle area use the development of the facility has first filled in the two ravines located northeast of the access road to a common elevation. Instead of continuing with the original plan of filling the third ravine across the road before starting Phase II, the second phase was begun.

The capacity of the site was estimated to be 16 million cubic yards in the original design report (Blakley, 1973). See section **V. F. 1994 DESIGN AND PROJECTED CAPACITY** of this report for revised facility capacity. The amount of capacity utilized at the site between opening and April 1, 1994 is estimated to be approximately 1,080,000 cubic yards. Currently the site has used approximately 27 acres to an average depth of 25 feet of waste.

## D. 1994 DESIGN APPROACH

Contemporary landfill design, as a general rule, includes liners and leachate collection and treatment systems to protect ground water from contamination by preventing leachate from infiltrating to aquifers. At Pickles Butte, the design was begun assuming the hypothesis that leaching through the waste would occur to some degree, and EPA's HELP Model computer program was used to quantify a projection of the amount of leachate that would be generated. The results of these calculations indicate that, where waste received has an average low water content (21.1% by volume was assumed for model runs) and where cover is taken from existing soil layers in which the measured in-situ moisture content is less than the agronomic wilting point, it is very unlikely that leachate will be generated from any precipitation moisture absorbed during the active life of the landfill. Hence, if entry of moisture is prevented subsequent to the active life of this landfill, there will be no percolation of water through the waste layers to the underlying soil. Therefore, if the landfill is closed in a manner that prevents significant net infiltration of moisture into the uppermost waste layer, there will never be leachate, and all questions of liner design become inapplicable.

In the arid-region design concept applied here, cover design is based on the concept of retention of all infiltrated moisture in the soil interstices, with annual balancing of infiltration by evapotranspiration. This is a departure from the concept of designing the cover as an impervious shield, as is common for landfills sited at humid locations; the cover in this case is expected to function more as a blotter or sponge. A particular advantage of this design concept (absorption balanced by evaporation) is that the cover has a very low degree of functional vulnerability to animal burrows and subsidence as compared to a cover designed as impervious. It also is not subject to any of the chemical-change considerations that affect selection of a flexible impervious membrane. Except under very rare and short-term conditions involving relatively small total quantities of water, the balancing or "field-capacity" cover functions without standing water on the surface or flow across it, so that cracks or animal burrows do not let disproportionate quantities of water past the upper surface of the cover. In addition, the water that does enter at a crack or animal burrow will be mostly or entirely absorbed into the cover fill through the sides of the opening, since the opening will certainly not be vertical in the case of an animal burrow and is unlikely to be exactly vertical in the case of a crack caused by subsidence. Hence, it is more justifiable to forecast landfill performance on the basis of zero percolation when using this style of cover than it would be if the design were based on performance of an impervious membrane.

This design is an alternative design, meeting the objective of protection of groundwater protection from leachate by utilizing the particular features of the climate, subsoil conditions and available native cover material of the site, as provided for by 40 CFR 258.40. The State of Idaho's criteria for appropriateness of a site for use of the arid design alternative, as listed in Idaho Code 39-7412(d) are that the site have annual rainfall less than 25 inches, net evaporative losses greater than 30 inches annually, and "holding capacity in native soils greater than annual absorbance" and;

"(i) solid waste is deposited no less than fifty (50) feet above the seasonal high level of ground water in the uppermost aquifer;

(ii) the geologic formation beneath the site and above the uppermost aquifer must have capillary capacities greater than the projected maximum volume of leachate generated during the active life of the MSWLF unit; and

(iii) 'no potential for migration' shall mean that the geologic formation beneath the site and above the uppermost aquifer has holding capacity adequate to contain all hazardous constituents generated during the active life, closure and post-closure care periods."

With regard to these requirements of statute and regulation:

1. the site's average annual rainfall is less than 8 inches, satisfying the stipulation that it be less than 25 inches.

2. Net average annual evaporation at the site is greater than 50 inches, satisfying the requirement that it be greater than 30 inches (see Table 21).

3. The waste will be deposited at least 400 feet above the uppermost water-bearing horizon and more than 800 feet above the uppermost aquifer, which exceeds the statutory requirement of 50 feet;

4. As elsewhere discussed, the projected maximum annual amount of leachate produced during the active life of the landfill is approximately 0.535 inches as predicted by the conservatism reflected in the assumptions applied in the HELP model simulation. Hence, the site has the required degree of "capillary capacity" above the uppermost aquifer for, at a minimum, more than at least 900 years.

5. As discussed in (4) foregoing, the site has adequate capillary holding capacity above the uppermost aquifer to contain all projected leachate generated during the active life of the landfill. It is further projected that there will be no significant leachate production after closure, due to the reliable functioning of the field-capacity cover. Hence, all leachate generated during the active life, closure and post-closure periods will be retained in this soil layer (above the uppermost aquifer) and all hazardous constituents of the leachate will be retained with it.

The ruling considerations for design of the landfill itself are efficiency of equipment use, efficient use of landfill space, adequacy of access, and conformance with the requirements of 40 CFR Part 258, Subpart C. In addition, special attention was paid to drainage to assure that the landfill operation sequence does not create pockets where short-term ponding of precipitation-derived moisture could increase infiltration deep into the waste layers.

## E. CELL DESIGN

The waste received each day will be placed in the waste cell location and compacted in lifts of about two (2) feet thick. At the end of the day all of the exposed waste will be covered with a six (6) inch layer of fine-grained soil. Cells will be completed in tiers with each tier consisting of several parallel rows of cells. Usually the cells in each row will be built consecutively. Row width and cell depth will be kept to uniform dimensions. The average probable row width will be not less than twelve (12) feet. Cell depth will be dependent to some extent on the average volume of waste received daily, and may be adjusted during operation.

The landfill is to be operated by the area-fill method, in which waste is deposited and compacted in orderly tiers of individual daily cells that are close-packed because they are constructed against the walls and on the tops of previously deposited cells. At the end of each working day, the exposed top and edges of the cell deposited that day are covered with earth that is hauled from a borrow area within or near the landfill. In the preferred mode of operation, the borrow area used for the bulk of the life of the landfill will be directly adjacent to the landfill (see section **V. G. DAILY AND INTERIM COVER MATERIAL**).

In order to limit ponding of rainwater and snowmelt water on the surfaces of the tiers of the landfill during operation, the typical intermediate cover (top of tier) incorporates a design side slope of 4% (see Figure 5). The design side slope of 4% is a compromise between the ideals of a level working surface for equipment and a slope that would assure quick drainage. A maximum side slope of 33 1/3% (3:1) is used in the design both for temporary and final covers.

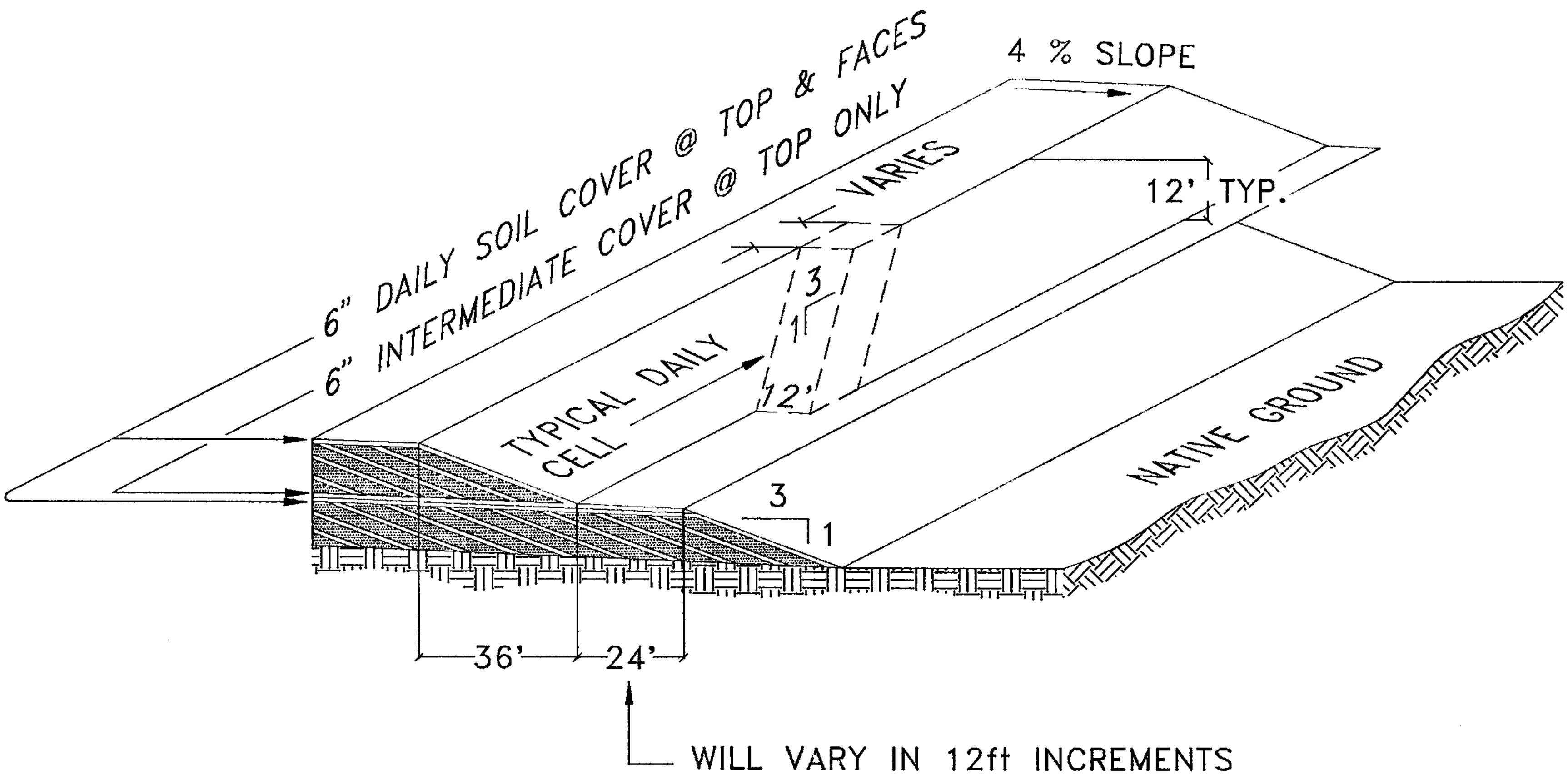



FIGURE 5
TYPICAL WASTE CELL DETAIL
CANYON COUNTY LANDFILL

## F. 1994 DESIGN AND PROJECTED CAPACITY

The base map for the 1994 design is the topographic contour map generated from the aerial photographic data collected on October 30, 1990. A facility grid system has been established based on north and east coordinates. For example, the collection booth is described as being located at coordinates N 667175, E 245710. A northwest-trending design cross-section station reference line is constructed through the northeast corner of the S 1/2, SE 1/4, SW 1/4 Section 21, and the northwest corner of the NE 1/4, SW 1/4, Section 21; both located in Township 2 North, Range 3 West, Boise Meridian. Design cross-sections are developed at even-numbered 200-foot intervals perpendicular to the reference line.

A Design Cross Section Index Map (Plate 6) and the Design Cross Sections (Plates 7 - 10) are included at the end of this report. The following conventions were applied in the construction of the 1994 design of the facility.

1. A minimum 660-foot wide buffer zone was maintained around the area of the facility which will not contain solid waste. The only exceptions is along the eastern rim of the canyon where an 800-foot section of the rim protrudes 230 feet into the buffer zone. No area containing waste when filled to capacity will lie less than 400 feet from the property boundaries.

2. A minimum 20-foot wide undisturbed zone is maintained between all top of cuts and the property boundary to allow for fencing and access.

3. Adjacent areas of cut and fill are separated by either 10-foot differences in elevation or 20 feet laterally.

4. Maximum slope of any element of the design is 3:1 (18.43 degrees) and minimum slope along the bottom of cuts is 20:1 (2.86 degrees).

5. A 300-foot wide section (shown as level on the design cross sections) is maintained along the crest of the fill to allow for equipment maneuverability.

6. All surface water run-off is routed off and around the fill. All potential surface water run-off originating on the facility is collected, stored and allowed to evaporate from pond(s) located at the bottom of the main drainage or in intermediate locations along the tributary drainage. Evaporation ponds are not constructed topographically and/or stratigraphically up gradient of any area containing waste.

7. Surface run-on water is aggressively controlled by diversion ditches which route water around the fill and run-off evaporation pond(s) to the main drainage. As cover material areas outside of the canyon are developed temporary intermediate ponds may be constructed. Although intermediate ponds may temporarily be located topographically above some areas of the fill these ponds will be constructed down stratigraphic dip of waste cells. The effect of this design criteria is that all subsurface flow will move away from the fill areas.

8. The current footprint (area containing waste) of the facility need not be enlarged beyond its present aerial extent until the area is filled at a 3:1 slope starting along the present access road to the top of the northeastern canyon rim and/or intersection with the design configuration. This volume alone should last for more than 50 years and would allow the main road to remain at the present location. This volume is approximately 9.0 million cubic yards.

9. By filling in the wedge between the outside toe (southwestern edge) of the fill and the canyon wall, the size of the fill can be kept to a minimum. This could be of particular importance if the facility must be prematurely closed for any reason. Also, slope stability, differential settlement, erosion, and cover design studies could be conducted over an extended period of time at the facility on areas of the site containing waste.

10. During the entire operational life span of the facility the fill will be sloped towards the main valley located to the northwest to allow for drainage of run-off waters from aperiodic storm events to evaporation ponds. Run-on slopes will drain to ditches that discharge into the main valley. During the

medium term (next 20 to 50 years) the southwest side of the fill will be sloped to the southwest to a collection trench located adjacent to the present access road. No depressions or excavations (non-draining) below grade will be allowed to exist on the fill nor especially along the edge of the fill adjacent to the canyon walls where surface waters from an aperiodic storm event could collect in the depression(s) and compromise the integrity of the unlined facility.

Volume calculations conducted for this report utilize the average end area method for volume estimates applied to design cross sections generated from the October 30, 1990 aerial map. The calculations indicate the remaining capacity of the site is approximately 25.7 million cubic yards (mcy) (see Table 19, Geographic Area Material Volumes). Adjusting this capacity calculation for the amount of waste accepted at the site since the map was produced results in approximately 25.3 million cubic yards of remaining capacity. This is a 65% increase in the available volume of the site compared to the original volume estimate of 16 mcy (Blakley, 1973). Assuming an annual fill rate of 100,000 cubic yards, moderate population growth rate, and a decreasing per capita waste generation rate, the facility could be a resource for the citizens of Canyon County for more than 200 years. It is impossible to predict future changes that will affect Canyon County for such an extensive period of time but this tremendous remaining volume at the facility illustrates its importance as an asset is to the County.

The difference between the two volume estimates is principally attributable to the peaked profile of the 1994 design as opposed to the flat topped 1973 design. The profile probably will not be built as a peaked design as shown on the design cross sections with 3:1 side slopes and a flat cross-sectional top but rather as a shallowly rounded dome across the flat cross-sectional top. A domed top will marginally increase the volume projections. The location of the proposed boundaries of both designs are essentially identical except that the 1994 design covers slightly less total acreage.

A peaked profile for the final design is preferable to a flat profile since some settlement of the solid waste is expected. The amount and the rate of settlement is a function of a number factors including: depth of solid waste, in place density, moisture content, waste composition, daily and interim cover material volume, infiltrated water volume and rate, time, aperiodic climatic events, and final cover integrity. Settlement occurring beneath a flat top may be expected to create depressions in the cover. These depressions could exacerbate the problems which the final cover is designed to avoid by allowing and directing surface water into the underlying waste. The peaked design will allow for settlement to occur without compromising the integrity of the final cover.

The remaining capacity of the site is approximately 25.3 million cubic yards which translates into an operational life span of potentially hundreds of years. It is impossible to predict the course of events over the projected long-term life of the facility but the methods and practices employed today should be evaluated for possible future impacts and consequences. The long term operation of the landfill will need to incorporate the evolution of new technologies and procedures. This long term plan of operation will need to be re-evaluated periodically and adjusted to current and accepted solid waste management practices. The County expects that new management techniques will be advanced for review during joint state, health district and County facility comprehensive review as required by 39-7419(2) Idaho Code.

## G. DAILY AND INTERIM COVER MATERIAL

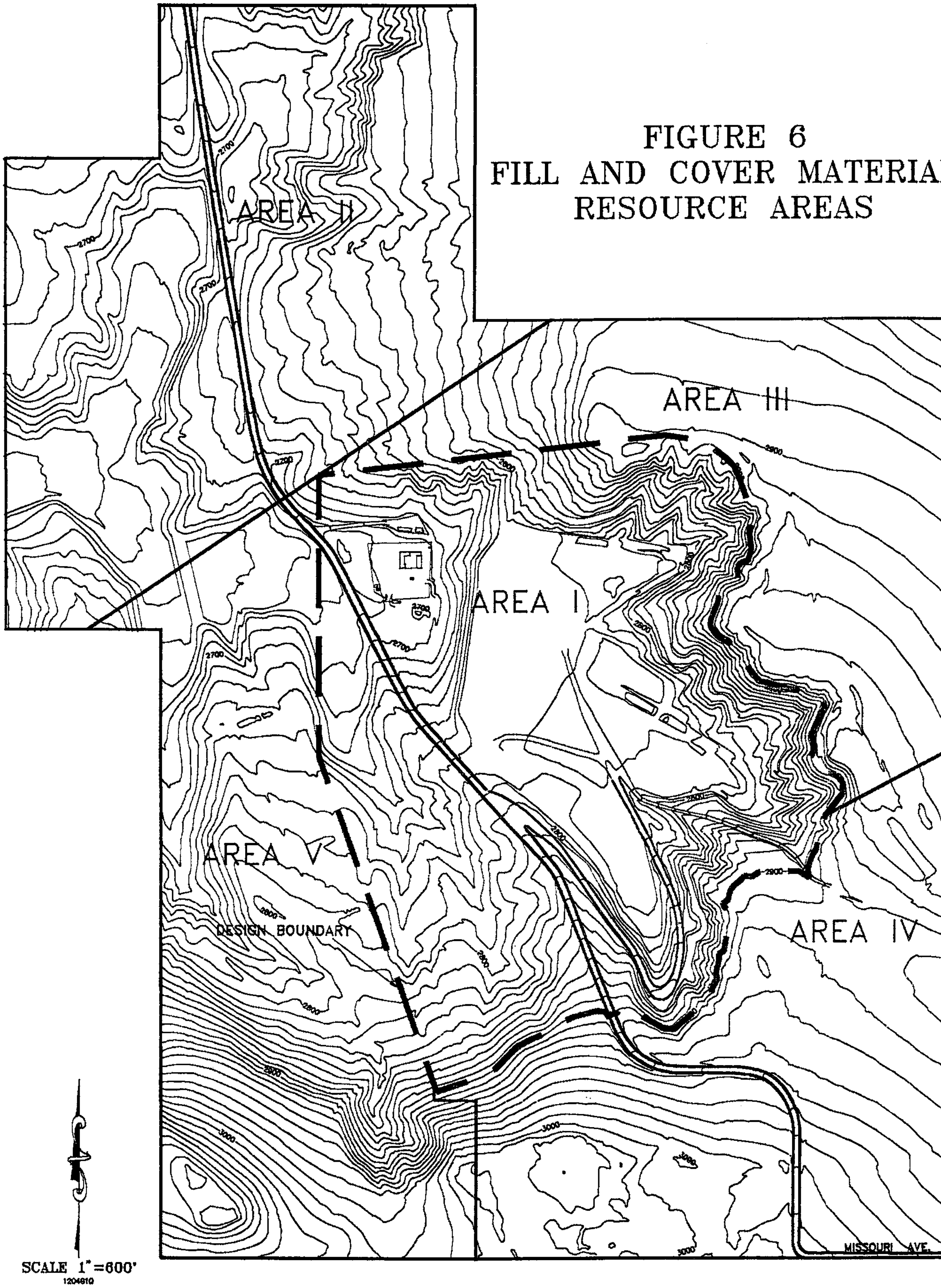
Three hundred and twenty acres of the 370 acres of property owned by the county has been divided into five geographic areas and these areas are shown on Figure 6 and on the Design Cross Sections Plates 6 through 9 located at the end of this report. Table 19 lists the acreage and the resource area volumes of the five geographic subdivisions. The area labeled Area I, located in the center of the property is the fill area. Areas II through are V are resource areas for daily and interim cover. Area VI and VII are resource areas for final cover material as shown of Figure 8 and are subsets of Area III shown on Figure 6. The total volume of cover material available within the property boundaries and outside of the fill area is approximately 14.25 million cubic yards. All the applicable conventions discussed in section **V. D. 1994 DESIGN AND PROJECTED CAPACITY** above were used to determine the design and volumes of the cover material source areas.

**TABLE 19: GEOGRAPHIC AREA MATERIAL VOLUMES**

| AREA | ACREAGE | VOLUME (cu. yds) |
|---|---|---|
| I | 98.33 | 25,673,056 |
| II | 61.40 | 3,966,539 |
| III | 54.69 | 6,136,375 |
| IV | 65.52 | 2,179,010 |
| V | 41.75 | 1,970,344 |

Since the landfill started operations cover material has been excavated from within the canyon and closely adjacent to the working face. Because the excavation is made available for filling with solid waste, this cover material does not effect the annual rate of fill of the site and is not a factor in determining the volume of deposited waste.

# FIGURE 6
# FILL AND COVER MATERIAL RESOURCE AREAS



Eventually the facility will exhaust the cover source areas within the canyon when the canyon walls are made inaccessible by buried waste. When cover material is mined outside the fill area (Area I) and hauled into the fill this volume will then become a significant factor affecting the annual fill rate of the facility. Under current regulatory requirements all wastes must be covered daily with at least six inches of soil material and those areas of the facility which will not receive additional wastes within one year must be covered with 12 inches of soil as interim cover. If these requirements continue after cover material must be hauled in, the net volume increase of the facility occupied by cover material could easily approach twenty to twenty-five percent of the total fill volume.

It is anticipated that the facility has an enormous excess amount of available cover material to complete the 1994 Area I design. The cover material borrow areas shown on Figure 6 and the Design Cross Sections Plates 6 through 10 (located at the end of th report) were designed to maximize the amount of cover material available and will not necessarily be developed as shown. The excavation of the material will follow the progression of the development of the solid waste lifts. Cover material will be excavated from the source area (Areas II-V) closest to the location of the landfill face at any particular time.

## H. SURFACE WATER MANAGEMENT

Control of run-on and run-off of surface waters is important in minimizing cover erosion and potential leachate generation. It is especially important for unlined arid facilities where control of surface water can mean the difference between methane and leachate generation or the waste desiccating and effectively becoming geochemically isolated and immobile within its environment. If unmanaged, surface waters from an intense aperiodic storm event could conceivably compromise the protective integrity of the cover and necessitate the need for otherwise unwarranted corrective actions or monitoring programs.

### Topography and Drainage Analysis

The topography within Deadhorse Canyon consists of steep walls with a relatively broad flat valley floor. The east and northeastern canyon wall forms badlands type topography which supports sparse vegetation. Wind erosion, mass wasting, rain splash and freeze-thaw are among the principle erosional processes modifying the northeastern canyon wall. The southwestern canyon walls are less steep and more uniformly sloped which support a relatively thick covering of sagebrush, grasses and small shrubs. The principle erosional processes which effect the southwestern and southeastern canyon walls are probably soil creep, freeze-thaw, and overland flow.

The wide, gently sloping nature of the valley floor is atypical of small valleys located in arid environments. Generally small valleys formed in arid environments have "V" shaped cross-sections. The broad nature of the valley indicates that either some structural control or a previously wetter climate may have influenced the valley's configuration. The valley floor supports a relatively thick covering of grasses and small shrubs. The erosional processes shaping the valley floor are wind (eolian deposition and erosion of dunes), freeze-thaw, overland flow and infrequent bedload transport.

