LANDFILL HYDROGEOLOGIC INVESTIGATION
ALCOA CLEVELAND WORKS

ALCOA

DATE: AUGUST 09, 1994

1.4 HYDROGEOLOGIC INVESTIGATION

1.4.1 Literature Review

In order to evaluate regional geology and hydrogeology, a review of historical data was conducted with a computer literature search of published sources related to the ground water and geology of Cuyahoga County. This effort was supplemented by data inspection visits to the offices of the ODNR, Division of Water. Informational sources obtained at the ODNR include:

- a map of the ground-water resources of Cuyahoga County by Katie Crowell, published in 1979 by the ODNR;
- a U.S. Geologic Survey (USGS) topographic quadrangle map for Cleveland South;
- a bedrock topographic map for Cuyahoga County;
- boring logs for test borings or water wells drilled in the vicinity of the proposed landfill upgrade;
- the location of oil and gas wells in the vicinity of the proposed landfill upgrade;
- the listing of sources of municipal water supply for Cleveland and surrounding municipalities; and,
- the report entitled, "Glacial and Surficial Geology of Cuyahoga County, Ohio" by John P. Ford, published in 1987 by the ODNR.

In addition, personnel at the Division of Water were interviewed concerning previous or ongoing geologic or hydrogeologic studies near the plant location. According to the Division of Water, no recent ground-water studies have been conducted by the state within the immediate area of study. However, a comprehensive report entitled, "The Water Resources of

Cuyahoga County, Ohio" (Winslow, White and Webber, 1953, ODNR) details the geography, surface-water and ground-water resources, and the chemical quality of the ground water and surface water in the area. Although this is not a recent report, the information provided regarding the geology and the water-bearing properties of unconsolidated and consolidated units in the area appears to be verified by more recent information obtained by boring logs and other investigations.

The Ohio Department of Transportation (ODT) and the Cuyahoga County Engineers were contacted to gain information on local borings that may have been completed in association with highway construction or engineering projects near the plant site. Neither of these sources were able to provide data pertinent to this PTI application. However, information relative to the Ohio canal in the vicinity of the plant was collected through the Ohio Department of Administrative Services and the Ohio Historical Society.

In order to obtain information on potential sources of contamination in the vicinity of the plant, several local governments were also contacted. The town of Cuyahoga Heights provided a listing of industries within Cuyahoga Heights. Further, the Cuyahoga Heights planning committee provided a partial list of hazardous substances used within Cuyahoga Heights. The City of Newburg does not maintain records on local industries; this information was therefore not obtained.

1.4.2 Regional Geology

1.4.2.1 General Geomorphology and Stratigraphy

Cuyahoga County is located within two physiographic provinces, the glaciated Allegheny Plateau of the Appalachian Plateaus

province on the south and east, and the Eastern Lake and Till Plains sections of the Central Lowlands province on the west and north (Fenneman, 1938). The two provinces are divided by the Portage Escarpment which crosses the county diagonally in approximately a northeast-southwest line. Ford (1987) has subdivided the area into four physiographic units: the Lake Plain, the Portage Escarpment, the Plateau, and valleys that drain the County northward to Lake Erie. The Lake Plain is a wedge-shaped area that extends across the northern portion of Cuyahoga County from Lake Erie south to the Portage Escarpment. The Lake Plain terrain is relatively flat and rises gradually to the southeast through a series of steps formed by beach ridges formed by higher lake levels during later glacial time. South of the Lake Plain, the Escarpment generally forms a long and gentle slope where it is underlain by thick shales. The Plateau, located in south-central and southeastern Cuyahoga County, consists of a rolling upland that represents the northwest margin of the Allegheny Plateau (Ford, 1987).

Because they form distinctive elements of the physiography in Cuyahoga County, Ford named the stream and river valleys as a separate unit. The valleys contain glacial till and lacustrine deposits through which the present rivers cut their respective channels. Figure 1.4-1 depicts the stream and river valleys along with the three other physiographic units in the County.

The regional geology in the vicinity of the Alcoa facility is typical of areas on the south shore of Lake Erie. The geologic formations which occur near the surface in the study area are of sedimentary origin. They comprise two classes including, from the surface downward, unconsolidated glacial deposits of Pleistocene, overlying bedrock of late Devonian, Mississippian and Pennsylvanian age. The unconsolidated Pleistocene glacial deposits in the area

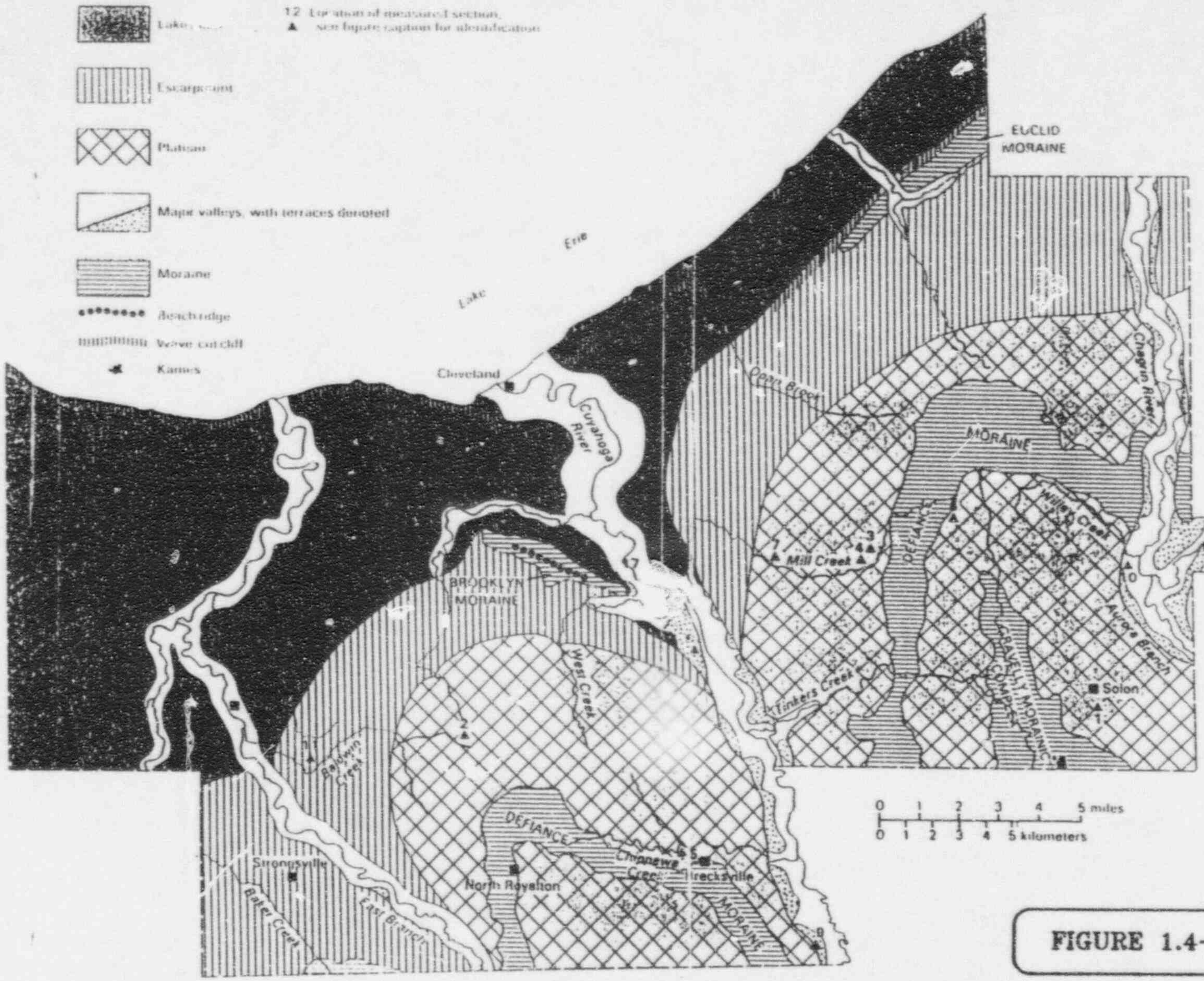

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FIGURE 1.4-1

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MAP SOURCE: FORD 1987

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PHYSIOGRAGHIC UNITS AND MAJOR GLACIAL FEATURES IN CUYAHOGA COUNTY, OHIO

typically consist of lacustrine (lake) or fluvial (river) silty clays, and tills interbedded with isolated sand and gravel lenses. Lacustrine silty clays and till (a heterogeneous mixture of clay, sand and gravel, with a predominance of clay) comprise the majority of the unconsolidated deposits in the study area.

Structurally, the geologic units in the Cleveland area are relatively flat-lying and have not experienced significant structural alteration. Bedrock surface elevation variations are due predominantly to pre-glacial and glacial erosional activities that have carved bedrock valleys.

1.4.2.2 Unconsolidated Units

The distribution of two general types of unconsolidated units (surficial lacustrine and fluvial deposits, and glacial till) is related to the physiography and geomorphology of the region. Within the primary buried bedrock valleys, thick sequences of glacial till are present, which may be covered by lacustrine or fluvial deposits at the surface. In areas outside of the buried valleys, where bedrock occurs relatively close to the surface, the till is often absent and the unconsolidated deposits consist of lacustrine and fluvial clays and silts. These silty clay sediments are generally present in the Lake Plain area north of the Portage Escarpment.

During the Pleistocene Epoch four major glacial stages covered the northern United States. In northern Ohio, evidence of the third and fourth glacial stages, the Illinoian and Wisconsin, is present. Illinoian deposits have been identified beneath tills of later age, predominantly in the deeply incised bedrock valleys. Wisconsin stage glacial ice advanced over Cuyahoga County at least three times. Most of the surficial till present in the County was

derived from Woodfordian glaciation, a sub-stage of the Wisconsin stage.

The surficial till units that have been identified in northeastern Ohio are presented on Table 1.4-1 (Ford, 1987). The glacial units listed on Table 1.4-1, except the Mogadore Till and a newly described till, the Northhampton Till (Szabo and Miller, 1986), are Woodfordian or younger in age. According to Ford (1987), Woodfordian ice advanced into northeastern Ohio from Lake Erie in three separate lobes: the Grand River, the Cuyahoga, and the Killbuck. Most of the till in Cuyahoga County was deposited in the Cuyahoga Lobe (White, 1982).

Of the till units listed on Table 1.4-1, Lavery Till is the most areally extensive and forms the uppermost glacial till over much of Cuyahoga County. In many locations the Lavery Till overlies bedrock or unnamed deposits of sand and silt.

1.4.2.3 Bedrock Units

Within Cuyahoga County, bedrock consists of thick shales and sandstones that range in age from Late Devonian to Early Pennsylvanian. Stratigraphically, the bedrock section includes, in descending order: 1) the Sharon conglomerate of Pennsylvanian age; 2) the Cuyahoga Formation of Mississippian age; 3) the Berea Sandstone of Mississippian age; and, 4) the shales and interbedded sandstones that underlie the Berea Sandstone, namely, the Bedford Shale of Mississippian age, the Cleveland member of the Ohio Shale, and the Chagrin Shale. The last two units are of Devonian age.

The Chagrin Shale is a gray, medium to thick-bedded unit that contains thin irregular interbeds of siltstone or sandstone that weather to a dark brown. The Cleveland Member of the Ohio Shale

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TABLE 1.4-1

Glacial Till Units in Northeastern, Ohio (from FORD, 1987)

Till Unit	Character of Material
Ashtabula Till	Silty to silty-clay till
Hiram Till	Silty clay to clay till
Lavery Till	Silty till
Kent Till	Silty, sandy till
Mogadore Till	Sandy till

is a dark gray to black, thin-bedded unit that weathers to thin slaty brown fragments. The Bedford Shale is a soft shale that varies in color from blue-gray to maroon.

The Berea Sandstone is a medium to fine-grained quartz sandstone that is usually light gray to yellowish brown in outcrop. The unit varies in thickness but, since it strongly resists erosion, it is a common outcrop in the region.

The Cuyahoga Formation consists of shaly beds and interbedded sandstones. The shales are dark gray or brown, soft and clayey. The sandstone interbeds are medium to yellowish gray and fine grained.

The Sharon conglomerate predominantly consists of medium to coarse-grained yellowish-brown to pinkish-brown quartz sandstone. In the Cleveland area this sandstone contains thin interbedded layers of pebbles but very little conglomerate is actually present.

1.4.3 Regional Hydrogeology

1.4.3.1 General

According to the definition presented in the Ohio Draft Solid Waste Rule Revisions, Chapter 3745-27-01, "regional aquifer" refers to the aquifer used as a primary source of water to wells within 10 miles of the solid waste facility. Strictly applied to the proposed landfill upgrade, the interpretation of this definition means that there are no regional aquifers in the area. Municipal water in the Cleveland area is obtained from Lake Erie and, therefore, aquifers are not used as the primary source of water. An inventory of municipal water-supply systems by county, conducted by the ODNR, Division of Water in 1977, indicate that municipal

water supplies for Cleveland and nearby communities are obtained from Lake Erie. The ODNR verified the current source of municipal water supply in August 1989. According to the Division of Water, Cleveland and nearby communities currently receive municipal water supplies from Lake Erie. In addition, the well logs at the ODNR and contacts with current property owners indicate that there are no public or private wells within 1 mile of the proposed facility.

However, within Cuyahoga County, ground water occurs in both glacial unconsolidated deposits in buried valleys and bedrock formations. Because the permeable sand and gravel deposits are limited to buried valleys and the bedrock units are generally low yielding, there are no formally-named regional aquifers in the area. Therefore, there is no generally established regional direction of ground-water flow. Ground-water flow, recharge, and discharge are influenced in localized areas relative to the presence and orientation of buried valleys and permeable unconsolidated sediments. As a whole, ground water in the buried valley sediments is expected to flow toward Lake Erie in a similar manner as the surface-water drainage.

Much of the region outside of the major buried valleys consists of unconsolidated lacustrine silty clay or till deposits that provide a very poor aquifer for even minimal water supplies. Much of the glacial till, a heterogeneous mixture of clay, silt and sand deposited directly by the ice mass, is a dense material that does not yield significant volumes of water. In many areas glacial tills with high clay content act as confining units that restrict the vertical flow of ground water between sand and gravel aquifers.

The bedrock units in the Cleveland area are usually poor sources of ground water. However, of the two basic types of bedrock in Cuyahoga County, sandstone and shale, the sandstone

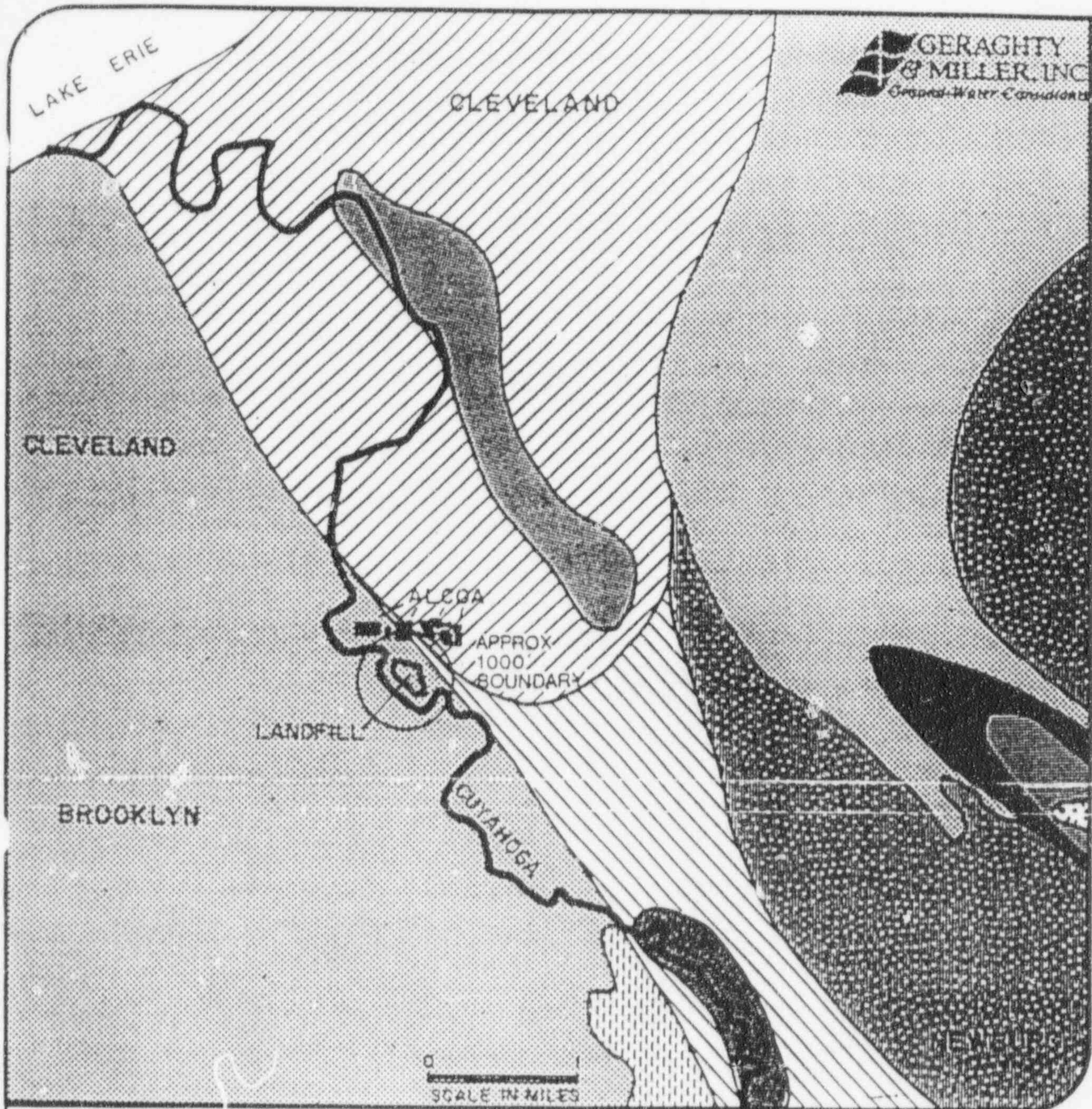
units can potentially provide greater volumes of water because of their increased porosity and permeability. In general, the average yield from the sandstone aquifers in the area is 5 to 10 gpm. The bedrock units generally produce water that is moderate to excessive in dissolved mineral content.

1.4.3.2 Buried Valley Ground-Water Resources

Within Cuyahoga County there are buried valleys that were incised by streams before and during the glacial epoch. Generally, these valleys are in-filled with glacial and lacustrine deposits through which the present rivers have eroded channels. Three of the buried valleys present in Cuyahoga County contain limited sand and silt deposits that form the more predominant water-bearing units. These buried valleys are the Cuyahoga River Valley, Mill Creek Valley, and the Chagrin River Valley.

In its lower reaches the present Cuyahoga River has partially eroded a wide area of sediment that was deposited in a deeper pre-glacial bedrock valley. Generally in this area, ground water may be obtained from buried valley sand and gravel deposits of limited thickness and extent. Cromwell (1979) indicates the permeable deposits may yield from 10 to 35 gpm. However, in this segment of the valley the entire thickness of the valley deposits may be devoid of any permeable sand and gravel zone. In a limited area of the Cuyahoga River Valley lower reach, near Independence, Ohio, sand and gravel deposits are present that may yield from 25 to 100 gpm.