## Run-on and Run-off Control

The landfill is located in a dry canyon which has been eroded into the northern rim of the inner Snake River Valley. The canyon has been eroded into the highest topographic divide separating the Snake River from the Boise River drainage. This topographic configuration prevents precipitation which falls outside of Deadhorse Canyon from flowing into or through the canyon. Therefore, only surface water from precipitation which falls directly within the canyon walls upgrade of the landfill requires any run-on control.

The strategy for limiting the buildup of moisture in the contents of the landfill prior to placement of the final cover is to maximize run-off and evaporation of rainwater and snowmelt. This will minimize water infiltrating the landfill to depths that are below the drying effects of the arid conditions of the following summer.

Run-on and run-off control consist of collection ditches constructed around the waste area and through the bottom of the cover material excavations. The run-off from the area containing waste will be directed into holding pond(s) and allowed to evaporate. The water collected from non-waste areas will be channeled into the natural drainage. Ditches will need to be constructed in phases in conjunction with the development of the facility. The entire surface water control system will evolve or expand as the facility matures.

The design always has the active face of the facility uphill of a collection ditch. In other words, the facility will first form a wedge filling the entire east-northeast rim of the canyon to the design elevation. This wedge will slope towards the axis of the canyon and towards the canyon mouth. Collection ditches will be constructed immediately above the canyon wall/waste interface and along the bottom of the waste wedge. The water collected from the bottom of the wedge will be held in an evaporative pond (see Figure 7). The water collected along the canyon wall immediately above the waste will be routed around the waste and into the natural drainage below the fill.

As the fill progresses, the wedge will take on a dome-shaped profile. Both collection ditches just described can then be directed to the evaporation pond. At this stage, cover material will probably need to be excavated outside the canyon. A drainage system

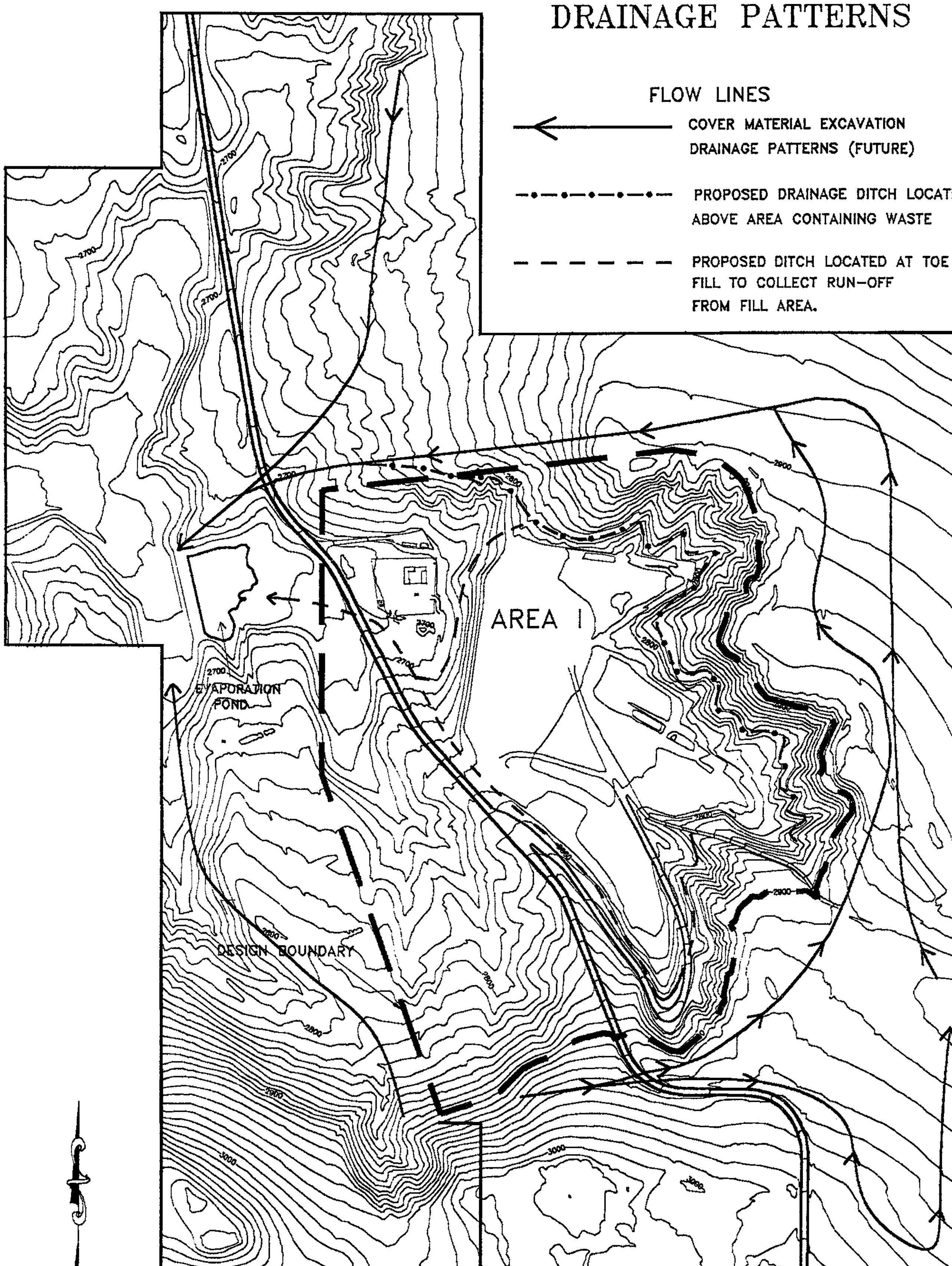
# FIGURE 7
# DRAINAGE PATTERNS

FLOW LINES

COVER MATERIAL EXCAVATION DRAINAGE PATTERNS (FUTURE)

PROPOSED DRAINAGE DITCH LOCATED ABOVE AREA CONTAINING WASTE

PROPOSED DITCH LOCATED AT TOE OF FILL TO COLLECT RUN-OFF FROM FILL AREA.



designed to collect water in these excavations will be constructed so water is not allowed to pond and infiltrate into the ground in an area topographically above contained waste. Since the geologic strata dip northeastward away from the canyon, any water that does infiltrate will migrate away from the canyon; hence construction of this drainage system is more precautionary than essential to protecting the facility integrity.

Figure 7 also shows future drainage pattern flow lines for the areas excavated for cover material. The flow lines (solid lines) located outside the design boundary, shown as Area I, drain the proposed cover material excavation areas. The ditch represented as a dash and dot line located in Area I protects the upper edge of the fill area from water flowing onto the fill. The ditch shown as a heavy dashed line in Area I drains the lower edge of the fill area. All water collected is held in an evaporation pond topographically below the landfill and is designed to retain in excess of 100% of the precipitation resulting from a 24-hour, 25-year storm event.

Using Idaho Transportation Department Bridge Design Criteria a 24-hour, 25-year storm event is predicted to result in 1.56 inches of precipitation. The maximum precipitation recorded at the Parma Experimental Station for a 24-hour period between 1922 - 1989 is 1.57 inches. If all the precipitation received during a 24-hour, 25-year storm event were to run off, this volume would constitute approximately 3.5 acre-feet of water drained from the existing 27 acres occupied by the landfill. If the facility is constructed to the design area of 98 acres a maximum potential of approximately 12.8-acre feet of water would be collected.

Environmental Protection Agency regulations (40 CFR Parts 122, 123, and 124; National Pollutant Discharge Elimination System Permit Application Regulations For Storm Water Discharges) apply to Pickles Butte as they apply to all "landfills, ... that receive or have received industrial wastes and that are subject to regulation under subtitle D of RCRA". These regulations are for those facilities which discharge storm water that flows from a waste containing facility to any offsite collection system. If storm water run-off from waste containing areas is collected and treated onsite, these regulations do not apply. The collection and evaporation system described above allows the facility to comply with these regulations since they were emplaced before October 1, 1992. The evaporation pond located below the design footprint is large enough to retain more than twice (approximately 8.2 acre feet capacity) the total amount of precipitation predicted

(25 year storm event) to fall on the twenty seven acres currently occupied by the facility. The evaporation pond was constructed by placing a 12-foot (allows two-foot free board) high, earthen berm across a local natural constriction of the drainage. Additional ponds will be constructed, as required, when the footprint increases.

## I. METHANE MONITORING

Title 39 Chapter 74, Idaho Code as provided in 40 CFR Part 258.23 requires implementation of a program to monitor and control explosive gases. The principal explosive gas of concern is methane generated by the life processes of anaerobic bacteria in the solid waste layers. Recommended designs include vent systems to release the methane from the landfill, and in some cases provisions for flaring of the methane.

With regard to methane generation, the predicted dryness of this landfill is again a modifying consideration. It is highly unlikely that any measurable quantity of methane will be generated in this waste, because the dryness of the waste will prevent bacteria growth except in small parts of the landfill and the immediate water holding capacity of the fine-grained material used for daily and intermediate cover (see section **III. H. HELP MODEL INFILTRATION SIMULATION**). The average moisture of the landfill will be below agronomic field capacity, and probably near the agronomic wilting point. Those materials that are wet when placed will be dried toward the average moisture level by wicking from the wetter to the drier materials. The relatively low moisture levels will greatly inhibit, and will in most parts of the landfill completely prevent, growth of methane-forming bacteria. Methane-forming bacteria are relatively primitive organisms with no tolerance for the cell-wall-disrupting effects of dryness, and are found only in environments that are saturated with water and are totally anaerobic. Although the action of facultative bacteria and molds can conceivably create anaerobic conditions in a unsaturated heap, the next stage required in order to get methane formation is replacement of facultative bacteria by methanogens, which requires saturation with water. Hence, based upon the aforementioned HELP model projections and history of precipitation, it is expected that detectable quantities of methane will not be generated at this landfill. As discussed below, validation of this expectation has been provided by DEQ and BLM contractor evaluations.

Because detectable methane formation is not expected, methane would not migrate from the landfill in quantities sufficient to create any hazard of explosion or asphyxiation, nor accumulate to pressures sufficient great enough to cause damage to any part of the landfill, if the landfill were built without a methane release system. Hence, the appropriate plan is to perform the surface methane monitoring required by 40 CFR Part 258.23, but not to build any methane venting system initially. As a check on the possibility that unanticipated methane production might cause surface bulging damage after closure of the landfill by lifting a portion of the soil cover, the maximum pressure that could be generated on the underside of the final cover by methane production at 0.04 cu.ft./lb.-yr., which would be twice the minimum value of the rate range recommended for use in collector system design in the Washington State Department of Ecology Solid Waste Landfill Design Manual (see graph on Page 4-64, op.cit.), was computed as representing a very conservative value for design. The value derived was 0.37 psi, which would be less than one-seventh of the weight of the soil cover. Hence, this type of damage is not risked in this case by building without a methane release or collection system. In addition, even on the unlikely assumption stated (production of methane at a rate of 0.04 cu.ft./lb.-yr.), buildings on the site are not significantly at risk from methane that might escape the landfill laterally, due to the wide separation between the landfill and the nearest enclosed building. In the unlikely event that methane in any quantity sufficient to cause concern is found through monitoring, a methane release system consisting of vertical boreholes with slotted or perforated casings can be installed as a retrofit in completed portions, and by modified operating procedure in uncompleted portions of the fill.

An inspection of the facility was made on March 8, 1990, as part of the compliance audit, conducted by Advanced Sciences, Inc., under contract with the BLM. An evaluation was made of the entire footprint of the landfill for hydrocarbon emissions. The results of the evaluation were "readings from the organic vapor detector (HNu meter) did not exceed 0.0 parts per million..." (ASI, 1990).

Idaho Department of Environmental Quality personnel conducted an inspection of the facility on November 14, 1990. The November 20, 1990, Idaho Division of Environmental Quality report Pickles Butte Sanitary Landfill Record Review and Inspection states "... a Summit Industries Organic Vapor Analyzer (OVA) was used to test for the presence of hazardous wastes in the landfill. No detectable amounts of toxins or explosive vapors were noted in the air above the landfill" (Rasmussen, 1990).

Surface methane monitoring will be conducted quarterly to ensure compliance with 40 CFR 258.23. A hand-held methane monitor will be used. Locations tested will include each room in every enclosed building of the maintenance complex and residence, and points spaced not more than 400 feet around the perimeter of the current footprint of the landfill, including the closed portions of the landfill as well as the open area. All readings shall be recorded, with location of each reading, and the record shall be dated, signed by the worker performing the tests and placed in the permanent record of the facility.

In the event that any reading greater the applicable limit as established by 40 CFR 258.23 (a) (25% of the lower explosive limit) is found in an enclosed building, the enclosure shall be purged of its enclosed air with a fan or portable blower (placed outside the enclosure, with a duct or tube to convey air into the enclosure), then closed and retested at 24, 48 and 72 hours after closure. In the event that retesting shows presence of methane, further tests shall be conducted at a frequency to be determined from circumstances of the location in order to supply data for determination of the required remedial measures. If a concentration greater than 50% of the lower explosive limit is detected during perimeter monitoring, further tests shall be made as circumstances warrant to define possible remediation measures.

# VI. FINAL COVER DESIGN

The scrutiny which landfills have undergone during the last two decades and the cleanups initiated under the auspices of the CERCLA Superfund amendments to RCRA illustrate that the care given during closure may be as important as the procedures followed during its operation. The scale of a potential environmental problem is directly proportional to the size of the facility. Until now the size of most landfills located in southwestern Idaho has been small, containing less than 500,000 cubic yards of waste material, and most containing much less when closed. The Pickles Butte facility if operated to its maximum capacity may contain up to 25 million cubic yards of waste.

This part of the report advances a cover design which balances precipitation with holding capacities of available soils, augmented by potential evaporation which conforms with the alternative cover criteria of Title 39 Chapter 74, Idaho Code. Vegetation and final slope are utilized to maximize run-off, minimize erosion, and enhance evapotranspiration.

## A. COVER MATERIAL EVALUATION

### Holding Capacity

The holding capacity of a soil is a function of actual grain size and grain-size distribution which also determine the porosity and permeability of a soil. The field capacity (FC) of a soil is the maximum volume percentage of water that a soil can contain without water moving downward as a result of the effect of gravity (FC is used here as an equatable term to specific retention). The wilting point (WP) is the volume percentage of water remaining in the soil below which plants are unable to absorb moisture. The hygroscopic coefficient is the volume percentage of water that is held by adhesive tension on the grain surfaces. The maximum holding capacity (MHC) of soils is equal to FC minus the hygroscopic coefficient. During summer months, in this area, evaporation drives soil moistures below WP towards the hygroscopic coefficient. The effective holding capacity (EHC) of a soil is equal to FC minus WP. For the purposes of this report the EHC will be used to determine the thickness of the final cover soil since it is a more conservative capacity estimate. Final cover design is discussed below in section **VI. D. COVER DESIGN.**

## Source Area

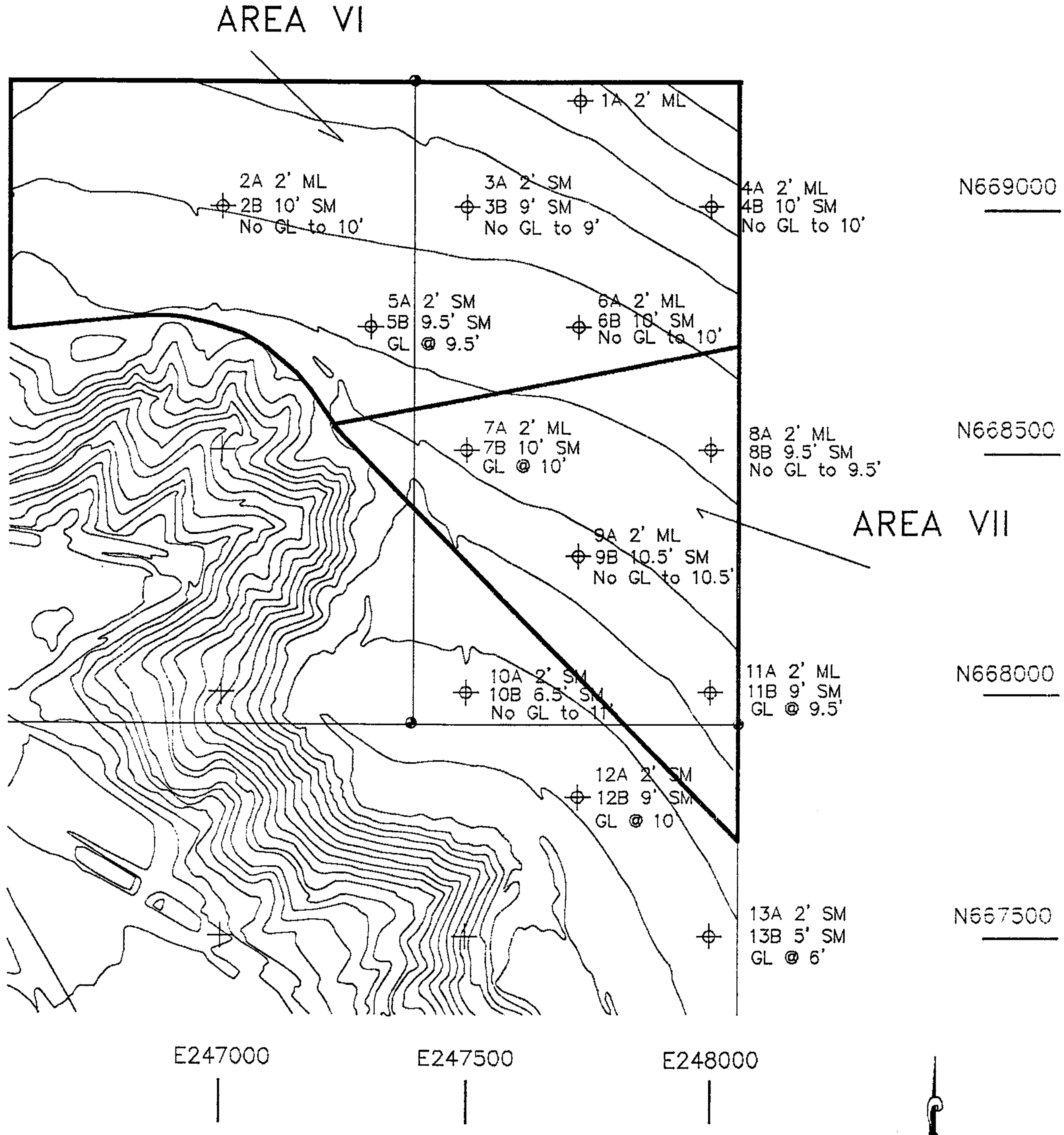
The source area of the final cover material is shown in Figure 8 and the area has been divided into Areas VI and VII which are subparts of the larger general cover material resource Area V. The areas are shown on the Design Cross Sections and Plates 8 and 9. Area VI encompasses approximately 20.4 acres and Area VII totals about 9.8 acres and the calculated volume are 617,000 and 283,500 cubic yards respectively.

The soil analyses in Table 20 are from materials sampled in the final cover material source areas delineated on Figure 8 and shown as Bruneau Formation lacustrine silts on Plate 2 Geologic Map. Soil samples were analyzed in conformance with American Society for Testing and Materials (ASTM) laboratory procedures. Some initial samples were dry sieved using ASTM Methods D 421 and D 422 but due to the fine grained nature of the soils and the drying process the results were biased towards the coarser grained fraction due to caking. Each soil sample was wet sieved using ASTM Method D 1140 which more accurately quantifies the grain size distribution of the collected soil samples. Liquid Limit, Plastic Limit and Plasticity Indexes were determined by ASTM Method D 4318 for six samples in which greater than 50% of the material passed the #200 sieve. The samples were classified using ASTM Method D 2487.

Three of the samples (2A, 3A, and 6A) in Table 20 had a large percentage of the material retained on the #4 sieve which was composed of calcium carbonate cemented concretions of fine grained material. These sample percentages were recalculated ignoring the amount retained on the #4 and the values are given in parentheses. These three samples were classified using the recalculated percentages.

All the samples are classified as either sandy silt or silty sand. In the field the sandy silts are always stratigraphically above the silty sand which lie directly on the Tuana Gravel. The samples are plotted on a Clay - Silt - Sand Ternary Classification Diagram (see Figure 9) used by the U.S. Soil Conservation Service. Using this classification system the samples plot as sand, loamy sand, sandy loam and silt loam. Hydrometer analysis was

# FIGURE 8
# FINAL COVER MATERIAL SOURCE AREA



not conducted on the samples to determine clay content. Since the clay content of the samples was not quantified, the resultant placement position of analyses on Figure 9 along the sand-silt axis of the ternary diagram assumes that clay content is zero. Field examination of the soils indicates that the clay content ranges from 10 to 25%. Increased clay content significantly increases the FC of the soils and by assuming no clay content the field capacities are conservatively estimated.

Delineation of the boundary of Area VII on Figure 8 was derived from the test results for the sample locations 7A, 8A, 9A, and 11A. On Figure 9 the diagonal percentage lines are moisture equivalent contours which approximate FC (Birkland, 1976, Figure 1-5, page 13). The FC on Figure 9 for the four samples varies from 16 to 19 volume percent and WP ranges from 7 to 9 volume percent (Buckman and Brady, 1969; Figure 7.4, page 168). Therefore the effective holding capacity of the soil of Area VII (EHC = FC - WP) equals 9 to 10 volume percent. Each one foot depth of soil will retain 1.1 to 1.2 inches of water.

The same series of calculations as outlined above conducted on the samples (1A, 2A, 3A, 4A, 5A, and 6A) within AREA VI yield the following results. FC varies from 13 to 16 volume percent, WP ranges from 6 to 7 and the EHC equals 7 to 9 volume percent. Each one foot depth of Area VI soil will retain 0.8 to 1.1 inches of water.