The northern segment of the Cuyahoga bedrock valley, in Cleveland, is located approximately 1 mile east of the present river valley. This is the case for the buried valley in the vicinity of the plant (Figure 1.4-2). Figure 1.4-2 indicates the



MAP SOURCE: CROWELL, 1979

EXPLANATION

- YIELDS 100 TO 300 GPM
- YIELDS 25 TO 100 GPM
- YIELDS 10 TO 25 GPM - SAND, GRAVEL
- YIELDS 10 TO 25 GPM - BEDROCK
- YIELDS 3 TO 10 GPM - SAND, GRAVEL
- YIELDS 3 TO 10 GPM - BEDROCK
- YIELDS LESS THAN 3 GPM
- YIELDS 300 OR MORE GPM

FIGURE 1.4-2

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GROUND-WATER RESOURCES
IN THE CLEVELAND VICINITY

northern portion of a larger area presented in a map by Cromwell (1979). The ancient bedrock valley located east of the plant is very wide and deep; at its lowest point it is at least 500 feet below the ground surface. In this northern section of the buried valley, there is a higher percentage of fine-grained material of lacustrine origin. These deposits consist of thick units of the fine sand, silt and clay that yield very limited water supplies unless thin isolated sand and gravel lenses are encountered.

In the center of the bedrock valley, along a thin axis, is an area where permeable sand and gravel deposits are interbedded with silt and clay (Figure 1.4-2). Yields of up to 300 gpm are available where sufficient coarse material is found in these deposits.

Cromwell (1979) indicates that east and slightly diagonal to the Cuyahoga bedrock valley is the buried valley of Mill Creek. A limited area along the center axis of this valley, immediately northwest of Maple Heights, Ohio, contains sand and gravel deposits capable of yielding up to 1500 gpm. These sediments represent the highest potential ground-water, yielding unconsolidated deposits in Cuyahoga County. Surrounding this high permeability area are slightly larger areas of less permeable sand and gravel deposits capable of yielding 100 to 300 gpm and 25 to 100 gpm each.

North of this area, the Mill Creek bedrock valley becomes shallow and is filled predominately with impermeable clay deposits. These units generally yield less than 3 gpm.

The Chagrin River Valley is located along the eastern edge of Cuyahoga County. This buried valley contains sediments capable of yielding limited supplies of ground water, typically from 3 to 25 gpm. Most of the ground water is obtained from sand and gravel deposits of limited thickness and extent in this area.

1.4.3.3 Bedrock Ground-Water Resources

Of the bedrock units described earlier, the Sharon Conglomerate and the Berea Sandstone exhibit the greatest potential as water-bearing units. Rocks of the Cuyahoga Formation can also yield low volumes of ground water.

Beneath the Berea Sandstone, the rocks are not uniform in their water-bearing capacities. Yields from these rocks are generally low and may vary widely in quality and quantity. It is also common to encounter brine below the Berea Sandstone. The three shale formations that immediately underlie the Berea Sandstone are, in descending order: the Bedford Shale, the Cleveland member of the Ohio Shale, and the Chagrin Shale.

In some areas in the buried valleys where unconsolidated aquifers are present, the water-bearing properties of the nearby bedrock units are improved. In the vicinity of Mill Creek Valley the Berea Sandstone yields greater than average water because of the recharge contributed by the permeable unconsolidated units.

The Sharon conglomerate is generally capable of yielding an average of 5 to 10 gpm. Wells drilled into the Cuyahoga Formation are less yielding, usually 3 to 5 gpm. The Berea Sandstone is probably the most areally extensive of the bedrock aquifers, and wells drilled into this unit usually yield 5 to 10 gpm. In a few areas the Berea Sandstone may yield higher volumes, up to 35 gpm. Most of the ground water in this unit is under artesian pressure and, therefore, the water level in a well rises above the top surface of the sandstone, and in several locations flows at the ground surface.

1.4.4 Site Geology and Hydrogeology

1.4.4.1 General

The site geology and hydrogeology presented in this section is derived from data collected during the current investigation at the existing landfill. As discussed in Section 1.3.4, the study included the drilling of 9 borings to determine geologic conditions, including soil characteristics and lithology. Subsequently, the 9 borings were converted to monitoring wells to establish hydrogeologic properties such as the hydraulic conductivity of the uppermost aquifer, ground-water flow rate and ground-water quality.

This field program was voluntarily implemented by Alcoa prior to the release of the OEPA Draft Solid Waste Rules. Therefore, certain supplemental aspects of the site geology and hydrogeology will be provided through implementation of the Hydrogeologic Site Investigation Work Plan described in Section 1.4.6. However, the required geologic and hydrogeologic information for the PTI has been obtained during the existing investigation. The methodologies and protocol for conducting the existing investigation are discussed in Appendix D: Field Exploration Methodology. In addition, the appendices include: boring logs (Appendix E), soil/sediment sampling logs (Appendix F), monitoring well construction logs (Appendix G), slug test results (Appendix H) and ground-water sampling logs (Appendix I).

1.4.4.2 General Site Geology

The results of this investigation indicate that the materials underlying the proposed landfill upgrade is comprised predominantly of unconsolidated glacial deposits overlying shale and sandstone

bedrock. A detailed description of the site geology is presented in the following sections.

1.4.4.3 Site Stratigraphy

The stratigraphy in the vicinity of the existing landfill includes unconsolidated deposits that are approximately 45 to 55 feet in thickness, and underlain by thick sequences of shale and sandstone bedrock. The unconsolidated deposits increase to 90 feet in thickness north of the landfill near monitoring well AL-4. The unconsolidated sediments in the landfill area are predominantly silty clays or clayey silts, with interbedded silts and sands. The characteristics of these units are typical of lacustrine and fluvial deposits in the Cleveland area. That is, the deposits usually consist of a significant portion of clay or silt followed by lesser amounts of gravel and/or sand.

The boring logs presented in Appendix E contain lithologic descriptions of the soil samples obtained during the field investigation. These descriptions indicate the percentage content in the sample of clay, silt, sand and gravel, as applicable, along with other characteristics. In addition, the logs include a graphic representation of each boring. Figure 1.4-3 indicates the locations in plan view of the generalized cross-sections constructed from these logs (Figures 1.4-4 through 1.4-7).

Examination of the cross-sections indicates several overall characteristics regarding the site stratigraphy. The unconsolidated sediments along the north side of the landfill consist of 4 basic units, including, from the surface downward: 1) fill material; 2) silty clay; 3) clayey silt; and, 4) clay (Figure 1.4-4). Of these units, the clayey silt is considered the uppermost aquifer zone as seen on Drawings PTI6 and PTI7. It is,

LEGEND:

585 — GROUND-WATER ELEVATION CONTOUR

→ GROUND-WATER FLOW DIRECTION

AL-7 — MONITORING WELL

FIGURE 1.4-3

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0 200 400 600
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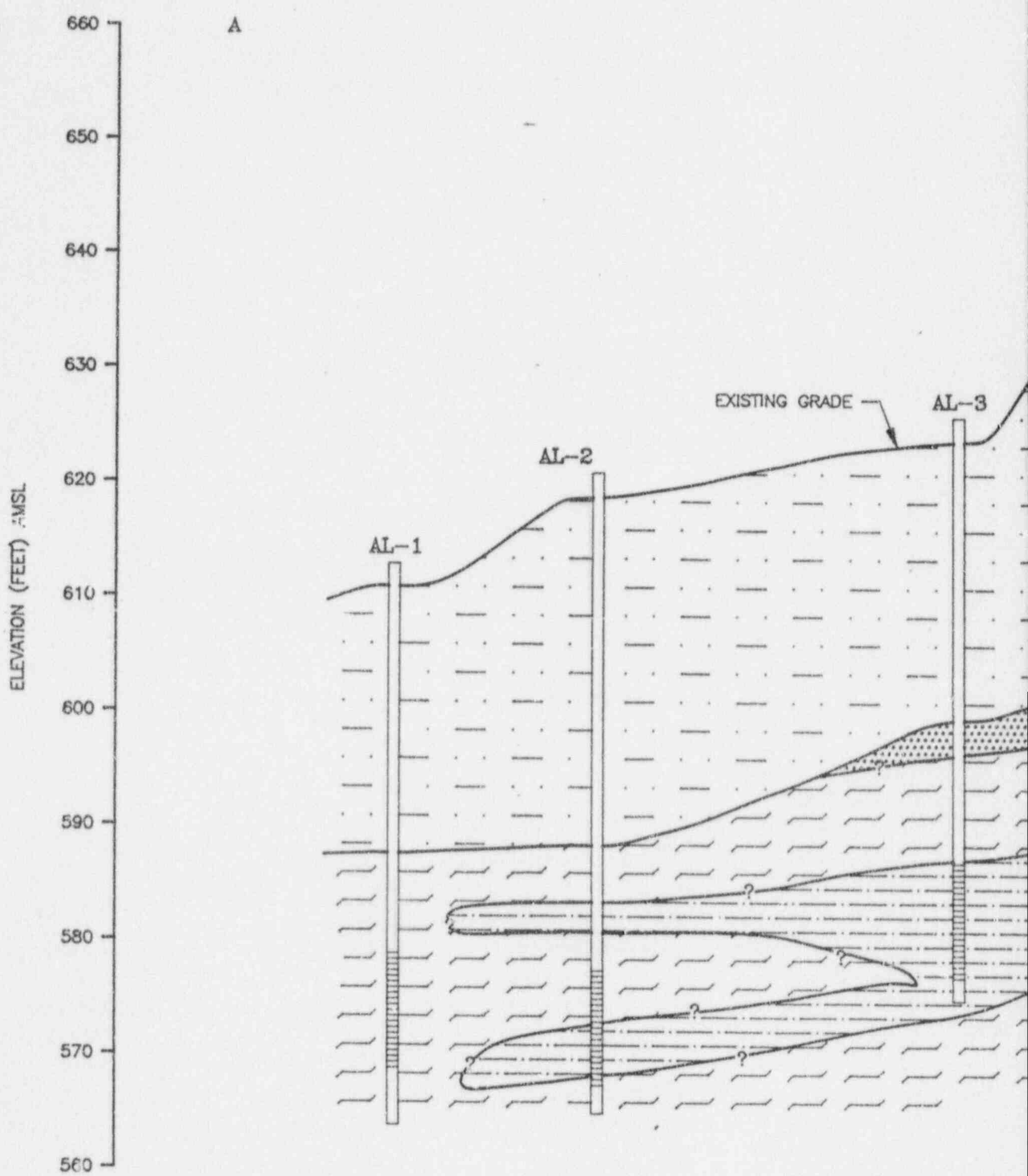
GEOTECHNICAL SITE PLAN