TABLE 20: COVER MATERIAL ANALYSIS

| SAMPLE | PERCENT PASSING SIEVE NUMBER | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COORD | # | FT | 4 | 8 | 16 | 30 | 60 | 140 | 200 | ASTM CLASS. | LL\PL |
| N 669250<br>E 247750 | 1A | 2 | 98 | 91 | 85 | 81 | 75 | 64 | 55 | ML SANDY SILT | 22\20 |
| N 669000<br>E 247000 | 2A | 2 | 89 | 82<br>(92) | 77<br>(87) | 73<br>(82) | 66<br>(74) | 55<br>(62) | 49<br>(55) | ML SANDY SILT<br>* | |
| N 669000<br>E 247000 | 2B | 10 | 100 | 99 | 98 | 96 | 81 | 22 | 15 | SM SILTY SAND | |
| N 669000<br>E 247500 | 3A | 2 | 74 | 65<br>(88) | 58<br>(78) | 54<br>(73) | 48<br>(64) | 41<br>(55) | 36<br>(49) | SM SILTY SAND<br>w/<br>CONCERTIONS | |
| N 669000<br>E 247500 | 3B | 9 | 93 | 84 | 79 | 75 | 60 | 27 | 20 | SM SILTY SAND | |
| N 669000<br>E 248000 | 4A | 2 | 92 | 82 | 76 | 73 | 68 | 58 | 53 | ML SANDY SILT | 20\18 |
| N 669000<br>E 248000 | 4B | 10 | 100 | 100 | 99 | 98 | 81 | 38 | 29 | SM SILTY SAND | |
| N 668750<br>E 247250 | 5A | 2 | 100 | 99 | 98 | 97 | 88 | 760 | 47 | SM SILTY SAND | |
| N 668750<br>E 247250 | 5B | 9.5 | 98 | 95 | 92 | 89 | 70 | 24 | 18 | SM SILTY SAND | |
| N 668750<br>E 247750 | 6A | 2 | 92 | 82<br>(89) | 75<br>(82) | 70<br>(76) | 65<br>(71) | 56<br>(61) | 49<br>(53) | ML SANDY SILT<br>* | |
| N 668750<br>E 247750 | 6B | 10 | 99 | 97 | 95 | 92 | 78 | 34 | 23 | SM SILTY SAND | |
| N 668500<br>E 247500 | 7A | 2 | 100 | 100 | 99 | 98 | 92 | 77 | 70 | ML SANDY SILT | 17\NP |
| N 668500<br>E 247500 | 7B | 10 | 88 | 84 | 80 | 75 | 59 | 23 | 16 | SM SILTY SAND | |
| N 668500<br>E 248000 | 8A | 2 | 99 | 94 | 89 | 86 | 80 | 70 | 60 | ML SANDY SILT | 24\NP |
| N 668500<br>E 248000 | 8B | 9.5 | 100 | 98 | 96 | 93 | 81 | 37 | 26 | SM SILTY SAND | |

TABLE 20: COVER MATERIAL ANALYSIS
(Continued)

| SAMPLE | PERCENT PASSING SIEVE NUMBER | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COORD | # | FT | 4 | 8 | 16 | 30 | 60 | 140 | 200 | ASTM CLASS. | LL\PL |
| N 668250 E 247750 | 9A | 2 | 100 | 100 | 100 | 98 | 92 | 77 | 68 | ML SANDY SILT | 20\15 |
| N 668250 E 247750 | 9B | 10.5 | 85 | 77 | 72 | 67 | 52 | 22 | 15 | SM SILTY SAND w/ GRAVEL | |
| N 668000 E 247500 | 10 A | 2 | 97 | 88 | 81 | 74 | 59 | 39 | 33 | SM SILTY SAND | |
| N 668000 E 247500 | 10B | 6.5 | 100 | 99 | 98 | 96 | 77 | 32 | 22 | SM SILTY SAND | |
| N 668000 E 248000 | 11 A | 2 | 95 | 88 | 82 | 77 | 72 | 65 | 60 | ML SANDY SILT | 25\NP |
| N 668000 E 248000 | 11B | 9 | 93 | 89 | 86 | 81 | 69 | 43 | 36 | SM SILTY SAND | |
| N 667750 E 247750 | 12 A | 2 | 100 | 98 | 95 | 90 | 72 | 35 | 27 | SM SILTY SAND | |
| N 667750 E 247750 | 12B | 9 | 100 | 100 | 100 | 97 | 73 | 19 | 12 | SM SILTY SAND | |
| N 667500 E 248000 | 13 A | 2 | 99 | 96 | 93 | 86 | 55 | 20 | 15 | SM SILTY SAND | |
| N 667500 E 248000 | 13B | 5 | 98 | 96 | 92 | 87 | 63 | 27 | 20 | SM SILTY SAND | |

Sample Coordinates are given in the Facility Grid System. Sample locations are shown on Figure No. 8.

FT = feet below the surface the sample was taken.

ASTM CLASS = American Society of Test Methods soil classification Method D - 2487.

* Material retained on the #4 sieve consists of concretions instead of gravel. Percentages in () show recalculated percent passing each sieve ignoring material retained on the #4 sieve. Therefore, the soil is classified as ML - sandy silt.

LL\PL is the Liquid Limit \ Plastic Limit and was only determine for the six samples with the highest percentage passing the #200 sieve.

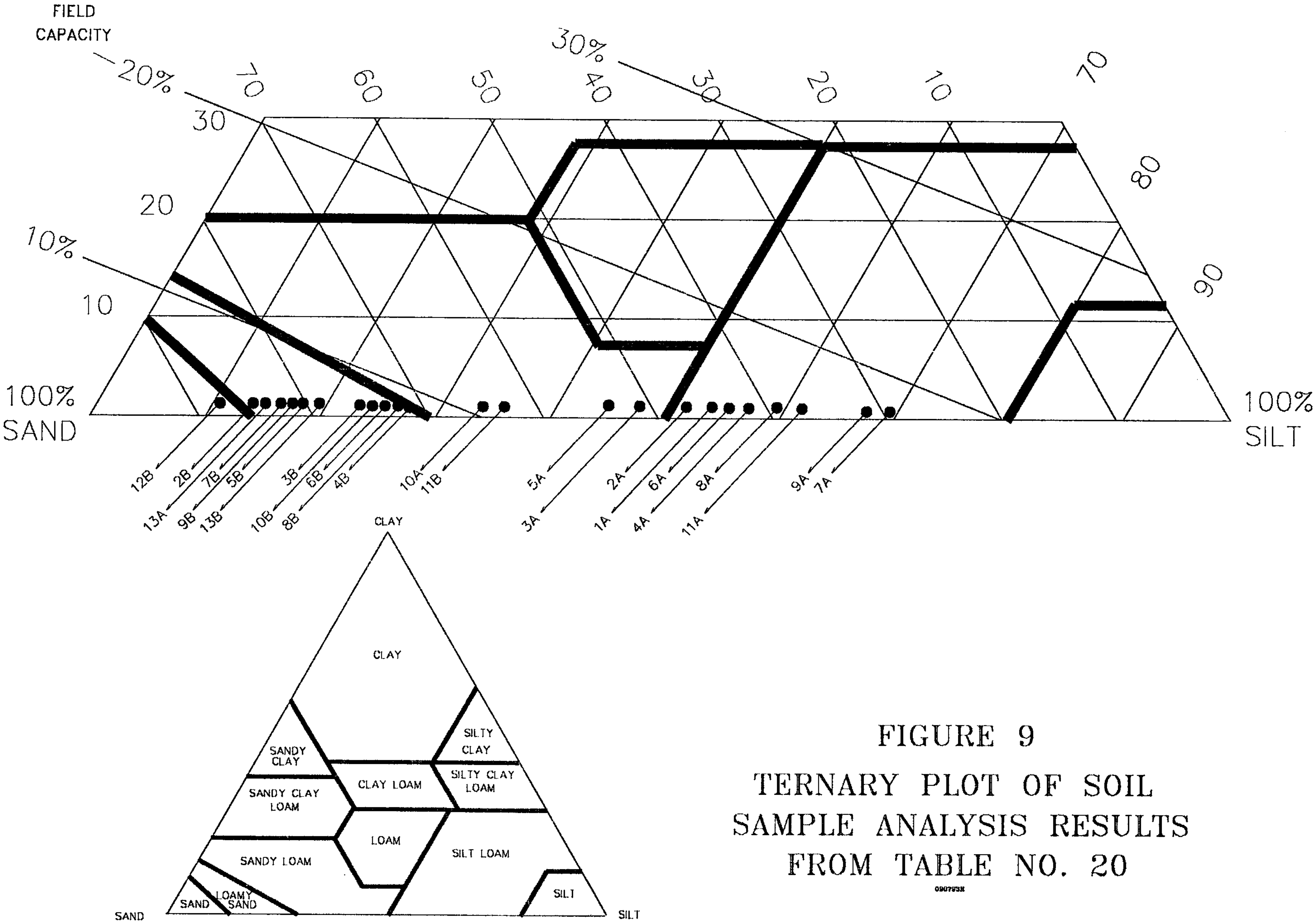



FIGURE 9
TERNARY PLOT OF SOIL SAMPLE ANALYSIS RESULTS FROM TABLE NO. 20

## B. EVAPORATION AND EVAPOTRANSPIRATION:

The best available local evaporation data is collected at the University of Idaho Experimental Station located at Parma, Idaho. Although similar to Pickles Butte, climatic conditions at Parma may vary enough during critical portions of the year to skew conclusions drawn from the data. In order to verify or refine the conclusions reached with the Parma data, a weather station will be established at Pickles Butte to collect local climatic data. The weather station will collect year round precipitation, pan evaporation, wind run, relative humidity, and temperature data. It is expected that maximum precipitation is 20 to 40% less and minimum pan evaporation is greater at the facility than those values reported at the Parma Experimental Station.

Pan evaporation data collected at Parma Experimental Station is presented in Table 21. Evaporation data is collected during the irrigation season beginning in April and continuing into October. Table 21 shows the monthly evaporation data for the ten year period 1981 to 1990. The maximum monthly precipitation recorded during the period extending from 1922 to 1989 is less than the minimum monthly evaporation for each month recorded. In the worst case situation, the minimum expected evaporation exceeds the maximum recorded precipitation for each month and evaporation can be expected to greatly exceed precipitation during normal conditions. Therefore, based on evaporation data alone, the maximum amount of water that a soil can be expected to retain will not exceed the maximum precipitation for any one month.

The transpiration rate will depend on the type of vegetation propagated on the cover. The type of vegetation should be drought resistant, shallow rooted grasses which can be expected to be dormant or inactive much of the year. The expected effective transpiration of a vegetative cover will be dependent on the specific grass(es) and their growing seasons. The active growing period for most grasses is spring which also has excess pan evaporation (see Table 21).

Evapotranspiration is the total amount of water that will be removed from the soil by evaporation and transpiration. The pan evaporation rate is probably in excess of the amount of water that will evaporate from a bare, unvegetated soil. Vegetation will play a two-fold role in maximizing the amount of evapotranspiration by direct transpiration and also by creating and maintaining capillary pathways which maximize evaporation. With vegetation established on a soil, the evapotranspiration potential may exceed

TABLE 21: TEN YEAR PAN EVAPORATION DATA FOR PARMA, IDAHO

| Year | April | May | June | July | Aug. | Sept. | Oct. | Total |
|---|---|---|---|---|---|---|---|---|
| 1990 | 6.60 | 8.99 | 8.70 | 10.23 | 8.99 | 7.80* | 4.65* | 55.96 |
| 1989 | 6.90* | 8.99 | 10.50 | 11.16 | 8.99 | 6.30 | 4.65* | 57.49 |
| 1988 | 6.20* | 9.92 | 10.80 | 12.40 | 10.23 | 6.30 | 5.58* | 61.43 |
| 1987 | 7.80* | 8.68 | 8.10 | 10.23 | 10.23 | 7.50 | 5.58* | 58.12 |
| 1986 | -- | 8.68* | 10.80 | 10.54 | 9.92 | 5.70* | 5.27* | 50.91 |
| 1985 | 6.00* | 8.37 | 10.20 | 9.61 | 8.99 | 5.10* | 4.03* | 52.30 |
| 1984 | 7.50* | 7.44 | 8.87 | 10.03 | 10.08 | 6.54 | 6.82* | 57.28 |
| 1983 | -- | 10.54 | 8.58 | 9.08 | 8.32 | 5.73 | 3.72* | 45.97 |
| 1982 | 5.70* | 8.60 | 7.29 | 8.62 | 9.20 | 6.38 | 5.58* | 51.37 |
| 1981 | 5.70* | 7.51 | 7.78 | 10.18 | 9.63 | 6.67 | 3.41* | 50.88 |
| MeME | 6.55 | 8.72 | 9.16 | 10.21 | 9.46 | 6.40 | 4.93 | 55.43 |
| MME | 5.70 | 7.44 | 7.29 | 8.62 | 8.32 | 5.10 | 3.41 | 45.88 |
| MMP | 3.36 | 3.94 | 2.96 | 1.49 | 3.58 | 3.39 | 3.06 | 21.78 |
| MeP | .86 | .94 | .87 | .20 | .39 | .56 | .77 | 4.59 |
| MEE | 2.34 | 3.50 | 4.33 | 7.13 | 4.74 | 1.71 | .35 | 24.10 |
| MeEE | 5.69 | 7.78 | 8.29 | 10.01 | 9.07 | 5.84 | 4.16 | 50.84 |

* Data missing for part of month or daily evaporation not recorded for entire month. Number entered represents the average daily evaporation (from the available data) times the numbers of day in the month.

MeME = Mean Monthly Evaporation during the ten year period.
MME = Minimum Monthly Evaporation during the ten year period.
MMP = Maximum Monthly Precipitation from Parma Experimental Station Climatological Summary 1922 - 1989.
MeP = Mean Monthly Precipitation from Parma Experimental Station Climatological Summary 1922 - 1989.
MEE = Minimum Excess Evaporation equals the difference between MME and MMP
MeEE = Mean Excess Evaporation equals the difference between MeME and MeP.

recorded pan evaporation rates during those times of the year that the vegetation is actively growing.

## C. VEGETATION

A detailed evaluation of the vegetation found in the area of the landfill has not been conducted as a part of this report. The United States Soil Conservation Service (SCS) issued a soil survey report of Canyon County in July 1972. The vegetation species which the SCS reported commonly grow in the soils types mapped in the area of the landfill are: Big sagebrush, Cheatgrass, Wild Mustard, Winterfat, Shadowscale, Indian Ricegrass, Russian-thistle, Sandberg Bluegrass, Needle and Tread, Thickspite Wheatgrass, Rabbitbrush, Horsebrush, Fourwing Saltbrush, Bluebunch Wheatgrass, Squirreltail, Shadscale, Budsage, and other annual weeds and grasses.

Generally the floor, southeastern and southwestern walls of the canyon support well established grasses, sagebrush and small shrubs. The badlands located along the northeastern canyon wall support only sparsely distributed shrubs and grasses.

The final cover will be vegetated with drought resistant, shallow rooted grasses that will create a continuous vegetative mat on the ground surface. This vegetative mat will serve the important functions of allowing maximum transpiration of water from the soil cover and stabilizing the slopes by reducing surface water erosion resulting from overland flow.

There are a number of commercially available grasses and grass mixtures which may be appropriate for use on the final cover. Possible grasses are included in Table 22. The vegetative cover will most likely be comprised of a mixture of grasses which span as long a growing season as possible that starts in early spring. Most of the grasses currently being developed are designed to be palatable to livestock and wildlife and to enhance wildlife habitats. When the landfill is closed the site needs a vegetative cover but it may be counter productive to be an overly attractive wildlife habitat. Those grasses which are least palatable and most drought tolerant may be the best grasses to vegetate the final cover.

## TABLE 22: VEGETATIVE COVER GRASSES

| Scientific Name<br>Common Name | Water | Food | Remarks |
|---|---|---|---|
| Agropyron dasystachyum<br>Thickspike wheatgrass | 8 | Diverse Palat. | Site stabilization and reclamation |
| Agropyron elongatum<br>Tall wheatgrass | 8 | Forage | Upland Bird habitat and reclamation |
| Agropyron inerme<br>Beardless bluebunch | 8 | Highly Palat. | Long lived and good drought tolerance |
| Agropyron riparium<br>Streambank wheatgrass | 8 | Rel. Un-Palat. | Aggressive grass and good erosion control |
| Agropyron sibericum<br>Siberian wheatgrass | 6-10 | High Forage | Drought tolerant and good light tex. soil |
| Bouteloua curtipendula<br>Sideoats grama | 8 | Highly Palat. | Drought tolerant & Wide soil varieties |
| Elymus cinereus<br>Great Basin wildrye | 8 | Excell Palat. | Drought tolerant & winter-wet/sum-dry |
| Ertagrostis superba<br>Wilman lovegrass | 8 | High Palat. | Extremely drought tolerant & robust |
| Hillaria jamesii<br>Galleta | 8 | Palat. | Drought tol. & soil binder/reclamation |
| Oryzopsis hymenoides<br>Indian ricegrass | 9 | Highly Palat. | Good in sandy soils |
| Poa sandbergii<br>Sandberg bluegrass | 8 | Good Palat. | Drought, salt & alkali tolerant |
| Rhynchelytrum repens<br>Ruby grass | 6 | ? | Adapted to sandy soils |
| Sitanion hystrix<br>Bottlebrush squirreltail | 6 | Moderat Palat. | Reclamation of dry hills, plains, etc. |
| Tricachne californica<br>Arizona cottontop | 7 | Highly Palat. | Drought tolerant |

Water is minimum required precipitation given in inches. Food is the food potential and generally given in palatability of the grass. Source for the information contained in this table was taken from the Granite Seed Co. 1991 Wholesale Seed Catalog.

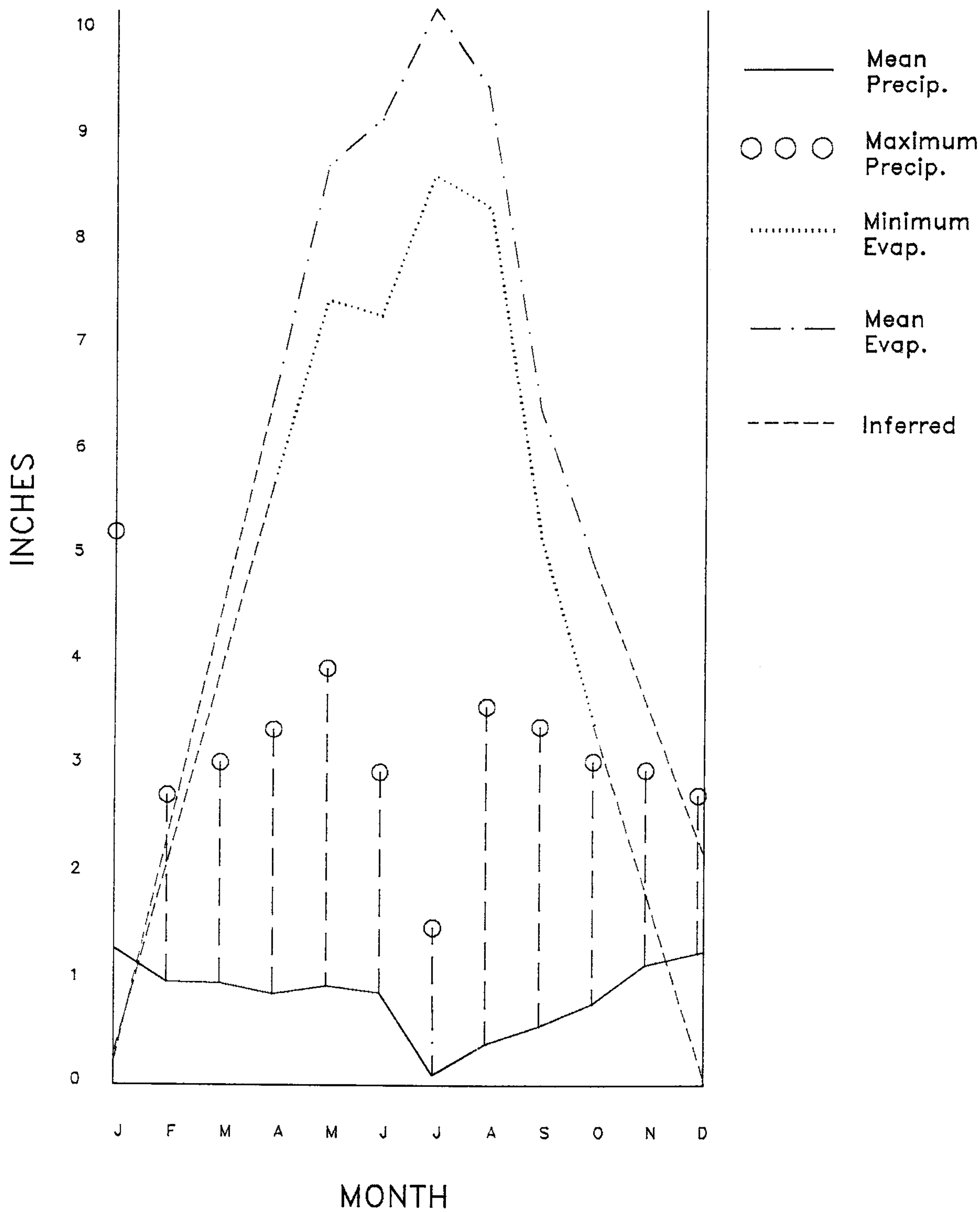
## D. COVER DESIGN

Figure 10 shows the relationship between mean monthly (MeP) and maximum recorded monthly (MMP) precipitation with mean monthly (MeME) and minimum monthly (MME) evaporation. During the months April through October when evaporation data is available, evaporation always exceeds both mean and maximum recorded monthly precipitation. Projection of the evaporation curves through the remainder of the year indicates that precipitation may exceed evaporation only during December and January. This is an extremely conservative approach since the projection of the curves indicates that evaporation approaches zero during December and January. The on-site weather station will verify the site specific conditions and provide year round climatic data. The mean cumulative amount of excess water equals 1.75 inches and the maximum monthly precipitation excess occurs in January and equals 4.6 inches. Therefore the cover material must have an effective holding capacity (EHC) of 1.75 inches of water to be capable of retaining all excess precipitation in an average year. In order for the cover material to retain the amount of precipitation of the wettest month ever recorded the material would require an EHC of 5.2 inches.

Monthly precipitation values do not equal the amount of water that infiltrates into the soil in an area during any given month. Many event specific factors influence the amount of water that is actually absorbed into the soil. These factors include: duration and intensity of storm event, ground conditions such as frost depth and surface saturation, topographic relief, vegetation, transpiration, evaporation, ablation, inter-event weather, permeability, porosity and infiltration capacity of surface soils, and surface water run-on. Except for surface water running onto a specific area, all of the above listed factors will decrease the amount of water that infiltrates into a specific area. The effect of surface water run-on can be minimized by the diversion of off-site surface water around the area of interest which requires protection (see **V. H. SURFACE WATER MANAGEMENT** section of this report).

Due to the factors which decrease water infiltration and the surface water run-on control measures, the maximum amount of water that a soil cover should retain will not exceed a percentage of the maximum recorded monthly precipitation. The final cover design presented below has a cover thickness which has a cumulative EHC equal to the maximum recorded monthly precipitation and, therefore, should exceed all historic climatic events that could cause water to pass through the cover.

# FIGURE 10
## EVAPORATION AND PRECIPITATION

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The EHC for Area VII soil material is 1.1 to 1.2 inches of water per foot of soil and the maximum recorded monthly precipitation is 5.2 inches. The final cover needs be to 4.3 to 4.7 feet thick. If Area VI material is used then the cover needs to be 4.7 to 6.5 feet thick. The thicknesses presented for soil cover should perform as expected since the caliche layer at the site in these soils is developed with top and bottom between four and six feet respectively. For comparison, the amount of Area VII and VI material needed to retain the monthly maximum precipitation for the average year of 1.75 inches would require 1.5 to 1.6 and 1.6 to 2.2 feet of cover material respectively.

If the facility operates to completion as per the 1994 design, the facility will occupy approximately 98 acres. Each of the testholes shown on Figure 8 increases in sand content with depth. The volume calculations for Areas VI and VII are 617,107 and 283,515 cubic yards respectively and are shown on Design Cross Sections Plates 8 and 9. Enough Area VII material has been identified to cover between 37 and 41 acres with 4.7 to 4.3 feet of soil respectively. Available Area VI material is sufficient to cover from 59 to 81 acres with 6.5 to 4.7 feet of material respectively. Use of both area soil materials should supply an adequate volume of material to close 96 to 122 acres. Currently the facility occupies approximately 27 acres and the 1994 design designates a total footprint of 98 acres.

The grade of the final cover will not be less than 20:1 (2.86 degrees) or greater than 3:1 (18.43 degrees) regardless of the slope of the surrounding topography. The slopes will be constructed to direct run-off past the edge of areas containing waste and retain it in evaporation ponds. See **V. H. SURFACE WATER MANAGEMENT** section of this report for a discussion of run-on and run-off control measures.

An arid design final cover appropriate for utilization at the facility may be constructed to the following criteria:

1) The cover constructed with a thickness of fine-grained moderate to low permeability soils.

2) The thickness of the cover material to be determined by EHC of the particular soil material based on maximum monthly precipitation values.

3) Establishment of a thick vegetative cover composed of a mixture of shallow and moderately deep rooted unpalatable plants which have the longest possible cumulative growing season. The maximum rooting depth of the vegetation not to exceed the thickness of the soil cover.

4). Final slope graded to maximize surface water run-off to the greatest degree possible without subjecting the cover to erosion. All run-off collected in ditches located outside the area containing waste and directed to holding pond(s) for evaporation.

# VII. CLOSURE

All physical design elements of closure are contained in section **VI. FINAL COVER DESIGN** of this report. As sections of the landfill are filled to the design top-of-waste level, the final soil cover will be placed and seeded in an annual operation. At periodic (three-to-five year interval, as provided by 39.7419 Idaho Code) joint meetings of staff from the County, Southwest District Health Department and Idaho Department of Health and Welfare will be convened at which time areas covered during the interim will be described by the County and certified as closed, as provided by 39.7415 Idaho Code.

At present, the precise form of fund reserve requirement for financial assurance of closure that will be mandatory for public entities owning landfills remains under discussion. Financial projections have been made, based on some assumptions as to the nature of the financial assurance requirement as it may finally be determined, but due to the speculative nature of these assumptions at this time, publication of reserve requirement projections is deferred, with the anticipation that current issues will be resolved. Upon resolution of issues and in conformance with Title 39 Chapter 7417, Idaho Code as provided by 40 CFR Part 258.70 effective date of April 9, 1995 (as amended) the County will submit financial assurance projections to the state.

# VIII. POST-CLOSURE MONITORING

Post-closure monitoring programs check the integrity of the control systems constructed and emplaced during the operation and closure of a facility to assure the systems are performing as designed. The post-closure period may be considered as that period of time required for the contained wastes to reach equilibrium status or that period needed for the wastes to degrade to innocuous material.

The post-closure period proposed in Subtitle D has a duration of at least 30 years and entails three principal concerns: 1) groundwater, 2) methane, and 3) surface water. The specific post-closure monitoring program which will be required at the facility will entail continued monitoring of those systems which have been installed and monitored during the active life of the facility in conformance with Idaho Code, Title 39, Chapter 74.

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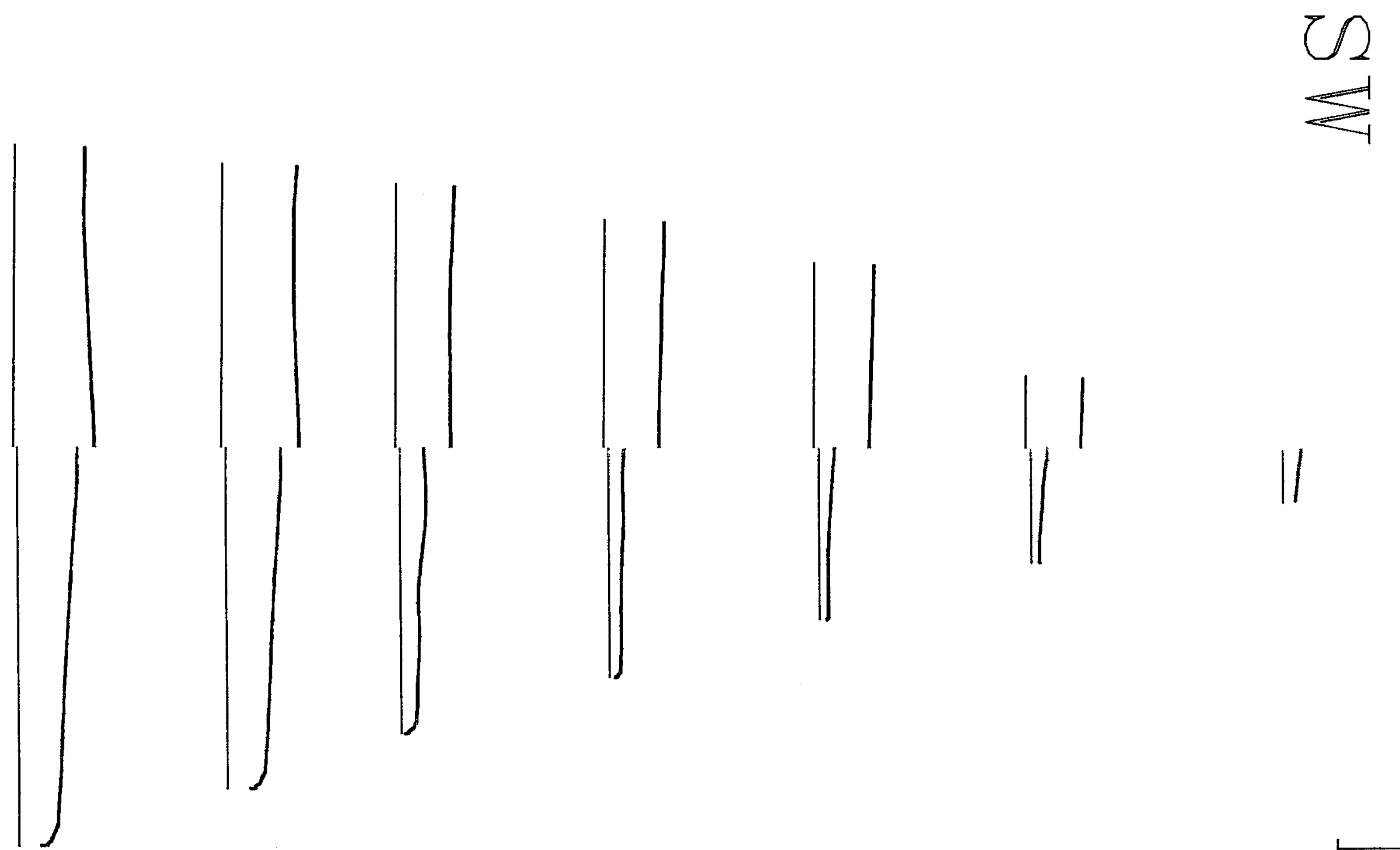


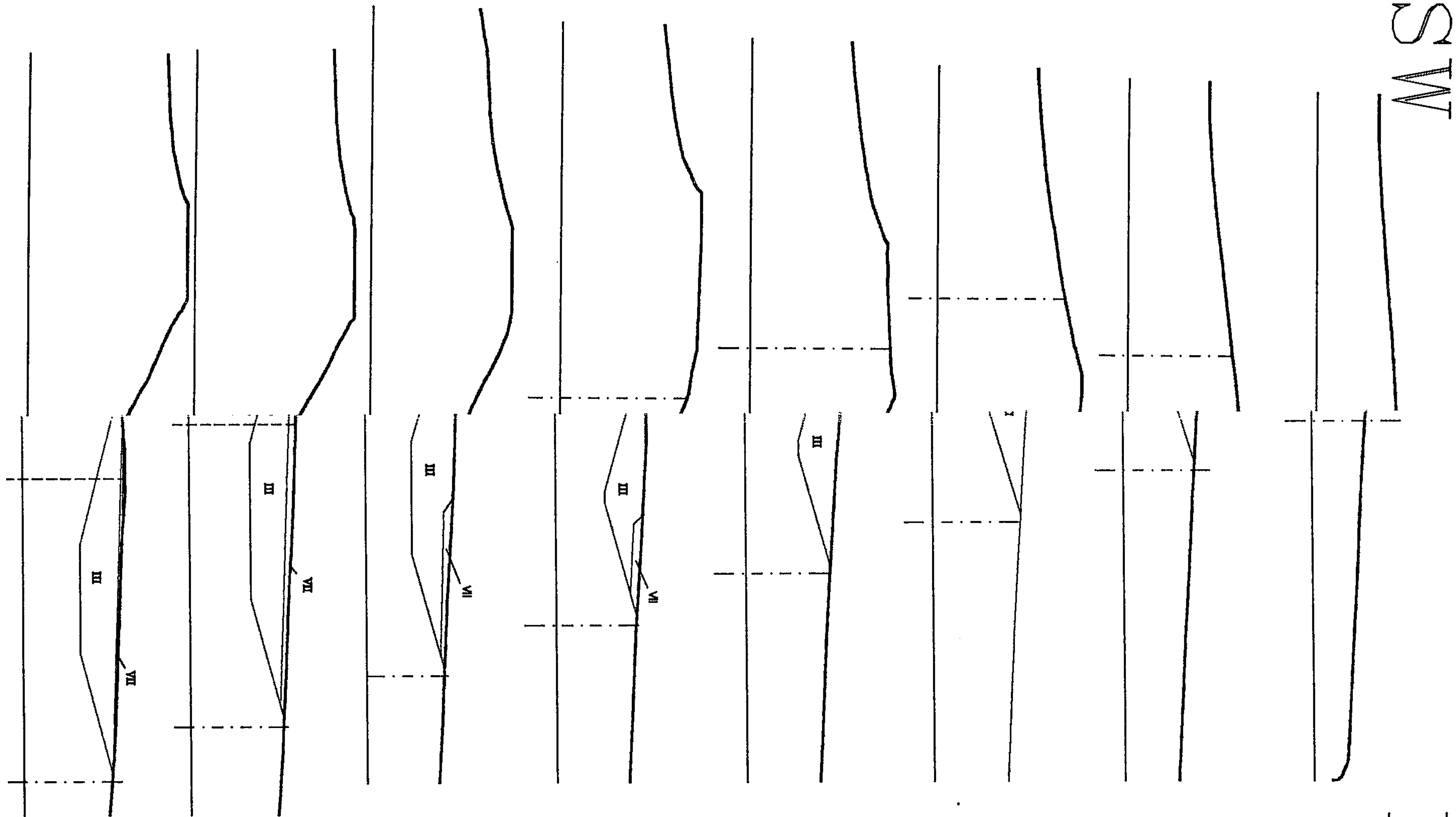

LEGEND

- · — · — · — · PROPERTY BOUNDARY
- — — — — — — BUFFER BOUNDARY
- ———————— DESIGN BOUNDARY
- —— · · —— BUFFER/DESIGN

090590E

SCALE 1"=400'

# PLATE 10
# DESIGN CROSS SECTIONS
# 120+00 TO 132+00



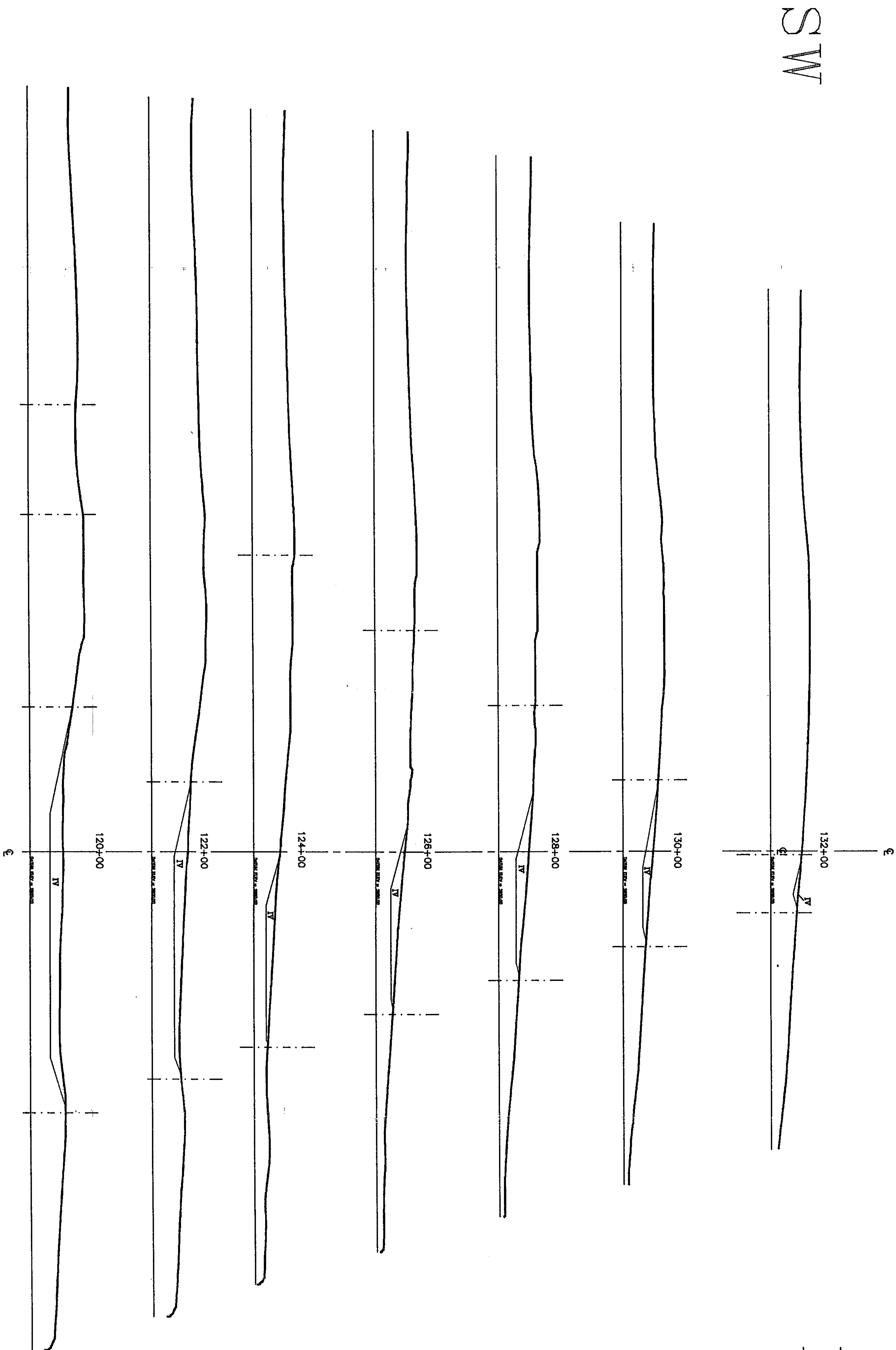

## LEGEND

- PROPERTY BOUNDARY
- BUFFER BOUNDARY
- DESIGN BOUNDARY
- BUFFER/DESIGN
- SOLID WASTE

090590E

SCALE 1"=400'

# PLATE 9
## DESIGN CROSS SECTIONS
## 104+00 TO 118+00



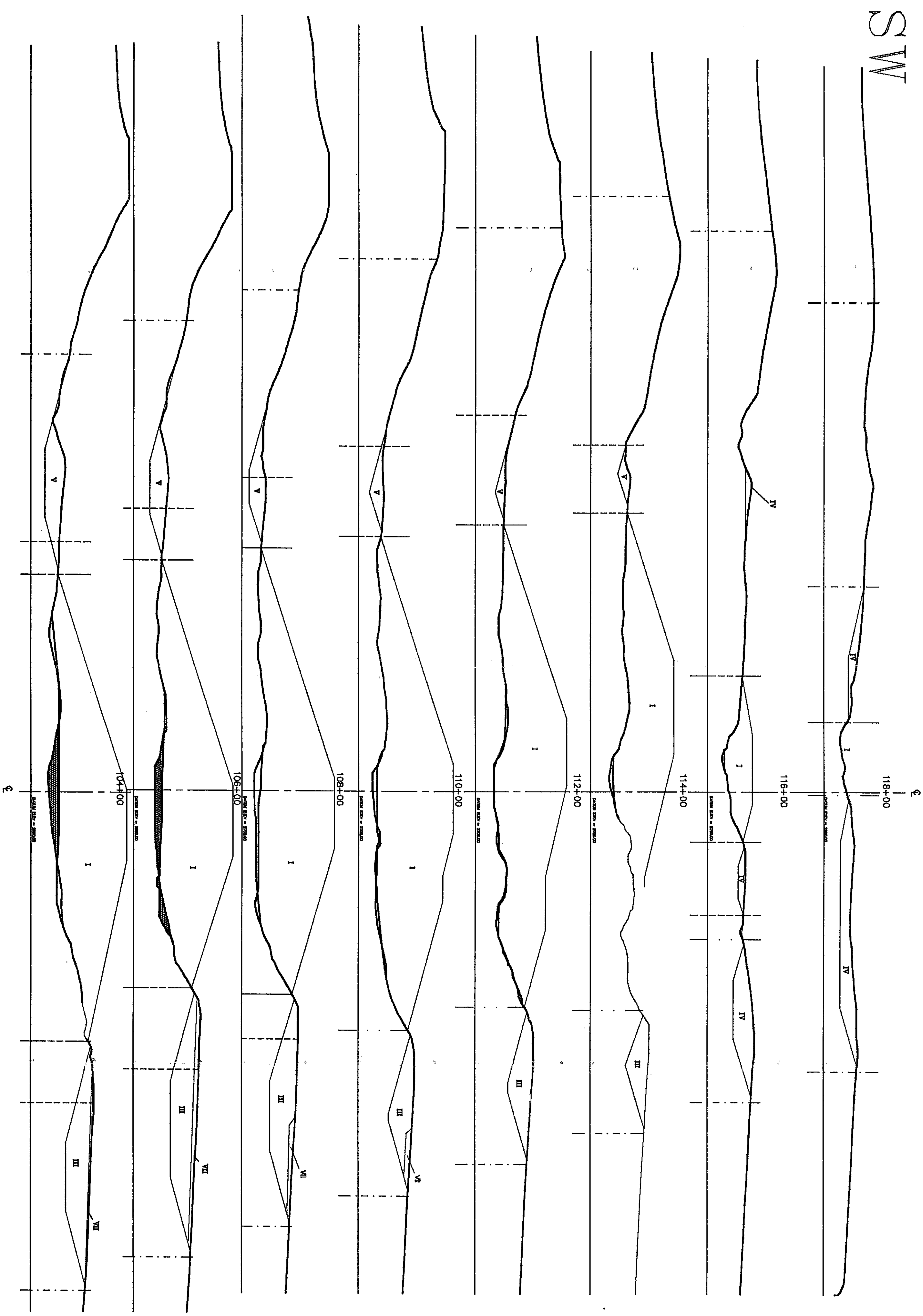

LEGEND

- PROPERTY BOUNDARY
- BUFFER BOUNDARY
- DESIGN BOUNDARY
- BUFFER/DESIGN

090590E

SCALE 1"=400'

PLATE 10
DESIGN CROSS SECTIONS
120+00 TO 132+00



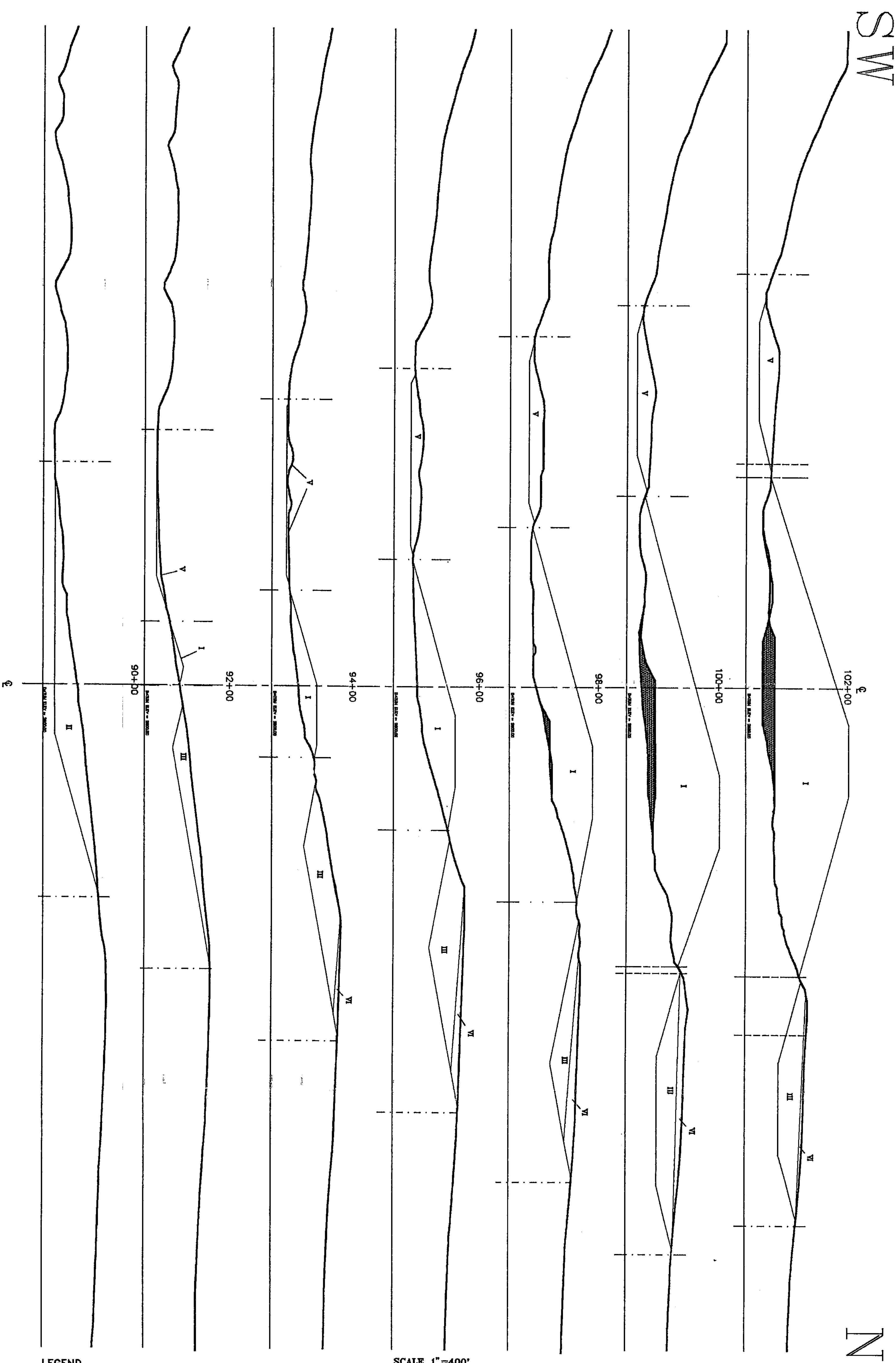

LEGEND

- PROPERTY BOUNDARY
- BUFFER BOUNDARY
- DESIGN BOUNDARY
- BUFFER/DESIGN
- SOLID WASTE

090590E

SCALE 1"=400'