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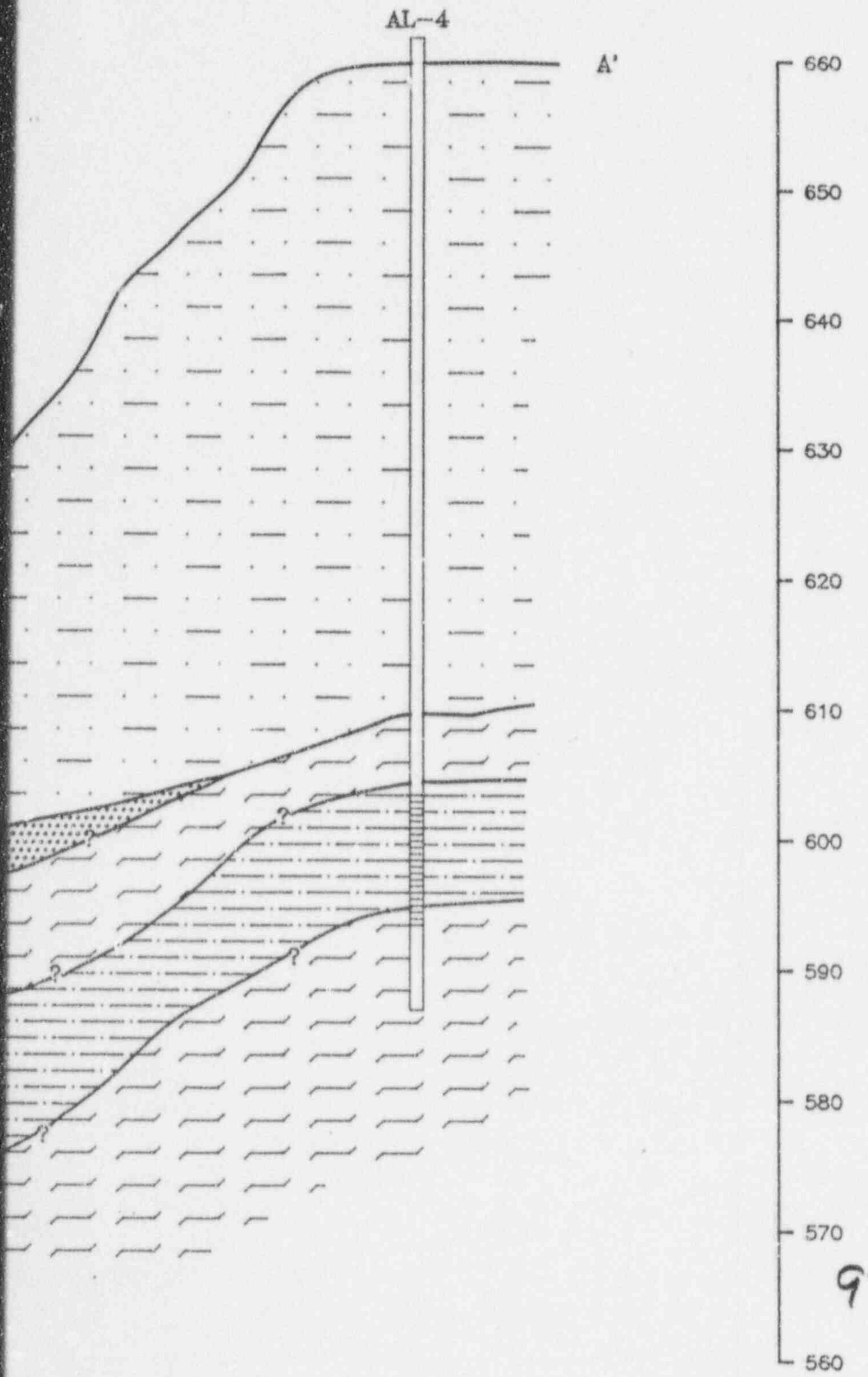

LEGEND

FILL

CLAY OR SILTY CLAY

SILT OR CLAYEY SILT

SAND

AL-4

MONITORING WELL

APPROXIMATE LOCATION OF WELL SCREEN

NOTES:

1. WELL DIAMETER NOT DRAWN TO SCALE.

FIGURE 1.4-4

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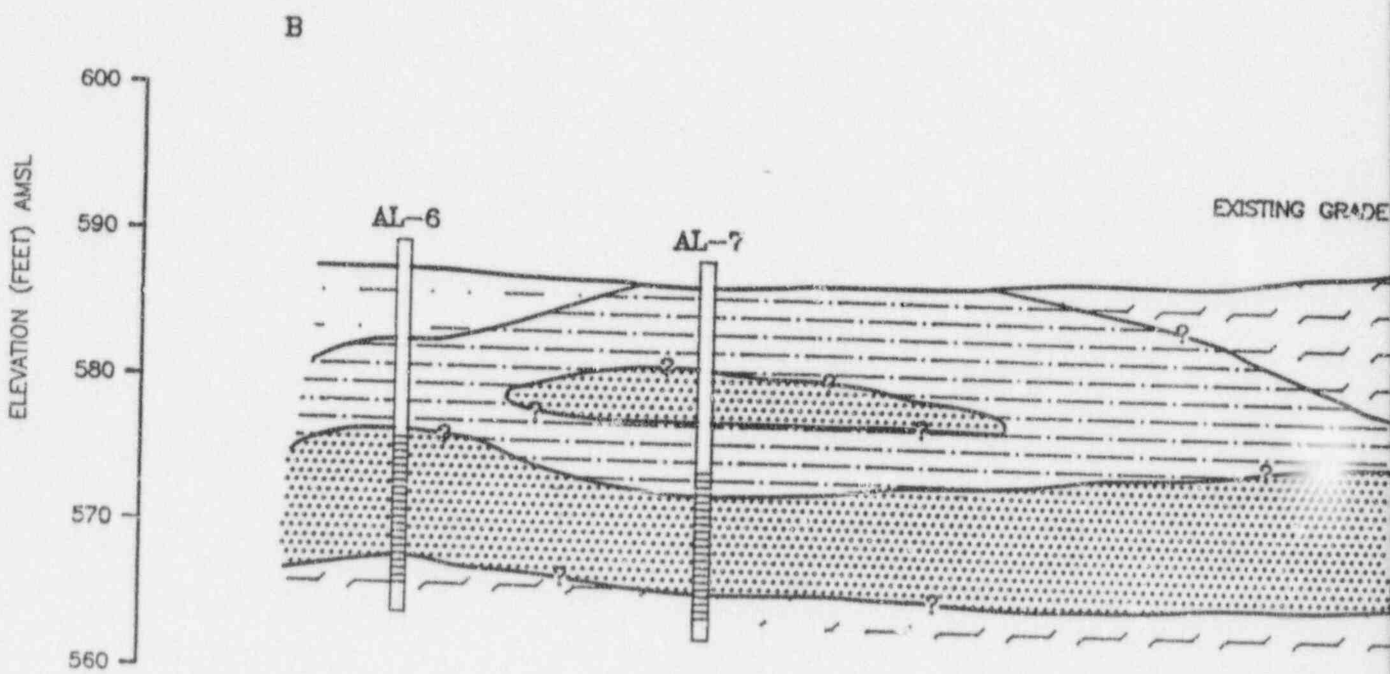
GEOLOGIC CROSS-SECTION
A - A'



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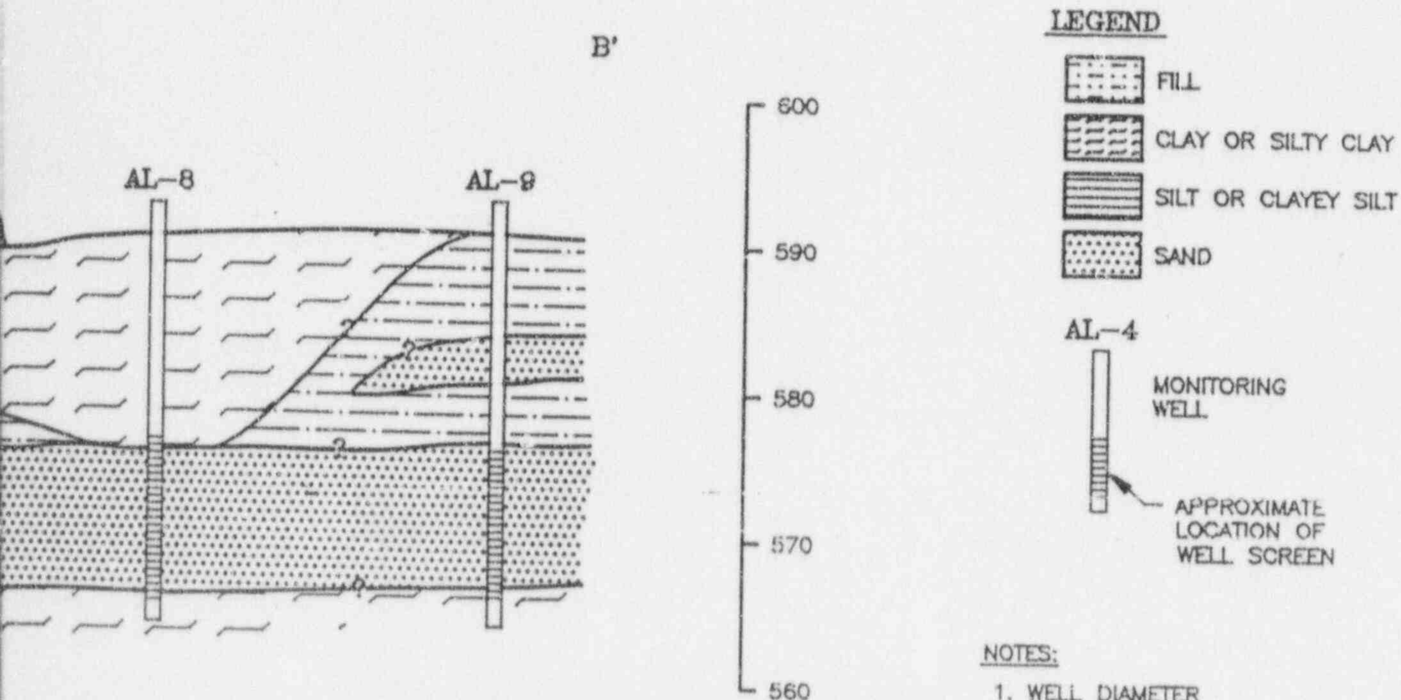

NOTES:

1. WELL DIAMETER NOT DRAWN TO SCALE.

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FIGURE 1.4-5

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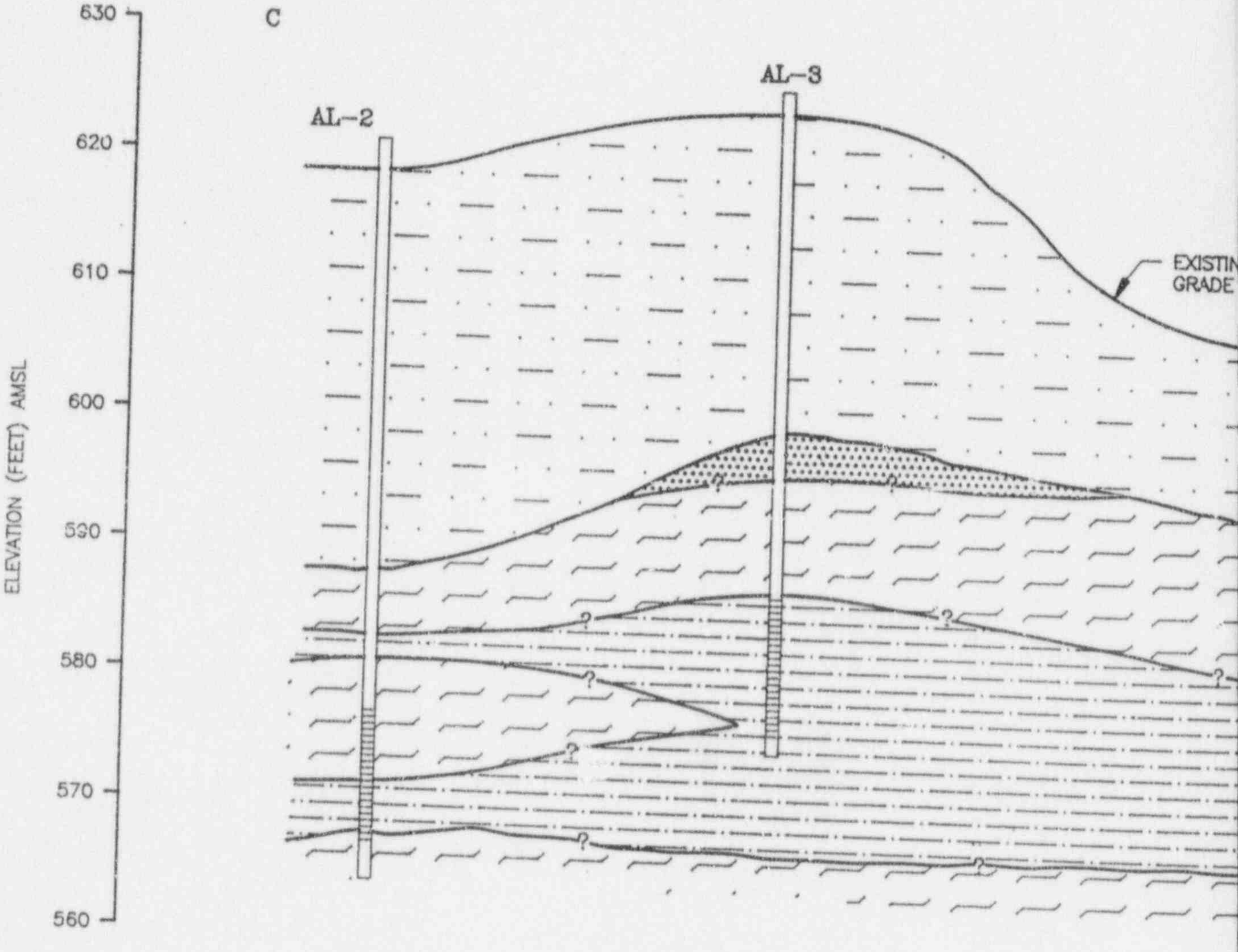
GEOLOGIC CROSS-SECTION
B - B'



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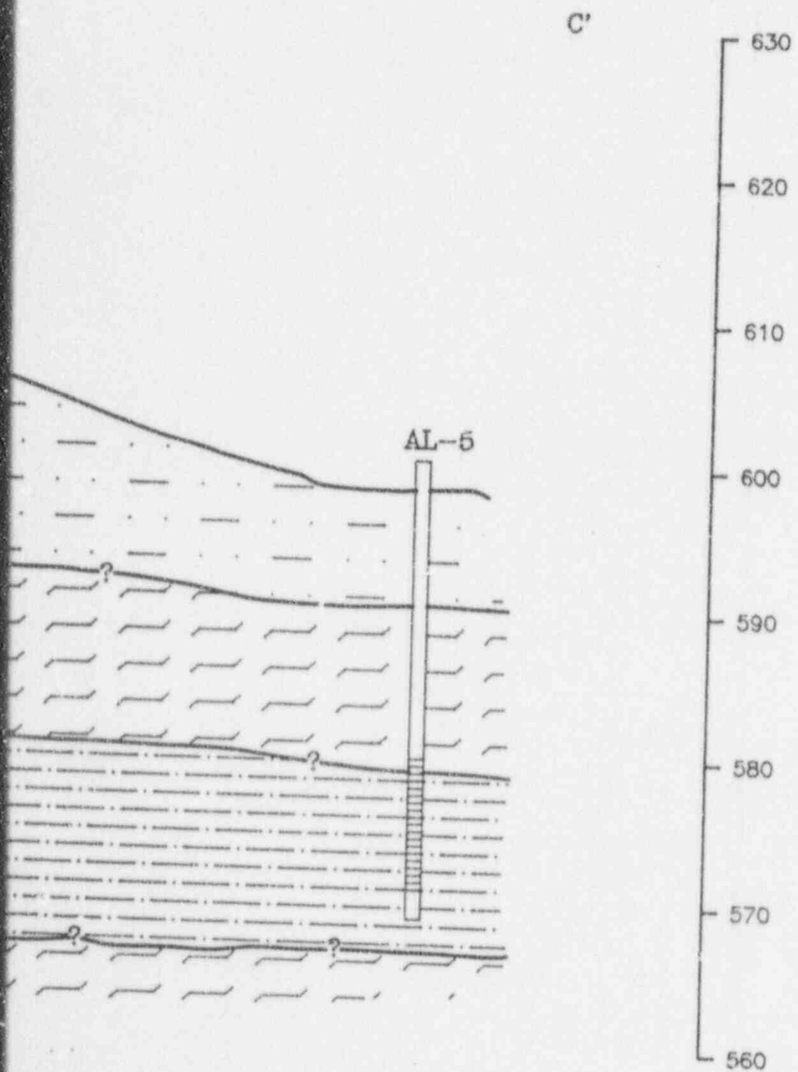

LEGEND

- FILL
- CLAY OR SILTY CLAY
- SILT OR CLAYEY SILT
- SAND

AL-4

MONITORING WELL

APPROXIMATE LOCATION OF WELL SCREEN

NOTES:

1. WELL DIAMETER NOT DRAWN TO SCALE.

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FIGURE 1.4-6

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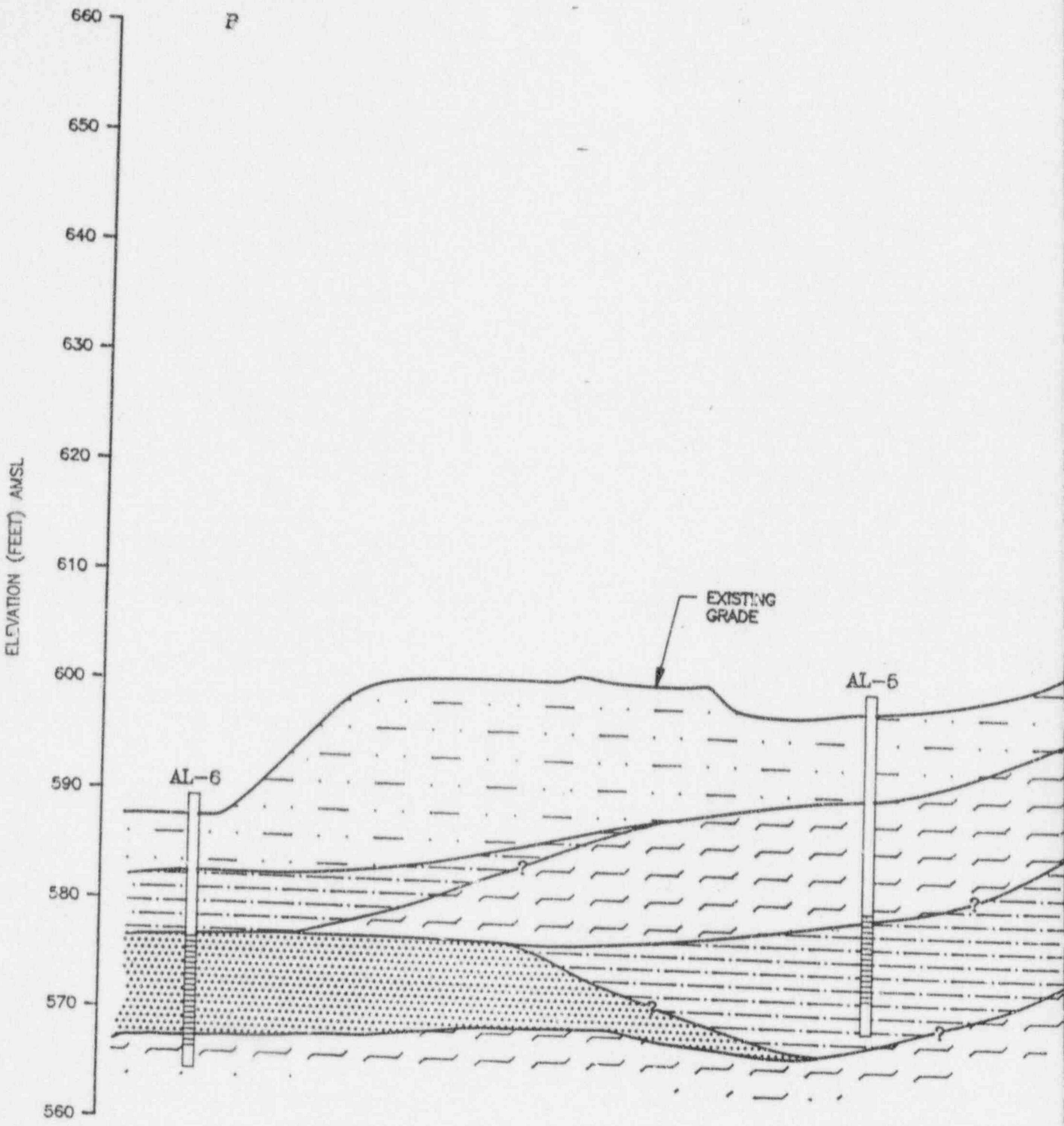
GEOLOGIC CROSS-SECTION
C - C'