# PLATE 9
# DESIGN CROSS SECTIONS
# 104+00 TO 118+00




LEGEND

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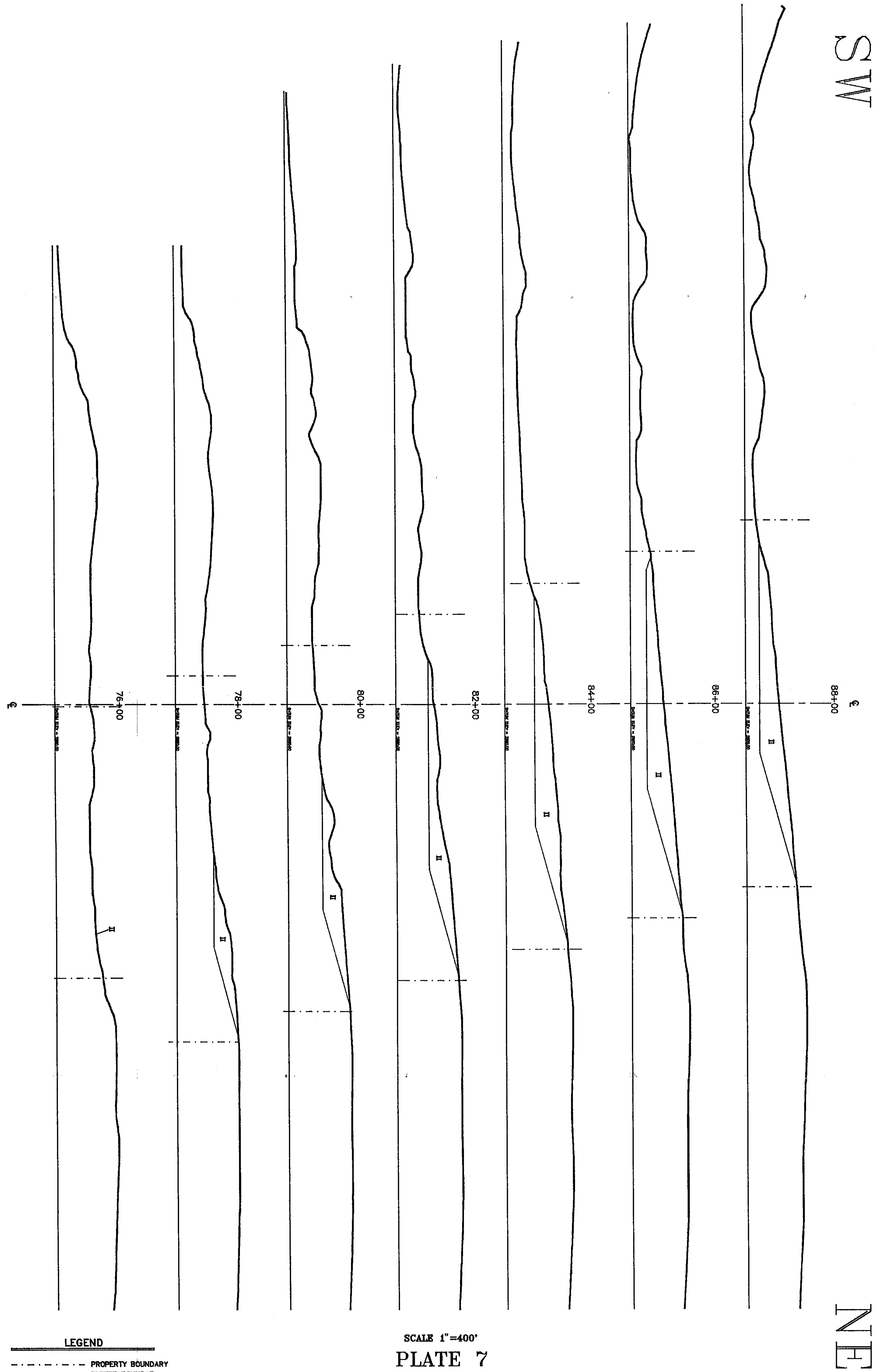
| —— · · —— | BUFFER/DESIGN |
| (shaded) | SOLID WASTE |

090590E

SCALE 1"=400'

# PLATE 8
## DESIGN CROSS SECTIONS
## 90+00 TO 102+00




**LEGEND**

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- ———— DESIGN BOUNDARY
- —— · —— BUFFER/DESIGN

SCALE 1"=400'

# PLATE 7
## DESIGN CROSS SECTIONS
## 76+00 TO 88+00

090590E

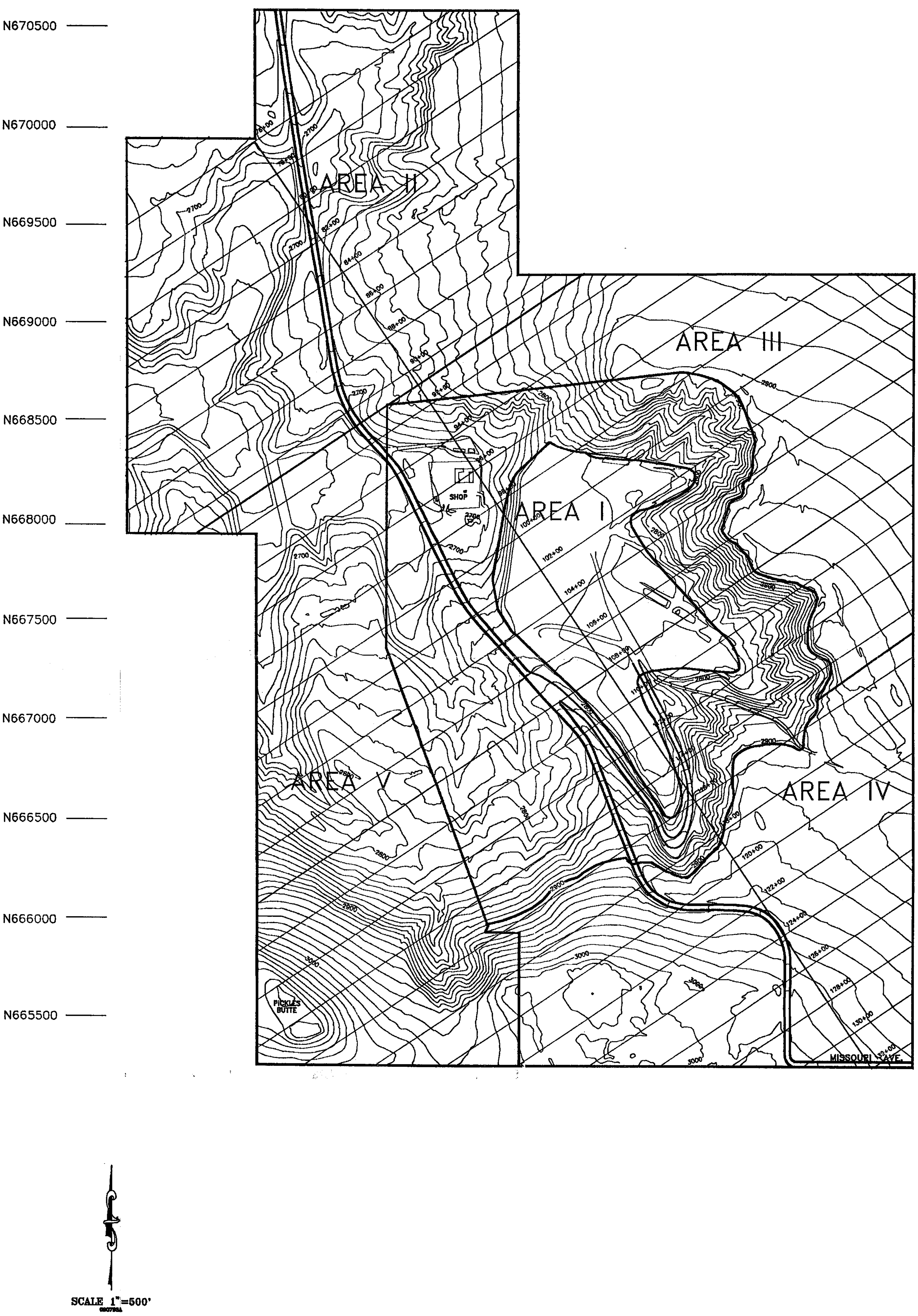



PLATE 6
DESIGN CROSS-SECTIONS
INDEX MAP

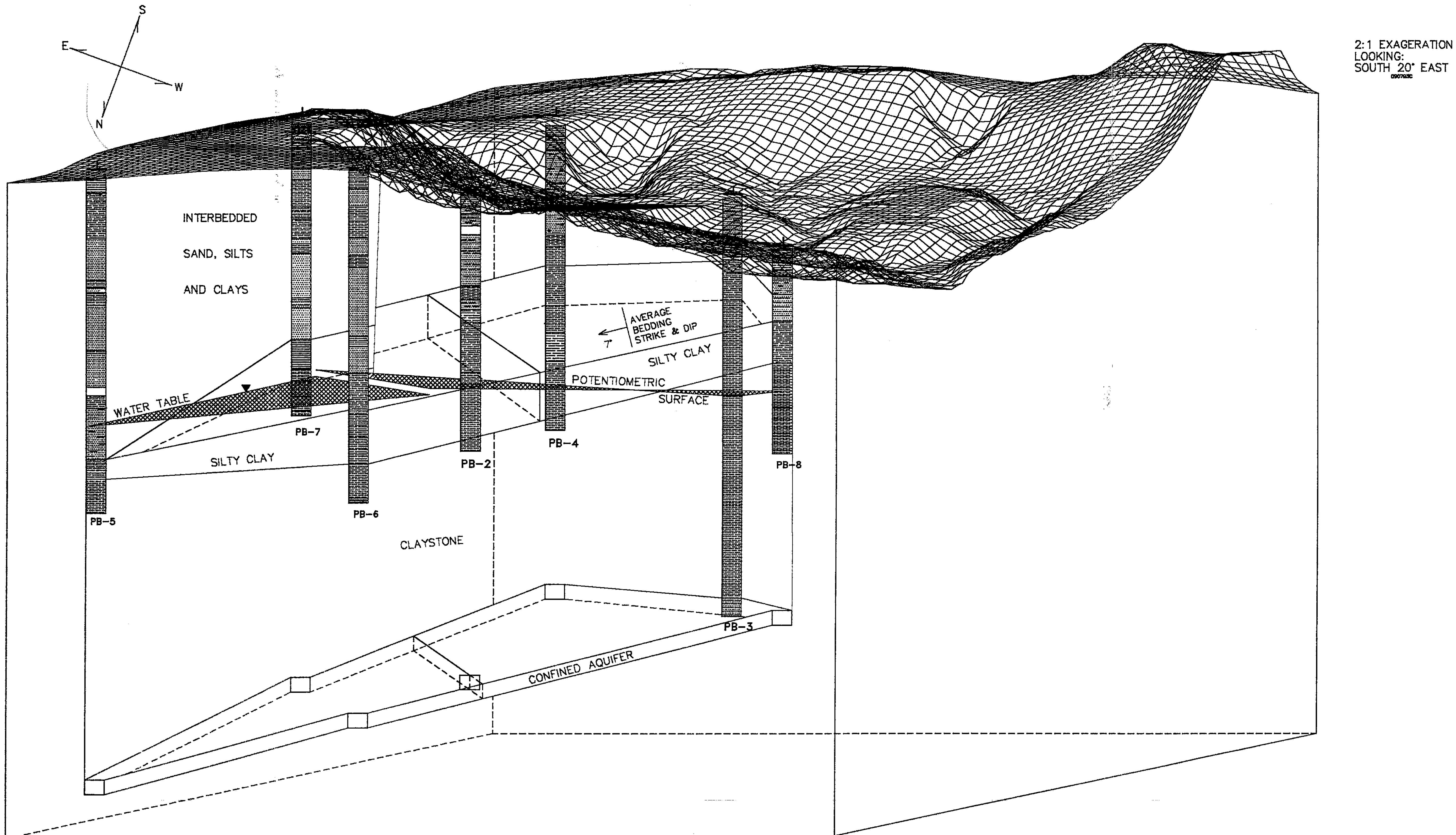
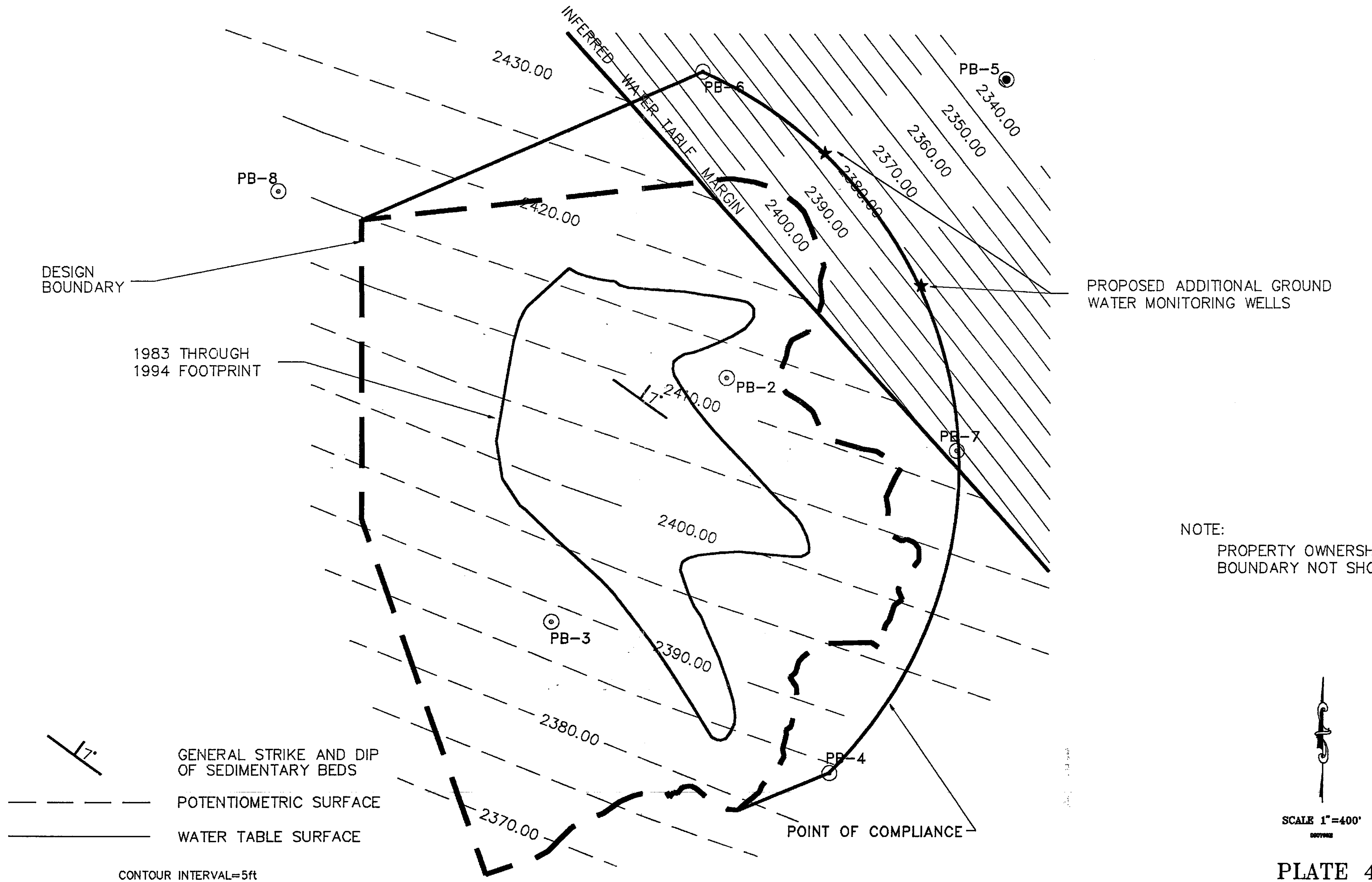
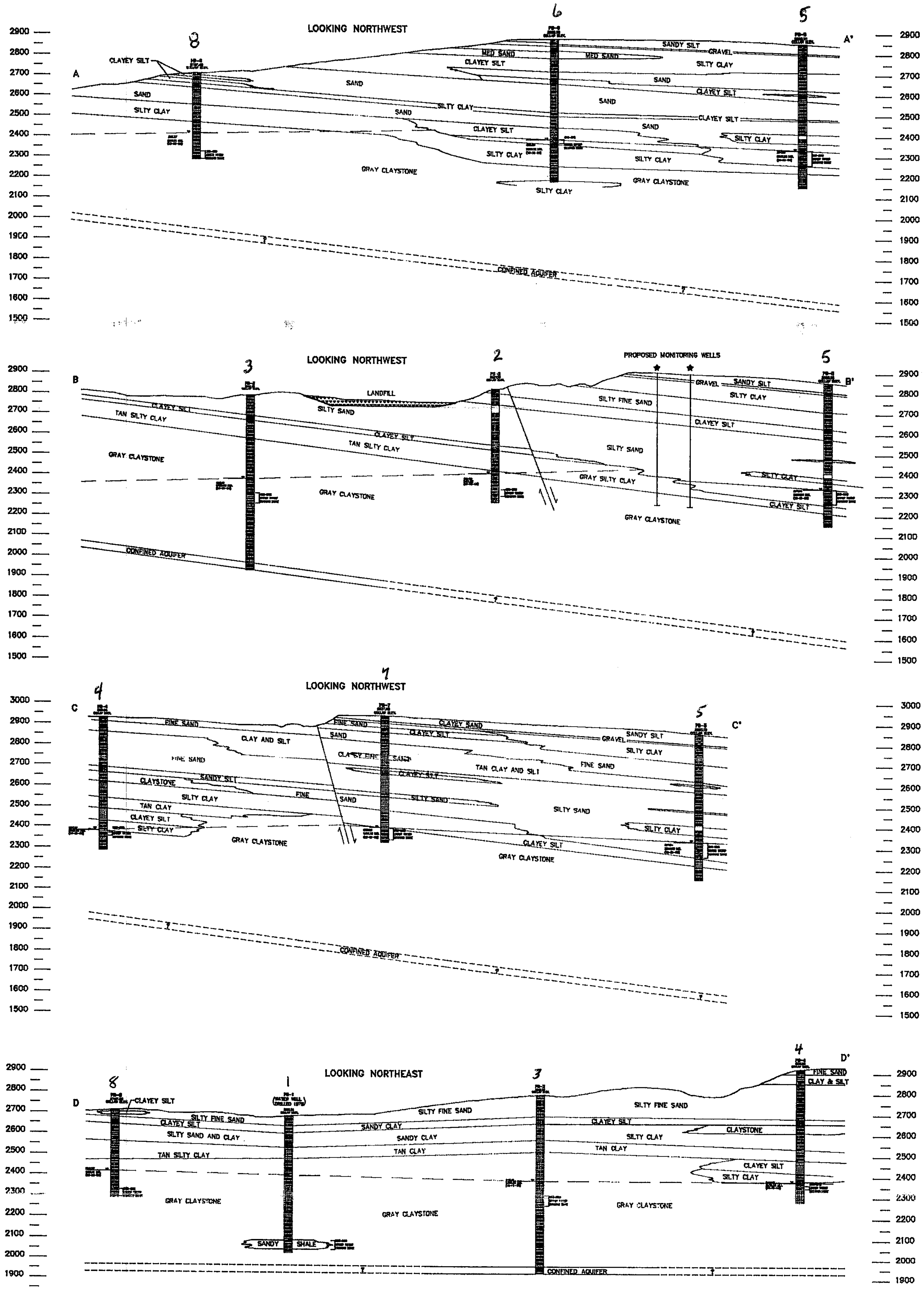



PLATE 5
OBLIQUE GEOLOGIC
CROSS SECTION




NOTE:
PROPERTY OWNERSHIP BOUNDARY NOT SHOWN.

# PLATE 4
# WATER SURFACE CONTOUR MAP




SCALE 1"=500'

PLATE 3
GEOLOGIC
CROSS-SECTIONS
A-A', B-B', C-C', & D-D'

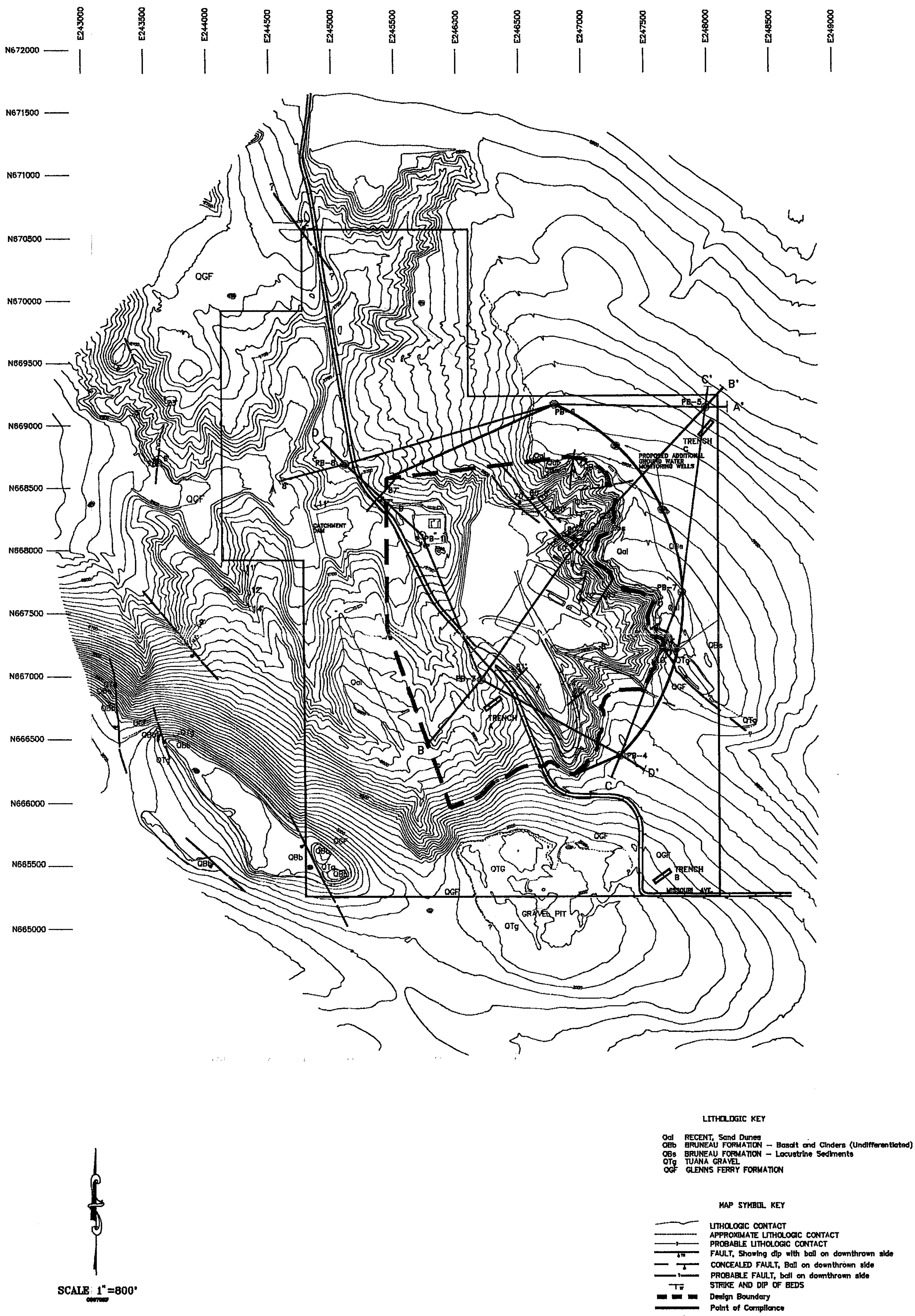



PLATE 2
GEOLOGY MAP

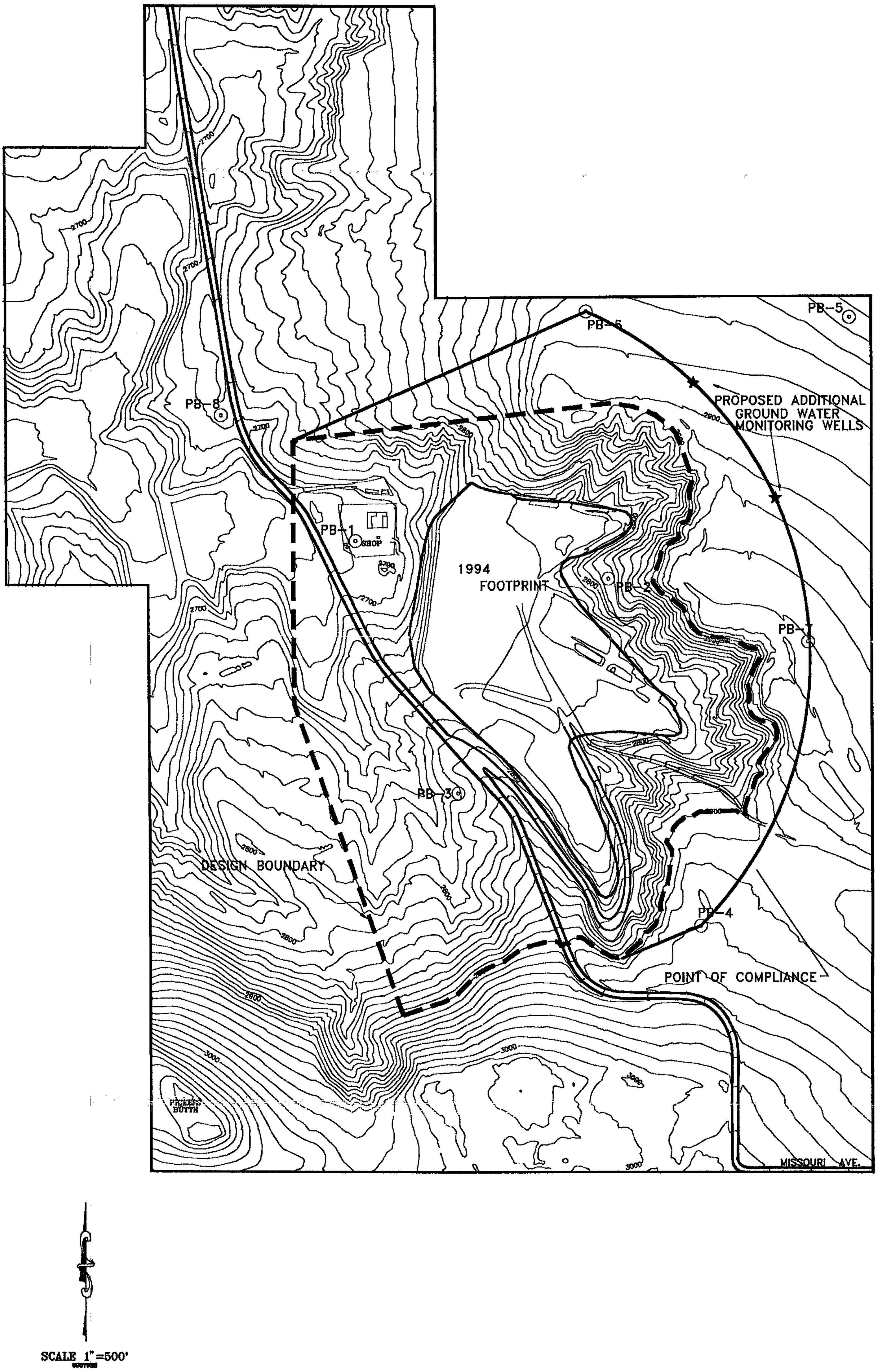



PLATE 1
GENERAL SITE MAP

# CORRESPONDENCE

The correspondence in this section are the DEQ comments to the preliminary investigation and design report and the point by point responses by Holladay Engineer Co. to DEQs comments.