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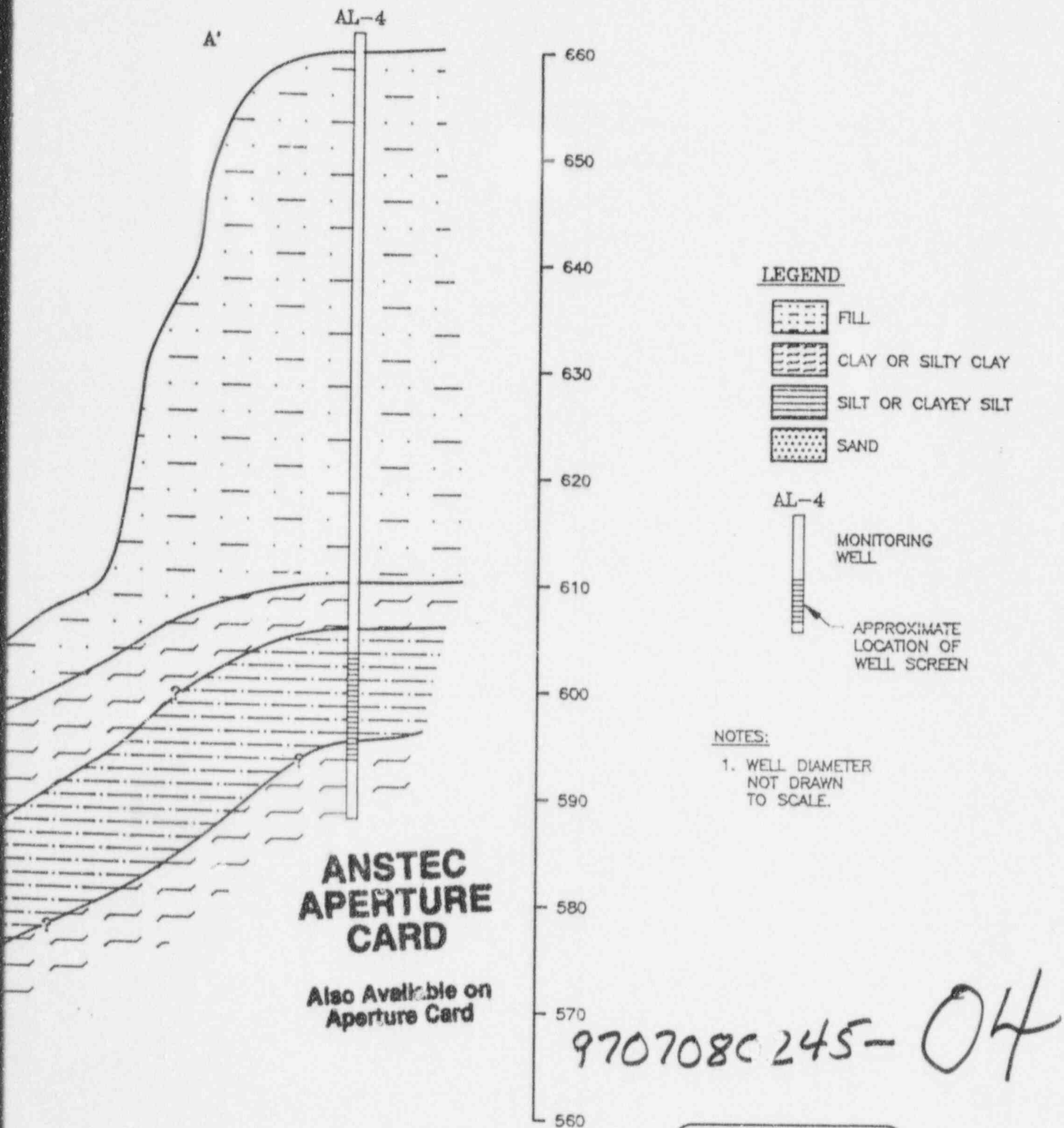

FIGURE 1.4-7

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GEOLOGIC CROSS-SECTION
B - A'

therefore, isolated between 2 relatively impermeable clay zones. This overall stratigraphic pattern appears to occur beneath most of the landfill, but varies in the area south of the landfill boundary, as indicated by cross-section B -B' (Figure 1.4-5). In the area south of the landfill, essentially 2 changes occur. The silty clay unit above the aquifer zone pinches out, and the aquifer zone increases in sand content, with a corresponding reduction in silt and clay.

The thicknesses of the units are indicated on the cross-sections and on the boring logs. The following discussion describes the units in descending elevation from the ground surface. The fill material varies from between approximately 10 and 50 feet in thickness, with the thickest portions occurring north and northwest of the existing landfill. The upper silty clay unit ranges from 0 to approximately 12 feet in thickness. The boring completed for monitoring well AL-1 indicates approximately 21 feet of clay because the underlying clayey silt unit at this location is not evident and the 2 clay units converge.

The clayey silt or sandy silt unit (aquifer zone) ranges in thickness from approximately 10 to 15 feet, according to the boring logs. The range of thickness for the lower clay unit beneath the aquifer zone was not established in all of the borings. However, the bottom clay sample from boring AL-1 contained shale clasts, indicating the presence of bedrock at approximately elevation 565 feet amsl. Assuming that the data obtained from boring AL-1 represents the surface of the bedrock across the site, and utilizing the data from the remaining borings to derive the elevations of the top of the clay unit, the approximate range of thickness of the clay unit was determined. According to these analyses, the thickness of the lower clay unit ranges from between less than 1 foot south of the landfill to approximately 28 feet along the north portion.

The lateral extent of the unconsolidated units has been inferred by interpolating similar lithologies between borings. The cross-sections indicate that the upper silty clay unit extends from beneath the area north of the landfill to approximately the southern edge of the landfill. In the area south of the landfill, the clay is present in a thick deposit near AL-8 but is absent elsewhere as indicated in borings AL-6, AL-7, and AL-9 (Figure 1.4-5). Each of these borings is close to the Cuyahoga River and, therefore, more likely to exhibit surficial sediments that are related to past fluvial action. In particular, there is evidence of silt with interfingering sand lenses is typical of river point-bar deposits.

Beneath the upper clay unit is the uppermost aquifer zone, as identified earlier. This unit appears to be laterally extensive across the landfill, but, as stated previously, it differs in lithologic characteristics across the site. The deepest unconsolidated unit, the clay beneath the aquifer zone, also appears to extend continuously beneath the landfill and surrounding area.

1.4.4.4 Site Geomorphology and Structural Geology

The surface deposits in the vicinity of the existing landfill consist of lacustrine and fluvial deposits and fill material. Topographically, elevations range from approximately 575 feet amsl along the Cuyahoga River to approximately 670 feet amsl north of the landfill in the plant area. The ground surface is relatively flat in the area south of the landfill along the Cuyahoga River floodplain. Toward the north, the topographic gradient increases near the 600-foot elevation along the southern toe of the landfill. The landfill surface gradually rises in elevation toward the north

where the slope steepens at approximately elevation 620 feet amsl. At the 620-foot elevation, a steep rise to the 670-foot elevation north of the landfill in the plant area begins.

Structurally, the geologic units beneath the existing landfill are relatively flat-lying and do not indicate evidence of structural alteration through seismic events.

1.4.4.5 General Site Hydrogeology

The site hydrogeology has been determined through the evaluation of drilling logs, cross-sections, water-level measurements, and slug tests completed in the 9 monitoring wells (Figure 1.4-3). These data indicate that a silty or silty/sandy aquifer zone is present beneath the site, ranging in thickness from approximately 10 to 15 feet. The water-bearing zone is slightly higher in elevation in the area north of the landfill but is relatively flat-lying beneath the proposed landfill upgrade. The depth to the upper surface of the aquifer zone ranges from approximately 12 feet below the ground surface south of the landfill boundary near wells AL-6, AL-7, AL-8 and AL-9, to approximately 55 feet below the ground surface north of the landfill near well AL-4. Laterally, the aquifer zone exhibits variable lithology. Along the north side of the landfill the water-bearing unit contains a large component of silt with secondary amounts of clay. In the area near AL-1, clay dominates the lithology of the water-bearing unit and, consequently, recharge to well AL-1 is very slow. Gradually, toward the south, the aquifer zone increases in sand content so that in the area near wells AL-6, AL-7, AL-8 and AL-9 a predominance of this material is present in the aquifer zone. Generally, wells on the north side of the landfill produce less water than the wells located south of the landfill along the river.