IDAHO DEPARTMENT
OF HEALTH AND WELFARE
DIVISION OF
ENVIRONMENTAL QUALITY

1420 North Hilton, Boise, ID 83706-1260, (208) 334-0550

Cecil D. Andrus, Governor

June 28, 1994

PICKLESB.694

Commissioner George Vance
Chairman of the Board
Canyon County Commissioners
1115 Albany
Caldwell, ID 83605

RE: Pickles Butte Municipal Solid Waste Landfill
Hydrogeologic Characterization, Proposed Monitoring System and Facility Design Report
Review Comments

Dear Mr. Vance:

Thank you for the opportunity to comment on the above referenced report. The Division of Environmental Quality (DEQ) has reviewed this report and has the following comments, suggestions and/or questions which must be addressed before approval may be given. For ease of response, the comments are arranged in order as encountered in the report and referenced to page numbers where applicable. Please respond to each question or concern explicitly in letter format and modify the report as appropriate.

1. Page 6 - Geologic unit contacts cannot be discerned on Plate 2. Please provide a clearer graphic presentation of this geologic map.

2. Page 8, paragraph 2 - The comment regarding hydraulic conductivity changes varying by a factor of 100 to 10,000 appears to be based solely on speculation and should be eliminated unless a specific reference is provided.

3. Page 11 - Clarify the term "linears" - suggest using clearer terms such as "linear structures" or "linear features."

4. Page 15, table 1 - The table would be much more useful if a column could be added to show well depth.

5. Page 16, paragraph 3 - The term "negative static water level" is not common. It would be useful to give a clear, brief explanation the first time that term is used.

6. Page 17, paragraph 4 - Please further explain the term "positive artesian pressures...from five to 256 feet...."

7. Page 18, paragraph 4 - This paragraph seems to imply that the site-specific aquifer units UA, MA, and BA described at Pickles Butte are regionally continuous and can be found and described throughout the Nampa-Caldwell area. Please modify this discussion to clarify the fact that units described at Pickles Butte may not exist elsewhere (i.e., the UA at Pickles Butte is very likely not similar to a "UA" in downtown Caldwell).

8. Page 20, paragraph 2 - Ground water gradients are based on the elevation of the static water level, not on the elevation where water is first encountered in the subsurface. This may be a significant issue and should be addressed in detail.

   Include legible copies of referenced driller's logs in an appendix.

9. Page 23, paragraph 3 - Provide a reference for the statement regarding published isotopic and hydrogeochemical studies on the character of MA and BA ground water.

10. Page 24, paragraph 1 - Change "contaminates" to "contaminants."

11. Page 24, paragraph 2 - Generally, confusion is created by the use of terms such as "characterization holes", "drillholes", "air rotary holes", etc. Clarify which wells correspond to the "first three drillholes."

12. Page 24, paragraph 2 - Given the importance of this data in the site characterization, the complete Daniel B. Stephens results, including any descriptive narrative from the lab, should be provided. The information should clearly describe the test methods employed and any qualifications of the results.

13. Page 25, paragraph 2 - A table or a clear narrative describing the types of drilling fluid (other than air), the approximate quantity, the specific source (if water), and the depth intervals involved needs to be provided.

14. Page 25, paragraph 4 - Explain how visual estimates of initial moisture are possible when viewing air-ejected cuttings influenced by the introduction of drilling fluid.

15. Page 25 - It does not appear that the complete 40 CFR Part 258 Appendix I list of constituents was analyzed in the induced drilling water. Please explain this apparent lack of completeness. The following constituents appear to be missing from these analyses:

    Acetone
    Acrylonitrile
    Carbon disulfide
    trans-1,4-Dichloro-2-butene
    2-Hexanone
    2-Butanone
    Methyl iodide
    4-Methyl-2-pentanone
    Vinyl acetate

    Furthermore, Appendix F (Appendixes of Primary Data) is not organized and labeled in a way that allows specific lab reports to be correlated with specific sources of drilling water.

    Finally, the laboratory report for the Johnson domestic well indicates that the method detection limit is 10 $\mu$g/l. This is not appropriate since many of the constituents have maximum contaminant levels (i.e., regulatory limits) lower than 10 $\mu$g/l. Analyses performed during detection and/or assessment monitoring must be capable of achieving appropriate detection limits.

16. Page 28, paragraph 3 - The selected dedicated pumping system must be compatible with VOC sampling.

17. Page 30 - Modify the statement regarding characterization for Appendix I constituents to clarify the fact that not all of the Appendix I constituents were included in the analyses.

18. Page 31, paragraph 1 - The scales and legend on the geophysical logs (Appendix D) are not legible. Please provide legible copies.

19. Page 40, paragraphs 2 and 3 - Change "presents" to "presence."

20. Page 49, paragraph 1 - What is the reason for presenting values for Darcy velocity (specific discharge)? A more useful value in the given context would be one for average linear velocity, a term that incorporates porosity estimates.

21. Page 51, table 5 - There are numerous discrepancies in this table which should be explained. For example, consider PB-3 at the depth interval 249-250. The reported initial moisture is 35.46% - the same as the calculated porosity. Given this fact, how can the reported $K_{sat}$ (1.8 X $10^{-9}$) and $K_{unsat}$ (3.0 X $10^{-14}$) differ by five orders of magnitude?

How can the moisture content at field capacity (expressed as a volume percentage) be greater than the porosity?

If the initial moisture content is equal to the porosity, and no drilling disturbances (as for PB-2) are noted why is the absolute hydraulic conductivity (presumably at this initial moisture content) lower than the saturated conductivity value?

22. Page 52, table 6 - There is a mix of upper and lower-case characters used in the equations which usually represents a significant difference in mathematically variables. This should be corrected appropriately.

A more precise reference for the source of the equations must be given (e.g., give page numbers for the reference material). A complete reference for Freeze and Cherry (1979) is omitted from the References section.

23. Page 53, paragraph 1 - The word "Results" is capitalized in the middle of a sentence. Is there a portion of a sentence missing or is this a typographical error?

24. Pages 54 through 60, tables 7 through 13 - The values for saturated travel time are not truly travel times without the consideration of porosity in the calculation of the velocity value. An appropriate change to the table or the values must be made.

Why are the terms field capacity and specific retention used interchangeably? As with field capacity, how can the specific retention be greater than the porosity? By overstating the specific retention the specific capacity is also overstated. Consequently the amount of water the vadose zone will retain prior to the initiation of gravity flow and the time frame during which this will occur are also exaggerated. These calculations should be revised in order to properly address the "no potential for migration" criteria in the regulations.

The saturated travel times for individual layers in Tables 7-13 appear to be excessively high, if the same general formulas in Table 6 are applied. What is the source of the large discrepancy between the travel times generated through averaged $K_{sat}$ values versus adding individual layer values?

The unsaturated travel times are calculated using $K_{unsat}$ values that, as noted above, correspond to moisture contents that, particularly in the case of PB-3, are equivalent to the porosity. Saturated conductivities should be used in these cases.

25. Page 63 - At least for the initial simulation, the values used for all the input parameters for all layers should be presented in tabular form. The summary output from the model is not so voluminous that it could not be included as well.

26. Page 63, paragraph 3 - How was the 21% initial moisture for solid waste determined? Provide a rationale for selection of this number.

27. Page 64, table 15 - What is the justification for using the extremely low value of 3% initial moisture content for a 120 foot sequence of silty sand? Were any samples taken for moisture from this unit?

28. Page 67 - What is the nature of the connection, if any between the two aquifer systems described?

29. Pages 67 and 68 - The conclusions presented on these pages may require modification depending upon the responses to our concerns.

30. Page 72 - Static water levels, ground water flow direction, and rate of ground water flow need to be determined prior to well purging at the time of each sampling event. A statement describing this must be added to the monitoring plan.

31. Page 72, paragraph 2 - Schedule: Comprehensive review should be conducted at intervals of not less than three years, nor more than five years in accordance with 39-7419 of the Idaho Solid Waste Facilities Act.

We recommend that there should be monitoring of other parameters, in addition to the Appendix I constituents, that would act as indicators of landfill activities and better characterize the waters being sampled.

32. Page 72, paragraph 3 - Assessment monitoring must include sample collection from each down gradient well, not just those where an increase in contaminants have been detected (40 CFR Part 258.55(b)). Modify this paragraph appropriately.

33. Page 73, paragraph 1 - Purging must take place sometime prior to sampling. A purged well does not have to fully recover in order to obtain a valid sample. Herzog et.al.(Ground Water Monitoring Review, Fall 1988) indicated that there were no significant differences in VOC chemical compositions at any time interval after purging during the sampling of 11 slowly recovering wells in fine-grained till. VOC concentrations were significantly lower before purging than after purging.The purging schedule as presented is unacceptable.

    Sample filtering is not acceptable (40 CFR 258.52(b)).

    VOC's cannot be collected in poly bottles.

    The ground water monitoring QA/QC protocol must be described in detail. This should include a discussion on the number of quality control samples to be collected during each sampling event.

    A beginning date for initiation of ground water monitoring must be provided. Given the location of the nearest drinking water intake (3000 feet), the monitoring program must commence by October 9, 1994.

34. Page 73, paragraph 2 - The issue regarding the validity of applying statistical analysis to slowly recharging wells in arid zones needs to be substantiated with citations from the literature rather than oblique references to them.

35. Page 74, paragraph 1 - The ground water monitoring well network, as proposed, does not seem reasonable. It is not clear in this proposal which areas of the active landfill may potentially contribute leachate to each of the supposed aquifer systems. This would allow an evaluation of the adequacy of the spacing of wells, etc. For example, if one used the depiction of the water surface in Plate 4 then only a small portion of the landfill area could contribute and be detected by the eastern network.

Of the three wells proposed to monitor the western confined aquifer one (PB-8) is cross-gradient and could not be influenced by landfill activities, one is within the footprint of the landfill itself (PB-3), and one (PB-4) will only be marginally down gradient of the active portion of the landfill. The presence of confined conditions may reduce but does not eliminate the potential for contamination of ground water from the landfill.

The U.S. Geological Survey (USGS) (Stevens, P.R., 1962 Water Supply Paper 1585) generally describes ground water conditions differently than presented in this report. The USGS report (page 20) describes an unconfined ground water flow direction to the south or southwest and a confined flow direction to the north in the vicinity of Pickles Butte. Due to this discrepancy and the direction of ground water flow depicted on Plate 4, DEQ recommends that well PB-3 be replaced with two additional monitoring wells placed south and southwest of the landfill once waste is deposited over PB-3. The monitoring plan should be revised to show the proposed location of these two additional wells and a revised point of compliance to the south of the landfill.

36. Page 76, paragraph 1 - The principle objective should also include minimizing environmental impacts following closure. Please modify. What is the basis for the statements made about the priority of environmental concerns as presented in 40 CFR 258.

37. Page 81, paragraph 2 - What is relevance of statement on whether cracks or burrows will be vertical in nature. The point should be that burrows or cracks may allow some water into the landfill cells if the cover is not maintained properly.

38. Page 82, item No. 2 - Please reference Table 21 for evaporation data.

39. Page 86, paragraph 1 - The Township and Range numbers are reversed. Please correct.

40. Page 86 and 87, items No. 4 and 9 - Has a slope stability analysis been performed on the overall landfill. If so, do these maximum slopes fall within acceptable limits? Does the toe of the landfill need to be keyed in to prevent sliding? The last sentence in item no. 9 alludes that these studies should be done over time. We recommend that this analysis be conducted prior to any additional construction at the landfill.

41. Page 92, paragraph 2 - This discussion should reference information contained at the back of the report (Appendix A?).

42. Page 94, paragraph 4 - Doesn't the rim of the canyon border the east as shown in figure 7 instead of the northwest?

43. Page 108 - What will be the reporting schedule/frequency for the site-specific climatological data?

44. Page 114, paragraph 2 - The measurement unit (feet) for the statement "6.5 to 4.7 of material" was omitted.

45. Page 116, paragraph 1 - The sentence describing the closure/review meeting is structurally incomplete. Please check and modify appropriately.

In conclusion, with the exception of the above noted items the hydrologic characterization appears adequate. The analysis of potential leachate generation via the HELP model requires better documentation of assumptions. The presentation and parameter values used in the simplistic saturated/unsaturated travel time and specific capacity analysis should be verified and documented and the results presented more clearly. The monitoring proposed is inadequate, however, and several issues regarding the location of wells, the number of wells, sampling methodology, and analytical parameters need to be resolved.

Sincerely,

Joy L. Palmer
Regional Administrator

JLP:JMG:ra

cc: Katie Sewell, DEQ - CO
Bruce Wicherski, DEQ - CO
Jack Gantz, DEQ - SWIRO
Rob Howarth, DEQ - SWIRO
Mike Smith, DEQ - SWIRO
Southwest District Health Department
Holladay Engineering Company
Source File #21
Reading File

**HOLLADAY ENGINEERING CO.**

ENGINEERS • CONSULTANTS

1431 Bus. Alt.-Hwy. 95 P.O. Box 235 Payette, ID 83661
(208) 642-3304 • Fax # (208) 642-2159

July 18, 1994

Canyon County Commission
1115 Albany Street
Caldwell, Idaho 83605

Dear Commission:

In response to the County's preliminary report submittal on May 26, 1994 the Division of Environmental Quality (DEQ) conducted an evaluation, dated June 28, 1994, of the HYDROGEOLOGIC CHARACTERIZATION, PROPOSED GROUND WATER MONITORING PLAN, AND FACILITY DESIGN report for Pickles Butte Sanitary Landfill. Their comments generally were directed towards a review of the reports' discussion of the geologic protection of ground water at the site. Some of their comments were editorial in nature. The following responses are organized in the same sequential order as DEQ's comment numbers and paragraphs within a individual comment. All correspondence regarding the preliminary report are included at the end of the final report.

1. A set of five color 24" by 36" plates which included a general site map, geologic map, geologic cross-sections, 3-D projection of the landfill design, and a 3-D projection of the site's hydrogeologic system were hand delivered to DEQ representatives on February 4, 1994 and should currently be on file in the DEQ SWIRO office. If these large plates are unavailable another set could be prepared if requested.

2. These estimates were made by a professional geologist as result of detailed mapping of the site stratigraphy. These estimates are appropriate and valid.

3. The term "linear features" has been employed for clarity.

4. Well depth is irrelevant to the regional analysis presented involving the top of the blue clay and the first water bearing interval.

5. Term explained in original text immediately following use of the term.

6. See Table 1 first water bearing interval denoted as "W".

7. This section discusses regional hydrogeology. The paragraph in question addresses temperature variations as recorded by Wood and Anderson in their

study as is noted by the sections referenced. The local hydrogeologic conditions, as discussed in the report's next section, closely fits the regional hydrogeologic model. Page 12 contains the description of the regional model.

8. The three point problems were calculated to attempt to estimate the regional stratigraphic dip of the waterbearing unit within the blue clay unit. The solutions were erroneously referred to as gradients and the text has been modified. Great significance cannot be assigned to estimates based on information recorded by three different water well drillers on wells as much a 1.75 miles apart.

   Official logs for the 72 wells included in Table 1 are available for review at the Idaho Department of Water Resource.

9. Reference include in final report.

10. Noted and modified.

11. All seven holes PB-2 through PB-8 are characterization holes, PB-2 is the core hole, PB-3 through PB-8 were drilled air rotary. The first three holes were PB-2, PB-3, and PB-4 and PB-3 through PB-8 were completed as potential monitoring wells. PB-1 is the designation used for the domestic water well drilled in 1978, and was not used for characterization due to the nature of drilling data available.

12. Complete copies of all Daniel B. Stephens reports will be provided with submission of final report.

13. Water sources are specified in detail in original report. All geologic information was collected prior to injection of drill agents except PB-2. Subsequent drilling to set casing and complete wells utilized bentonite mud predominately. MSDS sheets are on file to account for all additives used during drilling (as listed in the original report) and will be reviewed if any contaminants from 40 CFR Part 258 Appendix I constituents are encountered during routine monitoring.

14. As the report states, all drilling done to collect geologic information was conducted without the use of drill fluids. See discussion of conduct of investigation and notes on original drill logs included in Appendices of Primary Data (HECO, 1994). In the exceptional cases where fluids were injected, no moisture estimates were made and these exceptions were noted on the borehole logs.

15. The constituents listed as missing are included in the analysis of the Pintlar and landfill wells but are missing from the Johnson well. Testing the drill water for contaminants is not a regulatory requirement but was done in excess of the requirements as part of the investigation's QA/QC procedures.

    Laboratory reports are adequately and clearly labeled.

    Ground water monitoring analyses will be conducted in conformance with EPA test method SW-846.

16. The selected pump or bailer system will be compatible with VOC sampling as much as practicable considering water depth and recharge rate.

17. Comment in error, original statement is correct, see response No. 15 above.

18. Original logs will be provided with submission of final report.

19. Noted and modified.

20. The report has been revised to reflect average linear velocity values of ground water based on porosities of like materials immediately above the saturated zone within their respective boreholes. The higher resulting velocity yields a faster well response time for potential detection.

21. Initial moisture content on Table 5 were incorrectly copied from laboratory reports for intervals PB-2 395-396, PB-2 479-480, and all of the PB-3 intervals. All other data on table was checked for accuracy and no other changes have been made except the term field capacity has been changed to the more appropriate term specific retention.

    Porosity, as determined by the laboratory, is a calculated value whereas initial moisture, dry bulk density (DBD), specific retention, and hydraulic conductivity are measured. Porosity is determined using the formula (DBD - 2.65)/2.65. Porosity is specifically noted on the table to be a calculated value. Absolute hydraulic conductivity is determined by analysis of the relationship of pressure head vs moisture content, relative hydraulic conductivity vs pressure head and relative hydraulic conductivity vs moisture content bivariante graphs.

    Initial moisture content is measured, porosity is calculated.

22. The original equations are correct. Equation notation has been modified for consistency.

Freeze and Cherry reference included in final report.

23. Noted and modified.

24. The original equation contained in Table 6 for $V_x$ (average linear velocity) includes the term $n_e$ (mean average porosity) in the demoninator of the equation therefore original values are correct.

As explained in response to question 21, specific retention is a measured parameter and porosity is a calculated value. Specific retention and consequently specific capacity are not overstated and the calculations appropriately address the "no potential for migration" criteria in the regulations.

There is no discrepancy in the calculation of travel times. The formula does not call for determination of average linear velocity of the individual layer prior to determination of $K_{vavg}$ (average saturated hydraulic conductivity through all the layers of sediments). For fine grained sediments effective pore fraction is essentially 1.0 therefore effective porosity is equivalent to porosity (Fetter, 1988). The formula accounts for mean average porosity in the determination of the average linear velocity. Table notation of formula values have been labeled for clarity.

As explained in response to question 21, porosity reporting errors in Table 5 have been corrected but, more importantly, porosity is a calculated value and $K_{unsat}$ is determined using laboratory measured parameters. The unsaturated travel times calculated using the laboratory derived $K_{unsat}$ values remain correct and have been appropriately used.

25. The summary output for the simulation presented on Tables 15 through 18 is 160 pages long with an additional 20 pages of model parameter inputs. An additional paragraph which contains model parameters has been added to the text. The HELP Model version 2.05 is a public domain model and the simulation may be reproduced using the parameters provided.

26. The original text of paragraph 3 on page 63 and continued on page 64 specifically explained the rational for determination of initial water content.

27. The moisture content for the 120 foot thick silty sand unit designated as layer 11 in the HELP Model simulation is based on the arithmetic mean of 10 in house laboratory determined soil moisture contents from samples of this unit taken from drillholes PB-3 through PB-8.

28. The nature of the partial connection between aquifers was discussed in the original report on pages 18, 23, 45, the entire report section F. SITE HYDROGEOLOGY particularly page 48 paragraph two. As the report describes, the mixing between the lower aquifer and overlying aquifers from structural controlled underflow is inferred from age dates, isotope and water chemistry, and temperature based on the this investigation and the cited regional study. Wood and Anderson's (1981) conclusions are compatible, at least with what was found at Pickles Butte, and support the conclusions of this report.

29. While minor corrections and modifications have been incorporated within the report, the fundamental values forming the basis for the conclusions listed on pages 67 and 68 of the original report have not changed. Therefore, the conclusions have not changed.

30. Noted and included in the report.

31. The review schedule has been modified to reflect the schedule specified in 39-7419.

    Detection monitoring parameters in excess of those listed in Appendix I, 40 CFR, Part 258 are not required. However, according to the rule, constituents may be deleted by the Director and some or all of the inorganic constituents 1-15 (heavy metals) may be substituted in lieu of other inorganic constituents if the Director meets the determinations listed in 258.54 (a)(2)(i-iv). Also, an alternative list may be requested by the owner if supported by a certified report by a qualified professional (39-7410 (5)(b)).

32. Noted and modified.

33. More recent studies (Barcelona, et al., 1994; Powell and Puls, 1993; Seigel, 1994; among others) have shown that rapid purging multiple well volumes is unnecessary and especially in low-yield monitoring wells in fine-grained formations it diminishes sample integrity by inducing turbidity, increases total metals, and tends to mix stagnant water within the water column. Although we agree that sampling wells with some purging is more reliable for detecting VOC's, we are not at all sure that it is possible to acquire sufficient sample volumes shortly following total purging, much less without affecting parameters sensitive to total solids. Unfortunately, the great depth to ground water puts most non-intrusive sampling pumps (bladder, inertial, etc.) out of the realm of possibility. In fact, one well volume of purge in the slow recovering wells will withdraw the water level down below the screen (not a good practice either).