1.4.4.6 Ground-Water Flow/Hydraulic Conductivity

Water-level measurements were obtained in the 9 wells during each of 5 quarterly samplings completed at the site. The fixed monitoring well measuring point and the computed water-level elevation of each monitoring well is presented on Table 1.4-2. These data were utilized to construct ground-water elevation contour maps for each quarter of data (Figures 1.4-8 through 1.4-12). Also, Figure 1.4-11 indicates the seasonal high ground-water elevation at the site from the data obtained during July 1989. According to the data, ground-water flow is consistently toward the south/southwest across the landfill site.

The water table within the study area lies at an elevation of approximately 625 feet amsl near the northeastern portion of the landfill and 575 feet amsl along the Cuyahoga River to the south. With the exception of well AL-1, the elevations in the monitoring wells have changed only slightly during the measurement exams conducted between October 1988 and October 1989. The water level in AL-1 increased 19.63 feet between January and April 1989, and the July and October 1989 measurements indicate that the elevation in well Al-1 has maintained the higher level. Each data set of measurements is provided on Table 1.4-2 for comparative purposes.

Hydraulic gradients of 0.07, 0.03 and 0.01 for the northeast, site-wide average, and southern portions of the area, respectively, have also remained fairly constant between the 5 sampling events. The hydraulic conductivity for the aquifer zone was determined through the use of field slug tests conducted during November 1988 and September 1989. Details of the methodology utilized to conduct the tests and the procedures for analyzing the data are included in Appendix D: Field Exploration Methodology. The calculated

TABLE 1.4-2

Ground-Water Elevations

Well	Measuring Point Elevation*	Water Level Elevation*				
		10/12/88	01/16/89	04/17/89	07/18/89	10/23/89
AL-1	612.46	576.54	569.88	589.44	589.51	589.74
AL-2	620.05	580.83	581.86	582.75	583.84	582.14
AL-3	624.70	595.12	595.56	595.87	595.88	595.80
AL-4	659.76	622.06	624.03	624.72	625.95	625.00
AL-5	599.67	583.15	587.24	587.91	585.82	586.99
AL-6	589.27	573.88	575.95	575.75	574.44	575.29
AL-7	588.61	573.81	575.90	576.07	574.62	575.30
AL-8	591.22	573.37	576.50	578.37	576.94	576.37
AL-9	591.40	573.92	576.08	577.45	576.54	575.87
River	578.31	--	--	--	573.61	574.95

* All elevations are in feet, amsl

FIGURE 1.4-8

DRAWING NO:	
DRAWN BY:	DATE:
CHECKED BY:	DATE:
APPROVED:	DATE:

0 200 400 600
SCALE: FEET

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ANNAPOLIS, MARYLAND

PERMIT - TO - INSTALL
ALCOA INDUSTRIAL LANDFILL

GROUND-WATER ELEVATIONS AND FLOW DIRECTION (OCTOBER 1988)

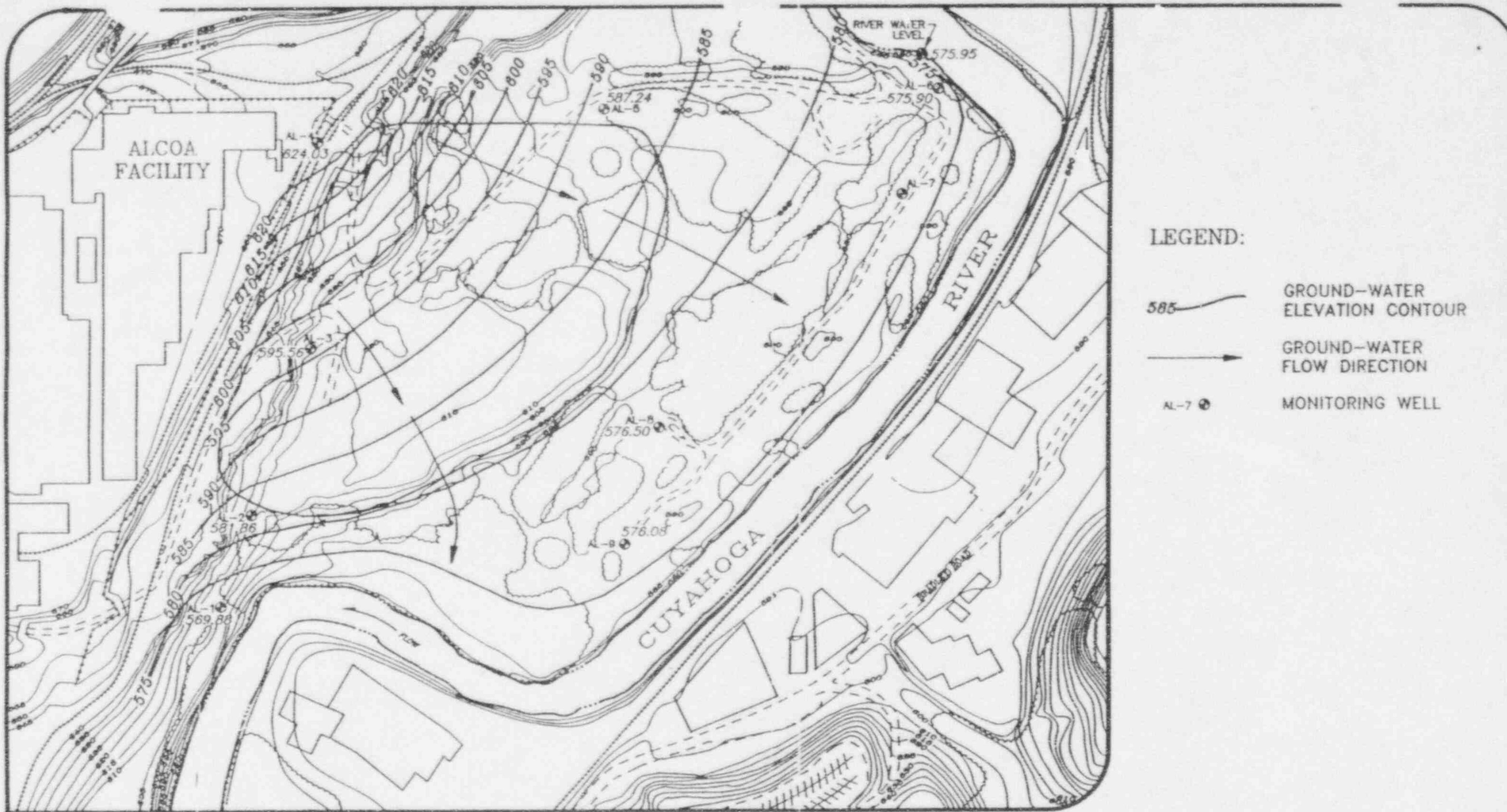

FIGURE 1.4-9

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APPROVED:	DATE:

0 200 400 600
SCALE: FEET

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ALCOA INDUSTRIAL LANDFILL

GROUND-WATER ELEVATIONS AND
FLOW DIRECTION (JANUARY 1988)

LEGEND:

585 — GROUND-WATER ELEVATION CONTOUR

→ GROUND-WATER FLOW DIRECTION

AL-7 ⊕ MONITORING WELL

FIGURE 1.4-10

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DRAWN BY:	DATE:
CHECKED BY:	DATE:
APPROVED:	DATE:

0 200 400 600
SCALE: FEET

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FIGURE 1.4-11

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CHECKED BY:	DATE:
APPROVED:	DATE:

0 200 400 600
SCALE: FEET

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GROUND-WATER ELEVATIONS AND FLOW DIRECTION (JULY 1989)

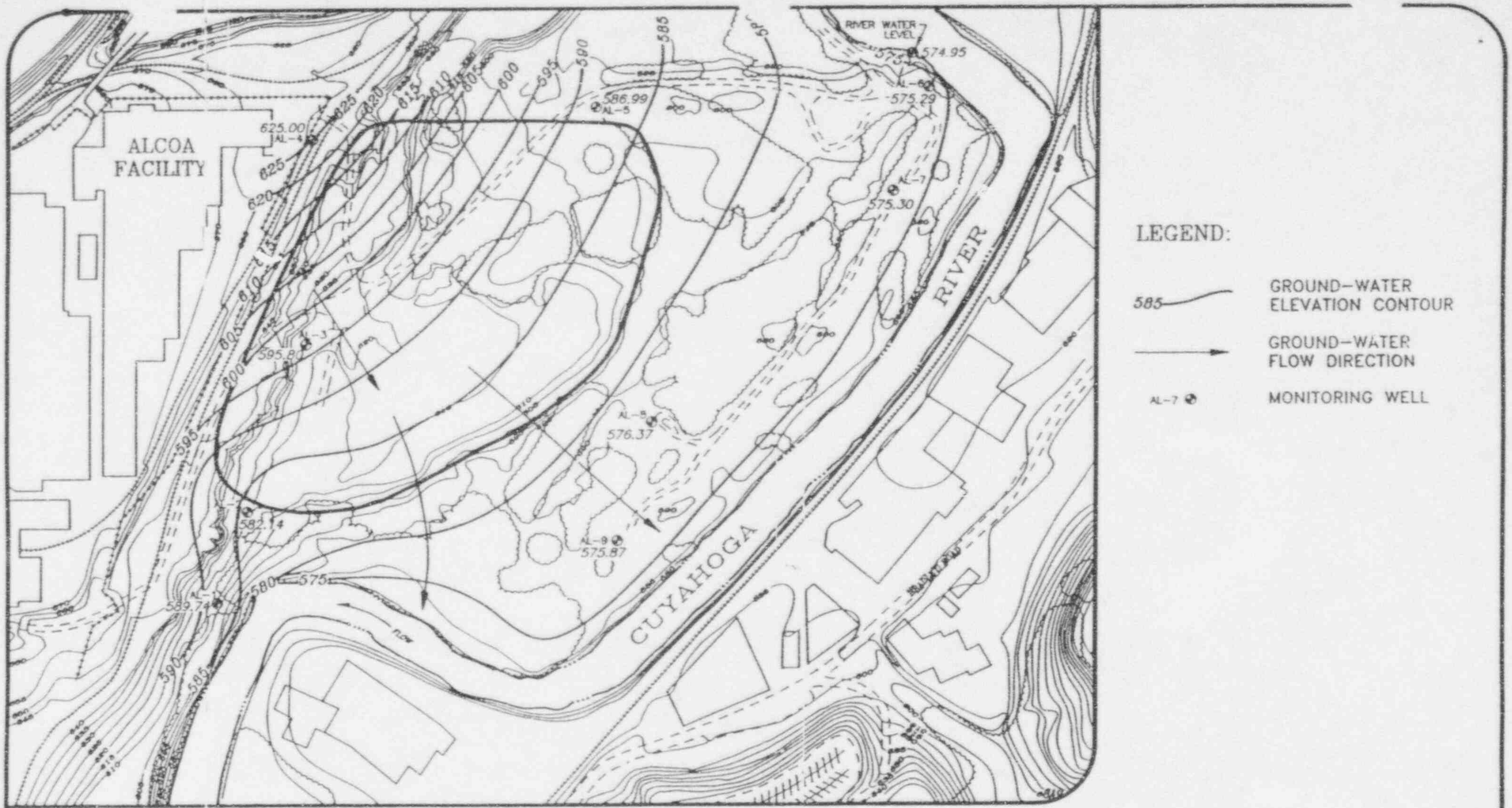

FIGURE 1.4-12

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APPROVED:	DATE:

0 200 400 600

SCALE: FEET

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hydraulic conductivities are listed on Table 1.4-3. Utilizing the hydraulic conductivity values and estimated porosity values (Table 1.4-3), a rate of flow of ground water beneath the landfill was calculated. Average flow rates for the northern portion and the southern portion of the site were determined to be approximately 0.005 and 1.16 feet per day, respectively. These flow rates were determined by averaging the values of hydraulic conductivity from wells AL-1 through AL-5 to represent the northern portion of the landfill, and wells AL-6 through AL-9 to represent the southern portion of the landfill. Based on these data, the highest rate of ground-water flow occurs along the southern portion of the landfill.

These data are consistent with the observed ground-water flow direction and hydraulic gradient determined for the site. Generally, given a uniform area and quantity of available water, hydraulic conductivity and hydraulic gradient are inversely proportional. Therefore, it is expected that lower hydraulic conductivity values will be observed in areas of higher hydraulic gradient, versus higher hydraulic conductivity values in areas of lower hydraulic gradient. However, the surface topography will also influence the hydraulic gradient at the site. A comparison of the hydraulic gradient (indicated by the relative spacing of contours on the ground-water flow maps) to the values of hydraulic conductivity listed on Table 1.4-3 indicates the presence of the expected relationship between the hydraulic gradient and the hydraulic conductivity. Additionally, the steeper topographic gradient in the northern area of the landfill contributes to the higher hydraulic gradient in this area. Conversely, the lower hydraulic gradient south of the landfill is partially a result of the flatter topographic slope.

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TABLE 1.4-3

Slug Test Hydraulic Parameters
(Revised, September 1989)

Well #	Hydraulic Conductivity (ft/day)	Estimated Porosity (%)
AL-1	3.6×10^{-3}	30
AL-2	1.8×10^{-2}	
AL-3	1.1×10^{-2}	
AL-4	5.7×10^{-2}	
AL-5	1.3×10^{-2}	
AL-6	7.2	15
AL-7	15.4	
AL-8	43.4	
AL-9	3.8	

The pattern of the distribution of hydraulic conductivities and hydraulic gradients at the landfill is directly related to the lithology of the unconsolidated deposits in the area as well as the surface topography. During the field investigation, the aquifer unit in the northern area of the landfill was documented to consist predominantly of a silty/clayey material, whereas the deposits toward the southern portion of the landfill along the river contain a higher percentage of sandy material. Therefore, it was expected that the silty/sandy upper aquifer unit in the vicinity of the river would be slightly more permeable and, consequently, have higher hydraulic conductivity values than the less permeable silty/clayey units to the north.

In summary, the ground-water flow data supports the south/southwest ground-water flow direction. Also confirmed is the presence of a steep hydraulic gradient in the north/northeast portion of the landfill, with a corresponding lower hydraulic conductivity and rate of ground-water flow, and a moderate hydraulic gradient in the southern portion of the area, with a higher hydraulic conductivity and rate of ground-water flow. The evaluation of the ground-water flow data compared to the river level indicates that ground water in the uppermost aquifer beneath the landfill discharges to the Cuyahoga River (Figure 1.4-11).

1.4.4.7 Ground-Water Recharge

Ground-water recharge in the vicinity of the landfill is influenced predominantly by precipitation, surface topography and the lithology of the uppermost aquifer and the overlying strata. As discussed previously, the water-bearing zone in the north area of the landfill is fairly impermeable and is overlain by a clay confining layer. The surface topography of this area of the landfill also has a steeper slope than the southern portion of the

landfill site. This ground-surface slope and the characteristics of the aquifer and confining layer influence the recharge in the northern portion of the landfill. Lateral recharge to the uppermost aquifer in the northern area of the landfill is probably limited because the low permeability of the aquifer zone precludes significant recharge by ground-water from upgradient portions of the aquifer zone. Most of the precipitation which would produce vertical recharge to the aquifer in this area is removed by surface drainage to the south due to the steep topography. The boring logs for monitoring wells located on the north side of the landfill indicate that the sediments above the uppermost aquifer are damp and moist; however, the upper clay confining unit acts as a barrier to vertical recharge of the aquifer in this area.

In the central portion of the landfill the recharge is altered slightly due to the change in surface topography. On the east-central portion of the landfill there is evidence of a several small ponds. In this area the surface topography is rather flat (Figure 1.4-7) permitting precipitation and surface run-off from the north to collect at the surface. Most of these ponds appear to be seasonal, although one pond directly east of the Alcoa property boundary perennially contains water. Recharge to the uppermost aquifer in the east-central area is limited by the same vertical and lateral constraints described for the north section, above. However, there is evidence from one boring (AL-5) of a thin zone of perched water on the surface of the upper clay confining layer. Because of the lower topographic gradient in this area, and therefore decreased surface drainage, the fill is probably more readily saturated during wet seasons. As the fill material becomes more saturated, ponding occurs at the surface and a thin zone of perched water may form along the surface of the upper clay unit along the east-central portion of the landfill. Any perched seasonal water in the fill material is under unconfined; i.e.,

water table, conditions and would probably flow toward the south/southwest across the site, similar to the direction of ground-water flow. In the active west-central portion of the landfill no surface ponding is evident. Borings AL-2 and AL-3 indicated damp or wet, but not saturated, sediments above the uppermost clay layer.

The southern vicinity of the landfill appears to be the area where recharge primarily occurs. Except for AL-8, borings in this area did not indicate the presence of the clay confining unit above the uppermost aquifer (Figure 1.4-5). In addition, the uppermost aquifer in this area is more permeable. The lack of the clay unit therefore allows vertical recharge to the upper aquifer from precipitation and surface run-off. Along the southern landfill boundary, there is some evidence of surface run-off drainage to the south; in the area south of the landfill there is no evidence of surface-water ponding. Therefore, it is likely that precipitation and surface-water run-off infiltrate the shallow sediments in this area. There were no obvious seeps or springs observed at the landfill throughout the field investigations.

1.4.5 Soil and Ground-Water Quality

1.4.5.1 General

A ground-water investigation at the existing landfill was implemented during August 1988 in response to Alcoa's voluntary desire to evaluate conditions in the vicinity of the landfill. During the drilling of the 9 monitoring well borings, 1 soil sample was collected from each boring for analysis. The soil samples, which were selected based on HNU headspace readings, were analyzed for the suite of priority pollutant compounds, including volatile organic compounds (VOCs), semi-volatile organic compounds, and polychlorinated biphenols (PCBs).

Currently, 5 quarterly ground-water sampling events from the 9 monitoring wells have been completed. The ground-water samples were collected following the sampling and Quality Assurance/Quality Control (QA/QC) protocols described in Appendix D. Water-quality data from the initial 4 sampling events have been evaluated.

1.4.5.2 Soil Quality

The analytical results of the soil samples collected during drilling are summarized on Table 1.4-4. Samples from 2 borings (AL-7, AL-8) were not submitted for analysis because the HNU headspace readings were either 0 or below 1 part per million (ppm). Table 1.4-4 lists only those parameters that were detected in one or more the soil samples. All additional priority pollutants that are not listed on the table, and spaces left blank, indicate no detection of those compounds. As indicated on Table 1.4-4, 6 of the 7 soil samples analyzed contained detectable concentrations of at least 1 priority pollutant compound. Concentrations of the compounds detected, however, were relatively low; all concentrations were 2 ppm or less, and most were less than 0.6 ppm. Only 2 of the soil samples analyzed contained more than 1 compound.

1.4.5.3 First-Quarter Ground-Water Sampling

The first quarter of ground-water sampling was conducted during October 1988. A list of the constituents analyzed and the corresponding concentration that was detected in each monitoring well is presented on Table 1.4-5. In addition, results from the set of duplicate samples, second samples of all constituents from AL-6, are included on Table 1.4-5. The duplicate set of samples was utilized to assess data reproducibility. Also indicated on Table 1.4-5 are the results from the equipment blank, which is used

TABLE 1.4-4

Priority Pollutants Soil Analytical Results

Parameter[1]	AL-1 (9-11')[2]	AL-2 (20-22')	AL-3 (0-2')	AL-4 (20-22')	AL-5 (10-12')	AL-6 (15-17')	AL-9 (2-4')
Di-N-Butyl Phthalate		0.44 mg/kg			0.54 mg/kg	0.50 mg/kg	
Methylene Chloride	188 ug/kg						
1,2-Dichloroethene (total)			13 ug/kg	6 ug/kg			
PCB-1248			340 ug/kg				
Tetrachloroethene			55 ug/kg				
Toluene			11 ug/kg				
Trichloroethene			20 ug/kg	8 ug/kg			
Naphthalene				2000 ug/kg			
Ethylbenzene				14 ug/kg			

1 Spaces left blank indicate nondetectable concentrations
2 Depth collected below existing ground surface