Since, in the opinion of the DEQ, purging is required, we have revised the QA/QC to include purging the calculated volume of the water standing above the screen in each well and then sampling as soon as practicable (more than one hour but less than 24 hours where feasible).

Note and modified to delete field filtering.

Noted and modified concerning sample bottles.

QA/QC protocol will be developed subsequent to selection and installation of dedicated well sample recover systems. This protocol will be placed in the facility operating record as provided by 39-7410(4)(a) IC consistent with 40 CFR 258.53(a).

Ground water monitoring will begin prior to October 9, 1994 for the currently constructed wells and additional wells be added to the monitoring schedule consequent to construction.

34. Noted and modified.

35. A lined facility would most likely leak from a hole in the liner and could produce a narrow contaminant plume consequently requiring closely spaced monitoring wells. In contrast, for an unlined facility, if leachate were to develop, the entire footprint containing waste behaves as a unit and any release would be from the entire unit. The spacing of the monitoring wells along the point of compliance will intercept a potential (theoretical in the case of Pickles Butte) release from the unlined facility. The pathway a potential front will follow from the unit is initially directly downward principally driven by gravity until interception with the top of the clay unit and then movement will be down stratigraphic dip towards the monitoring well network placed to intercept such a front.

The conclusions of the hydrogeologic investigation quantify that the natural geologic sttata provide more than adequate protection of ground water from contamination from the  landfill during the active life and post-closure period of the facility in accordance with 39-74 Idaho Code. From a geologic perspective, contamination will not occur in a confined aquifer which has a potentiometric surface above the water intercept elevation in the confining layer.

The USGS report referenced in the comments (P.R. Stevens, 1962) was a regional ground water study which covered 125 square miles. In the a 24 square mile area of the Pickles Butte Landfill the report bases its ground water contours on water level elevations in 7 wells. In this same 24 square mile area our conclusions are based on analysis of 72 well logs. The closest well to the landfill, for which the report states a water level elevation, is located at a distance of more than one mile. By further contrast, the landfill study utilizes eight wells in the immediate landfill area, seven of which were drilled under very specific conditions to collect geologic information. There is nothing in the U.S.G.S regional report which contradicts the landfill study and, in fact, much of the report supports the conclusions of the hydrogeologic investigation. DEQ's "recommendation" that PB-3 be replaced by two additional wells is not supported by either the USGS regional study or the results of this comprehensive local investigation. All of the conclusions of the hydrogeologic investigation, including the unsaturated travel time calculations are valid, and the monitoring well array as presented is appropriate for monitoring the geologically protected aquifer.

36. "... subsequent to closure." in the first sentence in original text refers to the time period after closure. Environmental concerns of EPA were focused in the discussion of section I.V. Major Issues, D. Ground Water Policy of the preamble, 40 CFR 258.

37. The relevance is that even if rodent holes or cracks develop in the final cover constructed with the native soils any infiltrated water will be absorbed into the soil through the walls of the non-vertical holes or cracks within the upper few inches of the cover.

38. Noted and modified.

39. Noted and modified.

40. Slopes identified in item number 4 are in conformance with design criteria of 39-74 IC. The slope stability in item number 9 refers to slope stability of compacted waste in excess of the 3:1 final design slopes during operation of the facility and during the ongoing construction of the waste cells.

41. Noted and modified.

42. Noted and modified.

43. All climatic data will be placed in the facility operating record as provided by 39-7412 IC.

44. Noted and modified.

45. Noted and modified.

The text of the report will be modified to reflect the changes as discussed in the preceding responses.

The information collected during the drilling phase of the hydrogeologic characterization remains consistent with County's 1973 investigation of site suitability and 1993 site certification. Also, the conclusions of two site audits conducted by DEQ (Rasmussen, 1990) and ASI (1990) performed in the process of procuring the site from the BLM remain compatible with this investigation. The basic conclusions of the hydrogeologic investigation presented in the original report, as focused on pages 67 and 68, remain unchanged. The final ground water monitoring system and landfill design consequently also remain unchanged from that presented in the preliminary report. The hydrogeologic characterization, ground water monitoring, and landfill designs have been developed by licensed qualified professionals as required by 39-74 Idaho Code.

Sincerely,
HOLLADAY ENGINEERING CO.

Jack H. Biddle

Jack H. Biddle P.G.

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# HOLLADAY ENGINEERING CO.

ENGINEERS • CONSULTANTS

1431 Bus. Alt.-Hwy. 95 P.O. Box 235 Payette, ID 83661
(208) 642-3304 • Fax # (208) 642-2159

The enclosed packet includes the following items for inclusion in the final report entitled Hydrogeologic Characterization, Ground Water Monitoring Design, and Facility Design, Pickles Butte Sanitary Landfill, Canyon County, Idaho.

1. ERRATA for modification of final text.
2. DEQ hydrogeologic characterization and arid design approval letter dated October 28, 1994.
3. HECO meeting notes regarding final report dated October 18, 1994.
4. DEQ review of final report letter dated September 15, 1994.
5. Full scale 24" x 36" Geologic Map.
6. Ground water sampling QA/QC Protocol (Draft).

**ERRATA**
for inclusion in:

The final report: **Hydrogeologic Characterization, Ground Water Monitoring Plan, and Facility Design; Pickles Butte Sanitary Landfill; Canyon County, Idaho** by Holladay Engineering Company, July, 1994.

5. Page 16, paragraph 3, line 4 change "stratigraphically above" to "at an elevation above".

6. Page 17, paragraph 4, last sentence change "Of the six wells" to "Of the seven wells" and change "five have positive artesian pressures" to "six have positive artesian pressures".

   Page 17, paragraph 4, following last sentence of the paragraph add "The wells designated on Table 1 in column No. 6 as "W" intercept the reported water bearing horizon within the Blue Clay layer and six static water levels are above the intercept elevation (positive artesian pressure) with values of 5, 5, 40, 155, 203, and 256 feet (range from 5 to 256 feet)."

13. Page 25, paragraph 2, line 3, after sentence ending "...drillrod joints." add "All geologic information was collected prior to injection of water and/or drill agents except PB-2 and those intervals noted on the PB-3, PB-4, and PB-6 drill logs included in Appendix F of APPENDIXES OF PRIMARY DATA (HECO, 1994)."

15. Page 25, paragraph 2, line 12 after sentence ending "... information." add "Only the domestic well (Johnson well) was not tested for the entire Appendix I suite of constituents.

18. Page 43, paragraph 1, following last sentence of the paragraph add "Full scale geophysics logs are on file with DEQ, the originals are kept as part of the operating record at the landfill, and copies are on file at Holladay Engineering Company."

23. Page 53, paragraph 1, line 6 replace "Results" with "results".

24. Page 53, paragraph 2 following the last sentence of the paragraph add "Specific retention, for those intervals for which the Daniel B. Stephens laboratory conducted pressure plate analysis, was interpreted to be the moisture content at one-third bar."

27. Page 64, new paragraph before Table 15 add "Initial moisture content for the 120-foot thick silty sand unit designated as layer 11 in the HELP Model simulation is based on the arithmetic mean of 10 in house laboratory determined soil moisture contents (ASTM method D2216) from samples of this unit taken from drillholes PB-3 through PB-8. The depth intervals and moisture contents are as follows: PB-3 @ 30' 2.73%, 95' 3.78%; PB-4 @ 235' 2.36%, PB-5 285' 3.28%; PB-6 @ 350' 2.96%, 395' 3.63%, 430' 2.28%; PB-7 @ 290' 1.41%, 350' 1.92%; and PB-8 @ 10' 6.12% for a arithmetic mean of 3.05% which was rounded up to 3.1%."

IDAHO DEPARTMENT
OF HEALTH AND WELFARE
DIVISION OF
ENVIRONMENTAL QUALITY

SIGN HERE

1445 North Orchard, Suite 100, Statehouse Mail, Boise, ID 83720-9000, (208) 334-0550

Cecil D. Andrus, Governor

October 28, 1994

PB-ARID.APP

RECEIVED
NOV 01 1994
HOLLADAY ENGINEERING CO.
PAYETTE, ID

Commissioner George Vance
Chairman of the Board
Canyon County Commissioners
1115 Albany
Caldwell, Idaho 83605

Re: Pickles Butte Municipal Solid Waste Landfill
Hydrogeologic Characterization, Proposed Monitoring System and Facility Design Report
Arid Design Approval

Dear Mr. Vance:

In a letter to the Canyon County Commissioners dated September 15, 1994, the Department of Health and Welfare, Division of Environmental Quality (DEQ), pursuant to Idaho Code § 39-7411(7), indicated that there were a number of issues that needed to be resolved before approval could be given to the Pickles Butte Hydrogeologic Characterization, Ground Water Monitoring Plan and Facility Design Report (Report) submitted by the county. On October 4, 1994, the Board of Canyon County Commissioners requested, pursuant to Idaho Code § 39-7411(8), a meeting to try to resolve the issues identified by DEQ. At this meeting, the parties agreed to extend the time frames provided in the Idaho Solid Waste Facilities Act so that by October 21, 1994 the county would provide additional information, and DEQ would respond with its final decision with respect to the Report by October 28, 1994. We have received and reviewed the additional materials submitted by the county. This letter represents our final decision with respect to the Report.

The Report presents an arid design for the landfill as provided for in Idaho Code § 39-7409. DEQ continues to disagree with some aspects (e.g., conservatism of HELP model input parameters) of the material presented by the county in support of the arid design. However, our analysis of the available information indicates an arid design is appropriate. Therefore, we approve the arid design.

The Report also provides a ground water monitoring design. At the same time, however, the county argues that there is "no potential for migration" as provided in Idaho Code § 39-7410. Based upon DEQ's analysis of the available information, we agree that the requirements for proof of "no potential for migration" is met and that a waiver of the ground water monitoring requirements is appropriate at this site pursuant to Idaho Code § 39-7410. We appreciate and applaud the county's commitment, notwithstanding the availability of a waiver, to conduct ground water monitoring. However, we continue to disagree with some aspects of the monitoring design and the arguments made by the county in the Report in support of the monitoring plan (the points of disagreement are set forth below). Because of the unique characteristics of this site that make the waiver available, our disagreement with the monitoring design does not prohibit the county from implementing this design.

DEQ has set forth below those aspects of the Report with respect to which it disagrees. These comments do not affect our approval, but instead are set forth because we believe the county should consider these matters in order to avoid the Report being used as a model for other sites where it may not be appropriate.

- As presented several times throughout the review process, DEQ considers the description of quality assurance/quality control (QA/QC) procedures an essential element of a ground water monitoring plan. We cannot concede to approving a ground water monitoring plan without this detail.

- The potentiometric surface determined by water level measurements from monitoring wells depicts two opposing ground water gradients bounded by the fault that dissects the northeast edge of the landfill. Because of this, DEQ believes that downgradient monitoring wells and a point of compliance need to be maintained to the south-southwest of the landfill. Well PB-3 is currently adequate for this purpose. However, the long-term landfill footprint will progress beyond PB-3 to the south at which time an additional well or wells would be needed to maintain an approved point of compliance.

- DEQ does not agree in full with Holladay Engineering Company's assessment of potential water movement and contaminant protection in the southerly "confined aquifer." The horizontal component of flow, as indicated by the southwesterly gradient, should not be ignored. We note the fact that the influence of the fault system at the upgradient boundary of this aquifer is not fully understood. Near the surface expression of the fault and well PB-2, the potentiometric surface approaches the top of the claystone unit greatly reducing the thickness of claystone available for "protection."

If you have any questions regarding this approval, please contact either Jack Gantz or Rob Howarth of this office at (208) 334-0550.

Sincerely,

Craig Shepard
for Joy L. Palmer
Regional Administrator

cc: Holladay Engineering Company
Jack Gantz, DEQ-SWIRO
Rob Howarth, DEQ-SWIRO
Mike Smith, DEQ-SWIRO
Bruce Wicherski, DEQ-CO
Katie Sewell, DEQ-CO
Tom Mullican, DEQ-SEIRO
Southwest District Health Department

Source File #21
Reading File

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Meeting for review of Division of Environmental Quality (DEQ) responses regarding the final report: Hydrogeologic Characterization, Ground Water Monitoring Design, and Facility Design, Pickles Butte Sanitary Landfill, Canyon County, Idaho.

A meeting was convened at the Canyon County Courthouse on September 18, 1994, at the request of the Board of Canyon County Commissioners, to reconcile differences of opinion in an effort to secure DEQ approval of an arid design for the Pickles Butte Sanitary Landfill. The meeting was attended by George Vance and Abel Vasquez representing the Board of Canyon County Commissioners, Rob Howarth, Bruce Wicherski, Jack Gantz, and Doug Conde representing Division of Environmental Quality (DEQ), and Vern Brewer, Bill Strowd, and Jack Biddle from Holladay Engineering Company (HECO).

The basis of the meeting was to review comments DEQ submitted to the County in a letter dated September 15, 1994 which addressed various portions of the final design report submitted to DEQ by the County on July 21, 1994. HECO categorizes the nature of DEQ's comments as: editorial changes, further explanation, and DEQ recommendation. Editorial changes will be provided in an Errata sheet separate from these meeting notes; response to a comment which requires further explanation will be included in these notes; and recommendations will be discussed in these notes.

As a result of the October 18, 1994 meeting between DEQ, HECO and the County it was agreed that these meeting notes, DEQ's September 15, 1994 letter, DEQ's letter of approval of the hydrogeologic characterization study, and all items for inclusion in the Errata will be compiled into a packet for incorporation into the final report. This packet will be delivered to all holders of the final report consequent to County receipt of DEQ approval.

Responses listed below are numbered according to enumeration in the original DEQ review of the Preliminary Report dated June 28, 1994. It should be noted that both DEQ's original comments and HECO's response are included as appendices in the final report.

1. An envelope for mounting at the end of the report with an full size copy of the geologic map will be included along with the Errata.

5. Please see Errata for report text modification.

6. Please see Errata for report text modification.

7. This discussion involves the regional hydrogeologic setting of the southern part of Canyon County which is also covered by the Wood and Anderson report. This section of the report is presenting broad regional conclusions based on the analysis of 72 well logs in a 24 square mile area in the vicinity of Pickles Butte. The point of this discussion is that Wood and Anderson state that on a regional basis there is a thermal differential between water occurring beneath the blue clay from that overlying the blue clay. The Pickles Butte final report does not address the differentiation of the UA in the Caldwell area nor does it indicate that the UA is universal in Canyon County; in fact, the UA does not exist beneath the site at Pickles Butte.

8. The purpose of this analysis was an attempt to characterize the regional geologic and hydrogeologic setting of the area adjacent to the landfill from existing water well drill logs. As is apparent from the results of the three point analyses, the top and bottom of the water-bearing stratigraphic horizons do not have the same orientation as the top of the blue clay unit; and as the report states the "aquifers within the blue clay may be laterally discontinuous and non-correlatable over long distances".

   Material from public information included by reference is an accepted standard of reporting practices. Official logs are on file at the Idaho Department of Water Resources and all relevant information, in respect to the analyses presented, are included on the Tables. DEQ decided during the meeting that submission of the well logs was not necessary.

9. The terms UA, MA and BA were defined in the HECO report (page 12, paragraph 3) to describe differences in ground water occurrence on a regional scale. The discussion (page 23, paragraph 3) is in regards to temperature, isotopes and recharge of the deep aquifer which referenced page 37 of the Wood and Anderson report. Page 37 of the Wood and Anderson report with the specific section underlined was provided for DEQ during the meeting.

13. The statement in the HECO, July 18, 1994 response was too broad. The correct information is listed on the drill logs.
    Please see Errata for report text modification.

    MSDS sheets will be included in the Operating Record and copies will be provided to DEQ for their records in addition to the Errata.

15. Please see Errata for report text modification.

SW-846 is an appropriate reference for the suite of test methods to be employed to fulfill the requirements of 40 CFR 258; pg. 51074 (Federal Register, Vol 56, No 196). The specific suggested test method numbers are include for all Appendix I constituents in Appendix II of 40 CFR Part 258. All laboratory tests will be conducted in accordance with EPA suggested test methods. More specifically test method 6010 will be used for the 15 metal analyses and method 8260 will be used for analysis of the 47 organic constituents.

18. Please see Errata for report text modification.

An additional copy of the geophysical logs will be provided to DEQ to make a complete set of three logs, one for each report.

21. The moisture content at saturation is one of seven laboratory derived values used to determine the bounds of specific retention capacity and develop the curves necessary to calculate unsaturated hydraulic conductivity values. Inclusion of moisture content by itself, is not definitive in the determination of specific retention or unsaturated hydraulic conductivity. This moisture content is not used in any other calculation. Use of these moisture values in the saturated time-of-travel calculations, as DEQ requests, <u>increases</u> the travel time by 7.83, 1340.20, and 24.69 years for PB-2, PB-3, and PB-4 respectively. HECO selected the more conservative approach.

For consistency, HECO used the criteria and nomenclature for pore space calculations and determination of initial moisture employed by the independent laboratory. Table 7 through 13 contain all the primary data necessary to reproduce the calculations presented at the bottom of the tables.

23. Please see Errata for report text modification.

24. A one third (1/3) bar value was used throughout the calculations for determination of specific retention. The formulas are correct as used. The reason a porosity term was not used for the values in the column on the right side of the tables is because the formulas do not include porosity at this point of the calculations. Porosity is used in the determination of average linear velocity. All calculations are correct.

Please see Errata for report text modification.

25. The allegation on the non-conservative nature of input parameters is incorrect.

The HELP model evaporative depth parameter value is correct and site specific based on caliche levels from 48 to 72 inches. Being conservative, HECO selected 48 inches.

The SCS number is correct; it has been checked against the criteria specified in the HELP Model documentation used by the SCS for determination of curve numbers and is accurate (SCS Engineering Field Manual, Chapter 2: Estimating Runoff and Peak Discharges). The use of an intuitive expression like, "seems justified" is not appropriate.

The runoff fraction is <u>not</u> a run-off percent but a factor. The model simulation predicts that 0.02 inches of water will become run-off on an annual basis. This is extremely conservative for the desert of southwestern Idaho.

The model simulation used the Boise default data for precipitation and evapotranspiration. The HECO statement that this overstates the precipitation data along the Snake River canyon rim is based on a SCS report, as referenced. The dataset from the University of Idaho referenced by DEQ apparently does not include a station in the vicinity of Pickles Butte. HECO's use of SCS data to substantiate the statement of relative rainfall is site specific (see SCS report page 107 section titled Climate).

26. The value, 8.3 percent, was not included in Mr. Schroeder's development of the 29.4 percent default value for municipal solid waste. As explained in original text, Mr. Schroeder estimates that municipal solid waste in Mississippi has an initial moisture content 8.3 percent less than the 29.4 percent default value. As presented at the meeting, the HELP Model climatic module estimates that the rainfall in Mississippi varies from more than 33 to 46 inches depending on geographic location. Schroeder's use of 21.1% in that instance confirms that HECO's use of 21.1% for initial moisture content is conservative.

27. Please see Errata for report text modification.

28. A <u>projection</u> of the two sets of equipotential lines cross but they are completely different in origin and have entirely different meanings as explained in the text. These concepts are crucial to understanding the site's hydrogeologic environment. The equipotential lines for ground water represent unconfined water table (phreatic surface). The equipotential lines for the lower aquifer (potentiometric surface) represents water confined by the thick and massive unsaturated claystone formation. The figure shows the juxtaposition of equipotential lines which illustrate, by definition, two very different surfaces. Should a local fault connection exist between the two aquifers ground water flow would be from the lower confined aquifer to the higher unconfined aquifer. The monitoring array

has been located within the pathway to intercept any potential migration of leachate.

33. The nature of arguments on protocol can become so site specific and potentially subjective that EPA simply states that QA/QC procedures belongs in the operating record (40 CFR 258,.53, Paragraph A, Pg 51023 of Federal Register, Oct. 1, 1991). The question of requiring the review and approval of the QA/QC protocol prior to design approval is not relevant since the County has submitted proof of an arid design.

When QA/QC protocol is developed based upon function of on-site equipment, practical sampling techniques and procedures the protocol will be entered into the Operating Record. A draft of the QA/QC protocol will be included in the Errata packet for inclusion in the final report.

34. The reference to conference discussions of materials presented in a seminar by Siegel, et al., was intended to identify emerging issues as they pertain to significant changes in background information. If a single, definitive study was available, it would be included.

35. Movement to the southwest is not implicit of a potentiometric gradient (as opposed to a phreatic surfaces's hydraulic gradient). Resistance to the potentiometric gradient is far to high for ground water movement in the claystone unit during the landfill design period. DEQ's argument is not supported by any evidence. During the active life of the facility and post-closure period a contaminant will not move through massive claystone with a potentiometric surface more than 400 feet above the aquifer, against a potentiometric head of more than seventy feet and two hundred feet of unsaturated claystone above the potentiometric surface in the vicinity where DEQ requests new wells. The unsaturated time of travel calculation, included on Table 14, for PB-2 is 26,200 years, PB-3 is 617,000,000 years and for PB-4 is 1,300,000,000 years. The travel times and therefore the protection, <u>increases</u> in a southwesterly direction.

Contaminant diffusion within the unsaturated zone is not an effective method of transport regardless of leachate chemistry. Any discussion of diffusion assumes that leachate has reached the saturated zone - which is not predicted by the HELP Model simulation during the active life and post-closure period. Therefore, the results of the HELP Model simulation indicate that diffusion as a means of transport can be disregarded.

There isn't "flow in two opposing directions" since HECO does not consider the lower confined aquifer a meaningful monitoring horizon. Consequently, the slope of the potentiometric surface of the confined aquifer does not represent a potential contaminant pathway or contaminant flow direction. DEQ agrees in their September 15, 1994 comments, that the northeast monitoring well array is adequate to detect potential contaminant movement down-dip of the facility. PB-3 will remain as a monitoring well and when the footprint expands PB-3 will be a monitoring well within the landfill footprint.

During the meeting, DEQ specifically disagreed with the first two sentences of the preceding paragraph. As a result of the discussion and the concerns presented by DEQ the County has agreed to evaluate the applicability for additional wells to the southwest of PB-3 when the current footprint of the landfill laterally expands to PB-3.

40. The design slopes conform to the EPA approved Idaho design performance criteria. Additional study, beyond the design criteria, would require authorization by the County to pursue this new work. The County will consider DEQ's recommendation to conduct a stability study of the final design slopes.

46. Either the County has an arid design demonstrating "no potential for migration" or the landfill must be lined within the requirements of federal and state laws. Construction of a non-performance based liner is outside the law and adds no protection. An alternative liner design is subject to complete proof of performance. EPA did not allow a predetermined equivalent liner design for state program approval.

The contention that a "homogeneous" native subgrade, to be achieved by over-excavation, blending, relaying and recompacting 24 inches of fine-grained sediment will afford greater protection than the native sediments (which are more than 300 feet thick) will somehow better protect the area beneath the site is insupportable. Localized subgrade heterogeneities are irrelevant to the overall performance of the site which has adequate protection to qualify for an arid design. And the long-term unwarranted cost to the County would potentially be in the tens of millions of dollars.

As is prudent with any facility construction, base conditions are evaluated for suitability at the time of construction. When the County laterally expands past it's current footprint an evaluation of the base conditions will be conducted as a part of site operating procedures.

IDAHO DEPARTMENT
OF HEALTH AND WELFARE
DIVISION OF
ENVIRONMENTAL QUALITY

1420 North Hilton, Boise, ID 83706-1260, (208) 334-0550

Cecil D. Andrus, Governor

September 15, 1994

PICKLESB.994

Commissioner George Vance
Chairman of the Board
Canyon County Commissioners
1115 Albany
Caldwell, Idaho 83605

RE: Pickles Butte Municipal Solid Waste Landfill
Hydrogeologic Characterization, Proposed Monitoring System and Facility Design Report
Second Round Review Comments

Dear Mr. Vance:

The Division of Environmental Quality (DEQ) has reviewed this revised report and the reply to our comments developed by Holladay Engineering Company. Unfortunately, several key issues remain unresolved and prevent us from providing complete approval of this plan. The remaining issues are presented below with numbers corresponding to our original comments. Note that one additional comment (item number 46) has been added.

As before, the following suggestions and/or questions must be addressed before approval may be given. Please respond to each question or concern explicitly in letter format and modify the report as appropriate.

1. Page 6 - Geologic unit contacts cannot be discerned on Plate 2. The report needs to function as a "stand-alone" document available for review by parties other than DEQ. Any maps, plates, or other forms of data presentation referred to in the text of the report need to be legible.

5. Page 16, paragraph 3 - In order to further clarify the term "negative static water level", we request that you replace the phrase "stratigraphically above" with "elevationally above".

6. Page 17, paragraph 4 - This response does not clarify the reason for the original comment. Please further explain the term "positive artesian pressures...from five to 256 feet...."

7. Page 18, paragraph 4 - This comment refers to the statement that "Wood and Anderson do not differentiate between the BA and MA." Again, the paragraph seems to imply that

the site-specific aquifer units UA, MA, and BA described at Pickles Butte are regionally continuous and can be found and described throughout the Nampa-Caldwell area. Please modify this discussion to clarify the fact that units described at Pickles Butte may not exist elsewhere (i.e., the UA at Pickles Butte is very likely not similar to a "UA" in downtown Caldwell). In fact, Anderson and Wood describe three geologically different, important, shallow, cold water aquifer systems as: "(1) a lower sand, silt and gravel, (2) a fractured basalt, and (3) an upper sand and gravel."

8. Page 20, paragraph 2 - We do not fully understand the "first water-bearing interval analysis" presented in this paragraph (we do agree with the last paragraph of page 21). Please provide additional clarification on the purpose and outcome of this analysis. Also, this analysis appears founded on data presented on three local driller's logs. We once again ask that you include copies of all driller's logs referenced in the report in an appendix.

9. Page 23, paragraph 3 - "MA and BA ground water" are not mentioned in the referenced report. Note that the geochemistry of the Nampa-Caldwell area is described by John C. Mitchell in Chapter 4 of the report. The reference provided should be modified to account for this. If inferences are made between Mitchell's analysis of area geochemistry and the character of MA and BA ground water, further discussion of the basis for these inferences must be provided.

13. Page 25, paragraph 2 - The response to DEQ's original comments states that "All geologic information was collected prior to injection of drill agents except PB-2." However, the field logs indicate that in at least two other cases (e.g., PB-3 beginning at 130 feet and PB-4 at 230 feet), drilling additives were introduced prior to completion of geologic sample collection. Please explain this discrepancy, include MSDS for the chemical additives, and provide a table or clear narrative describing the types of drilling fluid (other than air), the approximate quantity, the specific source (if water), and the depth intervals involved.

15. Page 25 - The report needs to be modified to clarify the fact that not all Appendix I constituents were analyzed for in the injected water from the Johnson well.

    SW-846 is not a test method in and of itself but refers to the compendium of test methods. This response does not adequately address the original comment.

18. Page 31, paragraph 1 - Legible copies of geophysical logs should be submitted with every report subject to public review. Alternatively, a permanent storage location for the logs could be stated in the report.

21. Page 51, table 5 - The response to this comment partially clarifies the source of the discrepancy but does not resolve it. The process used by D.B. Stephans to generate unsaturated K values uses the moisture content value measured at 0 cm pressure (or saturation). This value in every case is larger than the calculated porosity values. The range of the difference is from 1.8 to 7.2%. The saturated moisture content value should be included in Table 5 for clarity and because it is used to generate other pieces of information in the analysis (see other comments below and for 24.).

    Two values of the total pore space in the samples were therefore generated (one by calculation and one by lab measurements). These two values are used at different times in various parts of the analysis. While the lab data was used to generate specific retention, specific moisture capacity, absolute K, and unsaturated travel time estimates, the calculated values are the ones used to estimate saturated travel times. Which value more accurately represents the total pore space of the sample available to hold water? This value should be used consistently throughout the analysis.

    In Table 5 the values for initial moisture content are presented on a volume basis while in Tables 7 through 13, data is presented on a weight basis. These data should be presented in a consistent manner to avoid confusion.

23. Page 53, paragraph 1 - The word "Results" is capitalized in the middle of a sentence. Is there a portion of a sentence missing or is this a typographical error? The reply to this comment stated that a change was made, however, this is not the case. Please confirm.

24. Pages 54 through 60, Tables 7 through 13 - No values for the specific retention parameter are given in the D.B. Stephans report. How were these values generated? Was a particular pressure value chosen to develop these moisture contents? This should be clarified in the text. It appears that some extrapolation from the Stephans data was used, in which case the saturated moisture content value provided the starting point for the estimates.

    As in our earlier comment, the travel time values presented in the far left column for individual layers does not include the porosity term, and the summed value at the bottom of the column does not match the value presented in the boxed section at the bottom of the tables. This should be corrected or that particular column removed since it is misleading.

25. Page 63 - The values chosen for several model input parameters are not conservative values. They should be chosen to maximize the potential for contaminant migration. This will all result in reducing the amount of water infiltration. This will also affect the estimates involving specific moisture capacity.

HELP documentation for evaporative depth suggests conservative values of 18 inches for bare ground for the Boise area. Even for a drier site the 48 inches chosen is excessive.

The SCS curve number of 88 chosen is high and implies a large amount of potential runoff. Given the surface soil types present, the dry nature of the site, its likely disturbed condition while waste is being placed, and the likelihood that any runoff generated in the active area will not leave the site, a lower value seems justified. Please justify the use of this value for the soils to be used as cover at the site.

The runoff fraction should be set as low as possible and to be conservative should be zero and not 0.35.

Using the climatic data from Boise is a reasonable choice and does not overstate the amount of annual precipitation. The use of a dataset that is more complete (Univ. of Idaho using 1961-1990 data) than that found in the SCS soil survey for Canyon Co. (1972) indicates that the difference between Boise data (12.11 inches) and Caldwell (10.69 inches) and Parma Experiment Station (11.58 inches) data are only 11.7 and 4.4%, respectively. The 48 to 98% figures overstate this difference and should be revised in the text.

26. Page 63, paragraph 3 - Please further explain the use of the 21.10% initial moisture content for solid waste (i.e., versus the 29.4% default value). Has the "excess specific retention capacity of 8.3%" already been taken into account in development of the 29.4% default value?

27. Page 64, table 15 - Please expand the discussion regarding the "10 in house laboratory determined soil moisture contents..." How were the samples collected? At what depth were the samples collected? What testing procedures were used?

28. Page 67 - What is the nature of the horizontal aquifer connection across the fault? Plate 4 seems to indicate a connection between equipotential lines on either side of the fault.

33. Page 73, paragraph 1 - Please note that DEQ does not advocate rapid purging techniques in slowly-recovering wells. In accordance with Barcelona, et. al. (1994), we will approve a protocol that calls for purging a minimum of 0.5 wellbore volumes at a low rate prior to sampling (i.e., sampling within 24 hours of purging if feasible). Alternatively, a protocol that relies on stabilization of field-measured parameters (e.g., pH, temperature, specific conductance, and dissolved oxygen) will be considered.

The ground water monitoring plan is not considered complete without a detailed description of the quality assurance/quality control protocol. Approval of the ground water monitoring plan (in accordance with 39-7401(1)(e), Idaho Code) will not be given without this detail in the plan.

34. The reference to the seminar by Siegel (1994) does not allow reasonable retrieval of written material. Literature introduced by Siegel should be included in an appendix to the report if it is not readily available.

35. Page 74, paragraph 1 - The response to this comment does not adequately address our concerns about potential contaminant movement downgradient to the southwest. We do not agree that it is impossible for a "confined" aquifer to become contaminated. We base our position on several key site characteristics:

(a) The highly complex and variable nature of the subsurface (i.e., fluvial/lacustrine sedimentary environment complicated by faulting) cannot be ignored. It cannot be assumed that the hydrogeologic character or structural integrity/extensiveness of the "claystone" unit is fully understood across the entire site. A worst-case contaminant migration situation must be assumed.

(b) The chemistry of certain leachates may have an adverse effect on clay barriers. Natural diffusion of certain contaminants through low-permeability materials cannot be ignored.

(c) Geologic cross-sections (Plate 3) indicate that the potentiometric surface intercepts the top of the "claystone" near the fault and the northeastern part of the current landfill. Thus, the ground water in this area is not protected by the "claystone" unit.

It is our opinion that the unique behavior of ground water near the landfill (i.e., flow in two opposing directions) requires monitoring and designation of a point of compliance at both downgradient directions. The northeastern boundary appears adequately covered by existing or proposed monitoring wells. We do not believe that the south or southwestern boundary is adequately covered by monitoring wells.

Of the three wells proposed to monitor the western confined aquifer one (PB-8) is cross-gradient and could not be influenced by landfill activities, one is within the footprint of the landfill itself (PB-3), and one (PB-4) will only be marginally down gradient of the active portion of the landfill.

40. Page 86 and 87, items No. 4 and 9 - The intent of our original question appears to have been misunderstood. To clarify, we are asking whether a geotechnical stability analysis has been done for the overall landfill. It appears from the cross-sections given that the final landfill will entail the construction of a new large land mass which will consume

a large portion of the existing canyon. Therefore, we are concerned about the long term stability of the landfill. We again recommend that a geotechnical analysis be conducted prior to any additional construction at the landfill.

46. Chapter V., general comment - The design section of the report should address how the native subgrade material will be prepared in order to assure a homogeneous natural liner at the interface with the proposed municipal waste material. In other words, we feel that the design should include provisions for overexcavation of the subgrade (at a minimum 24-inches) in those areas where the subgrade material is not uniform in nature (i.e., pockets of gravel, blocky material, etc.). These areas should then be backfilled and compacted with material similar in nature to that of the surrounding suitable native material in order to provide a uniform homogeneous layer beneath the landfill area. The design should also address the scarification and compaction of the remaining native subgrade to ensure uniformity of the subgrade interface with municipal waste. The discussion should also include sequencing of the subgrade preparation as the subgrade is exposed.

To summarize, the major issues left to resolve include better documentation or explanation of the HELP model assumptions for the analysis of potential leachate generation. The presentation and parameter values used in the simplistic saturated/unsaturated travel time and specific capacity analysis require further modification or discussion. The monitoring proposed is inadequate and several issues regarding the location of wells, the number of wells, sampling methodology, and analytical parameters need to be resolved.

Sincerely,

Joy L. Palmer
Regional Administrator

JLP:rh:ajc

cc: Katie Sewell, DEQ - CO
Bruce Wicherski, DEQ - CO
Jack Gantz, DEQ - SWIRO
Rob Howarth, DEQ - SWIRO
Mike Smith, DEQ - SWIRO
Southwest District Health Department
Holladay Engineering Company
Source File #21
Reading File

# GROUND WATER SAMPLING

# QA/QC PROTOCOL

for

## PICKLES BUTTE SANITARY LANDFILL

CANYON COUNTY, IDAHO

November, 1994

Holladay Engineering Company

# TABLE OF CONTENTS

# I. GROUND WATER SAMPLING AND ANALYSIS

## A. Monitoring Schedule

Samples shall be collected on a quarterly basis for the first two years of sampling for determination of background values of constituents denoted in section I. ANALYTICAL PROCEDURES of this report and thereafter sampling will occur semi-annually. The first quarterly sampling event will begin with during the first calendar quarter of 1995. See final report entitled **Hydrogeologic Characterization, Ground Water Monitoring Plan, and Facility Design; Pickles Butte Sanitary Landfill; Canyon County, Idaho** by Holladay Engineering Company, July, 1994 approved by the Division of Environmental Quality on October 28, 1994 for location of monitoring wells. New monitoring wells proposed in the above report will follow a simular scheduled starting with the first quarterly sampling event following their completion.

## B. Field Parameter Equipment and Calibration Procedures

Temperature, pH and specific conductance of ground water from each well will be measured in the field. Portable equipment required for the measurements shall be calibrated in accordance with manufacturer's specifications. Calibration of the pH meter will occur prior to each sampling event and any time the pH value is not near each individual well site's established norm. The pH meter will also be routinely checked against a standardized buffer solution during monitoring. Also, specific conductance and temperature calibration will be checked daily with a standard solution and a standard mercury thermometer respectively.

## C. Sampling Equipment

Dedicated stainless steel bailers and cable shall be installed in each well. A portable winch will be used to purge wells prior to sampling. No water sampling equipment surfaces will be common to more than one well. Any equipment surface posing a potential risk of cross contamination between wells will be decontaminated following the procedures outlined in section I. E. of this report. Samples shall be collected in laboratory supplied bottles containing preservatives appropriate for the intended suite of analytical tests.

## D. Water Level Elevation Measurement Procedure

Static water level measurements shall be collected prior to well sampling. Water levels will be measured with an electronic well probe dedicated to the Pickles Butte wells. That portion of the well probe which is immersed into a well water column will be decontaminated using the procedure discussed in the following section. The water level, time, date, well number and personnel involved will be recorded in the Field Log Book at the time of measurement. Ground water gradient will be determined from the measured water levels and results of the determination will be entered into the Field Log.

## E. Decontamination Procedures

The necessity for decontamination of equipment will be minimized since each well will be constructed with dedicated purge and sample equipment. No water sampling equipment surfaces will be common to more than one well. If equipment decontamination is necessary it will be rinsed with laboratory provided deionized water.

## F. Well Purging Procedure

Wells will be purged prior to sample collection after to water level measurement. Purging will be accomplished with the dedicated sampling bailers. Due to the slow recover rate in most wells, purging will consist of one-half well volume where static water level conditions occur substantially above the screen, or purging the volume of water above the screen when static water level is less than one-half well volume above the top of the screen. To avoid the potential for water cascading within the well, purging will not occur in wells with a static water level which occurs within the screened zone. Samples shall be collected as soon as practicable but not less than one hour after purging. For slow recovery wells, samples will be taken within 24 hours if feasible.

## G. Field Data

Well data for each sampling event will be recorded on field sheets in a log book. The field data will include well number, sampler(s) name, number and type of samples, date and time of collection, field measurements, and any deviation from standard procedure. A preliminary scan of the field parameter data will be conducted after each well measurement and sampling event. Anomalous results shall be noted and data recollected if necessary.

## H. Sample Preservation and Custody

Samples shall be taken in laboratory supplied bottles containing preservatives appropriate for the specific analytical tests that will be conducted on the sample(s). Samples shall be cooled to 4°C, packed in portable coolers with blue ice, and shipped within 48 hours of collection to an EPA certified analytical laboratory. Ample blue ice will be added to cooler to insure a sample temperature of 4°C when delivered to the laboratory.

A standard chain of custody (COC) form will record sampling data for each sampling station at the time of collection. The COC will be included with the samples when shipped to the laboratory. A copy of the COC form will be included in the Field Log Book. An analysis request form, which may be a subpart of the COC, will be include with each sample shipment. A copy of the COC form will be included the Field Log Book and the original sent with each shipment set sent to the laboratory.

## I. Analytical Procedures

Samples will be analyzed for Appendix I, 40 CFR Part 258 constituents by methods included in Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846. Analytical test procedures will be conducted by a EPA certified laboratory. See section V. LANDFILL DETECTION MONITORING CONSTITUENTS of this report for a table of Appendix I constituents, EPA test method, PQL, and established MCL's. Test methods specified in the table were developed in consultation with an EPA certified laboratory utilizing as a guide the suggested test method for analytical procedures from 40 CFR Part 258 Appendix II. For constituents for which a MCL has been established a method with a PQL which will either be equal to less than the MCL has been specified except for vinyl chloride. Note that analyte #19 - Bromochloromethane will not be reported since this compound is an internal standard for EPA method 8240 and is not on the EPA 8010 list of analytes.

## J. Sample/Laboratory Quality Assurance/Quality Control

One set of trip blanks, supplied by a certified laboratory, containing reagent grade water shall be analyzed for each monitoring event. Since all water sampling and purging equipment is dedicated to each well, equipment blanks will only be taken should field decontamination of equipment, other than the water level probe, be necessary.

The certified laboratory will complete the chain-of-custody, record analysis requested, and log sample arrival and analysis completion dates. Copies of this information will be returned by the laboratory when the sample results are reported.

# II. DATA PRESENTATION

Copies of Field Logs, chain of custody forms, and analytical results will be included in the Pickles Butte Sanitary Landfill operating record in the accordance with recordkeeping provisions of Title 39 Chapter 74 Section 12 Standards for Operation subsection (9) in conformance with 40 CFR Part 258.29(5).

# III. STATISTICAL ANALYSIS

Analysis of the sampling data will be conducted at the completion of one year of collection. GRITSTATS version 4.14 computer statistical program will be used to evaluate analytical results and perform ANOVA tests. Analysis will be included in the Pickles Butte Sanitary Landfill operating record.

# IV. RESAMPLING

If analytical results indicates that a constituent concentration has increased, an analysis shall be performed to determine if the increase is a "statistically significant increase" as described in the appendixes of 40 CFR Part 258. If the increase is a statistically significant the well will be resampled and tested and all methodologies including sampling, handling and laboratory QA/QC methods will be reviewed and confirmed. In the case that the analytical result is a false positive, routine sampling frequency will resume. If the retest results indicate that a statistically significant increase for a constituent(s) has occurred, DEQ will be notified and a meeting shall be held.

# V. LANDFILL DETECTION MONITORING CONSTITUENTS

APPENDIX I 40 CFR Part 258

| | Common Name | Test Method | PQL (ug/l) | MCL (ug/l) |
|---|---|---|---|---|
| 1 | Antimony | 7041 | 5 | 6 |
| 2 | Arsenic | 7060 | 2 | 50 |
| 3 | Barium | 6010 | 10 | 2000 |
| 4 | Beryllium | 6010 | 1 | 4 |
| 5 | Cadmium | 7131 | 0.5 | 5 |
| 6 | Chromium | 6010 | 10 | 100 |
| 7 | Cobalt | 6010 | 10 | NA |
| 8 | Copper | 6010 | 10 | 1300 |
| 9 | Lead | 7421 | 1 | 15 |
| 10 | Nickel | 6010 | 20 | 100 |
| 11 | Selenium | 7740 | 2 | 50 |
| 12 | Silver | 6010 | 5 | 50 |
| 13 | Thallium | 7841 | 1 | 2 |
| 14 | Vanadium | 6010 | 10 | NA |
| 15 | Zinc | 6010 | 10 | 5000 |
| 16 | Acetone | 8240 A | 10 | NA |
| 17 | Acrylonitrile | 8240 A | 10 | NA |
| 18 | Benzene | 8240 A | 5 | 5 |
| 19 | Bromochloromethane Internal Standard for | 8240 A | NA | NA |

| | Common Name | Test Method | PQL (ug/l) | MCL (ug/l) |
|---|---|---|---|---|
| 20 | Bromodichloromethane | 8010 | 2 | 10 |
| 21 | Bromoform; Tribromomethane | 8010 | 1 | 10 |
| 22 | Carbon disulfide | 8240 A | 5 | NA |
| 23 | Carbon tetrachloride | 8010 | 1 | 5 |
| 24 | Chlorobenzene | 8010 | 2 | NA |
| 25 | Chloroethane; Ethyl chloride | 8010 | 3 | NA |
| 26 | Chloroform; Trichloromethane | 8010 | 1 | 10 |
| 27 | Dibromochloromethane; Chlorodibromomethane | 8010 | 1 | 10 |
| 28 | 1,2-Dibromo-3-chloropropane; DBCP | 8240 A | 10 | NA |
| 29 | 1,2-Dibromoethane; Ethylene dibromide; EDB | 8240 A | 10 | NA |
| 30 | o-Dichlorobenzene; 1,2-Dichlorobenzene | 8010 | 2 | 600 |
| 31 | p-Dichlorobenzene; 1,4-Dichlorobenzene | 8010 | 2 | 75 |
| 32 | trans-1,4-Dichloro-2-butene | 8240 A | 10 | NA |
| 33 | 1,1-Dichloroethane; Ethylidene chloride | 8010 | 1 | NA |
| 34 | 1,2-Dichloroethane; Ethylene dichloride | 8010 | 1 | 5 |
| 35 | 1,1-Dichloroethylene; 1,1-Dichloroethene; Vinylidene chloride | 8010 | 1 | 7 |
| 36 | cis-1,2-Dichloroethylene; cis-1,2-Dichlorethene | 8240 A | 5 | 70 |
| 37 | trans-1,2-Dichloroethylene; trans-1,2-Dichloroethene | 8010 | 1 | 100 |

| | Common Name | Test Method | PQL (ug/l) | MCL (ug/l) |
|---|---|---|---|---|
| 38 | 1,2-Dichloropropane; Propylene dichloride | 8010 | 1 | 5 |
| 39 | cis-1,3-Dichloropropene | 8010 | 1 | NA |
| 40 | trans-1,3-Dichloropropene | 8010 | 1 | NA |
| 41 | Ethylbenzene | 8240 A | 5 | 700 |
| 42 | 2-Hexanone; Methyl butyl ketone | 8240 A | 10 | NA |
| 43 | Methyl bromide; Bromomethane | 8240 A | 10 | NA |
| 44 | Methyl chloride; Chloromethane | 8010 | 3 | 5 |
| 45 | Methylene bromide; Dibromomethane | 8240 A | 10 | NA |
| 46 | Methylene chloride; Dichloromethane | 8240 A | 5 | NA |
| 47 | Methyl ethyl ketone; MEK; 2-Butanone | 8240 A | 10 | NA |
| 48 | Methyl iodide; lodomethane | 8240 A | 10 | NA |
| 49 | 4-Methyl-2-pentanone; Methyl isobutyl ketone | 8240 A | 10 | NA |
| 50 | Styrene | 8240 A | 5 | 100 |
| 51 | 1,1,1,2-Tetrachloroethane | 8240 A | 10 | NA |
| 52 | 1,1,2,2-Tetrachloroethane | 8240 A | 5 | NA |
| 53 | Tetrachloroethylene; Tetrachloroethene; Perchloroethylene | 8010 | 1 | 5 |
| 54 | Toluene | 8240 A | 5 | 1000 |
| 55 | 1,1,1-Trichloroethane; Methylchloroform | 8240 A | 5 | 200 |
| 56 | 1,1,2-Trichloroethane | 8010 | 1 | 5 |
| 57 | Trichloroethylene; Trichloroethene | 8010 | 1 | 5 |

| | Common Name | Test Method | PQL (ug/l) | MCL (ug/l) |
|---|---|---|---|---|
| 58 | Trichlorofluoromethane; CFC-11 | 8240 A | 10 | NA |
| 59 | 1,2,3-Trichloropropane | 8240 A | 10 | NA |
| 60 | Vinyl acetate | 8240 A | 10 | NA |
| 61 | Vinyl chloride | 8010 | 3 | 2 |
| 62 | Xylenes | 8240 A | 5 | 10,000 |

F:\HE\CC\APPENDIX.I

Test methods specified were developed in consultation with an EPA certified laboratory utilizing as a guide the suggested test method for analytical procedures from 40 CFR Part 258 Appendix II. For constituents for which a MCL has been established a method with a PQL which will either be equal to less than the MCL has been specified except for vinyl chloride. Note that analyte # 19 Bromochloromethane will not be reported since this compound is an internal standard for EPA method 8240 and is not on the EPA 8010 list of analytes.