Technical Memorandum

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Hydrogeological Characterization
of "Back Forty Area"

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FOREWORD

The hydrogeological investigation reported in this document was a joint effort of the Environmental Research Division and the Occupational Health and Safety Division of Argonne National Laboratory. The investigation was undertaken as part of a Formerly Utilized MED/AEC Sites Remedial Action Program survey to assess the radioactive contamination at the U.S. Bureau of Mines' Albany Research Center in Albany, Oregon. The investigation was not intended to provide a comprehensive analysis of all hydrogeological factors in the area of the Albany Research Center; instead, it was designed to answer specific questions pertinent to radiological conditions at the site.

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INTRODUCTION

The Albany Research Center (ARC), operated by the U.S. Bureau of Mines, is located in the western part of Albany, Oregon (Fig. 1). During the Manhattan Engineer District/Atomic Energy Commission era, work involving radioactive materials was performed at the site. The wastes generated from the Bureau of Mines operations were disposed of at the southeastern corner of the fenced portion of the ARC site (Fig. 2).

Recently, radiological surveys were conducted by Argonne National Laboratory to determine the potential migration of radionuclides from the waste area to the area commonly referred to as the "Back Forty". The Back Forty is a 5.7-ha (14-acre) area located in the southern portion of the ARC site (Fig. 2). The survey results (Wynveen et al. 1983) indicated that parts of the Back Forty contain soils contaminated with uranium, thorium, and their associated decay products. However, the extent of radionuclide migration was not fully determined.

A hydrogeologic characterization study was conducted at the Back Forty as part of an effort to more thoroughly assess radionuclide migration in the area. The objectives of the study were: (1) to define the soil characteristics and stratigraphy at the site, (2) to describe the general conditions of each geologic unit, and (3) to determine the direction and hydraulic gradient of areal groundwater flow. The site investigation activities included literature review of existing hydrogeological data for the Albany area, onsite borehole drilling, and measurement of groundwater levels.

CLIMATE

The Albany area has a temperate climate, characterized by wet winters and dry summers. Topography, proximity to the Pacific Ocean, and exposure to middle-latitude westerly winds are the principal climatic controls.

Figure 1. Location of Bureau of Mines Site.

Figure 2. Map of Bureau of Mines' Albany Research Center Showing Location of Back Forty Area.

The average annual precipitation in the area is about 100 cm (39 in), occurring principally as rain. The wettest period of the year is November through January, when about 45% of the average annual precipitation occurs. In July and August, normal precipitation is less than 13 mm (0.5 in), and occasionally in midsummer no rain falls for periods of 30 to 60 days.

TOPOGRAPHY AND DRAINAGE

The general area surrounding the Back Forty is part of a broad alluvial plain that lies between the Cascade and Coast Ranges in the Central Willamette Valley. The lowland part of the area is an alluviated plain with irregular bottomlands along the streams, which are 1.5 to 9 m (5 to 30 ft) below valley-plain terraces. The valley-plain and associated terraces are practically all level or gently rolling and have elevations ranging from 60 to 90 m (200 to 300 ft) above mean sea level (MSL). The western margin of the area consists of isolated hills and ridges of the Coast Range, which rise to elevations of 150 to 460 m (500 to 1500 ft) MSL. To the east, a series of isolated hills rise above the valley floor to elevations of 90 to 430 m (300 to 1400 ft) MSL. The land surface elevations at the Bureau of Mines site range from 69 m (225 ft) MSL in the north to 66 m (215 ft) MSL in the south.

The Albany area is drained primarily by the Willamette and Calapooia Rivers (Fig. 1). The Willamette River, which is the major stream, generally flows northward and then turns eastward in the Albany area. The Calapooia River provides much of the local drainage for the Back Forty area and flows into the Willamette River north of the site. The Albany-Santiam Canal is about 1 km (0.6 mi) east of the Back Forty area. The water surface elevation in the canal is about 70 m (230 ft) MSL.

SOILS AND GEOLOGY

Soils contiguous to and on the Back Forty site consist of various types of silt loam. Distribution of the soil types on the site is shown in Figure 3. Soil characteristics presented in Table 1 indicate that the depth of the soils

Figure 3. Soil Distribution in the Back Forty Area.

Table 1. Soil Characteristics of Back Forty Site

Map Symbol	Soil Type	Depth (m)	Subsoil Permeability	Position	Slope (%)	Problems	Remarks
200 A	Amity silt loam	1.5	Slow	Gently sloping terrace	0 - 3	Internal drainage; sheet erosion	The available moisture is high (20-30 cm) for total profile; soil is medium acid.
210 A	Concord silt loam	1.5	Slow	Gently sloping terrace	0 - 3	Surface and internal drainage; erosion	The available moisture is high (20-30 cm) for total profile; soil is poorly drained; pH is low.
220 A	Dayton silt loam	0.3-0.5	Very slow	Nearly level terrace	0 - 3	Surface and internal drainage	The drainage is poor and the pH is low.
250 A	Woodburn silt loam	1.5	Moderately slow	Gently sloping terrace	0 - 3	Internal drainage; sheet erosion	The available moisture is high (20-30 cm) for total profile. The soil is moderately well drained, with an average pH of about 6.4.

Source: U.S. Soil Conservation Service, Corvallis, Oregon, Office. 1983. Personal communication.

varies from 0.3 to 1.5 m (1 to 5 ft). Also, soils in the area generally have high moisture content and are slightly acidic. Internal drainage and erosion are the principal problems associated with these types of soil.

The geologic units in the Albany area consist of consolidated rocks and unconsolidated deposits (Beaulieu et al. 1974; Frank 1974). The principal bedrock units include the Siletz River Volcanics, the marine Tyee, Spencer, and Eugene formations (fine-grained sandstone, siltstone, and shale), the intrusive igneous rocks, and the Little Butte Volcanic Series. Consolidated rocks in the upland parts of the Albany area yield small quantities of water to wells, but such rocks at depth beneath the valley fill generally have low permeabilities and therefore do not readily transmit water to wells.

The unconsolidated material consists of isolated terrace deposits, older alluvium (Pleistocene and Holocene age), which underlies the valley plain, and the younger alluvium (Holocene age), which is coextensive with the present floodplain of the Willamette River. The terrace deposits are dissected deposits of gravel, silt, clay, and sand that generally rest on a bedrock shelf at some elevation above the valley plain. Where the deposits are sufficiently thick to hold and store water, they yield small to moderate quantities of water to wells.

The older alluvium, together with the younger alluvium, forms the principal and the most productive aquifer in the area. Included in the older alluvium are the Willamette silt, as mapped by Allison (1953), and thin, younger alluvial deposits of fine sand and silt that are present along the minor streams. Below a thickness of 1.5 to 4.5 m (5 to 15 ft) of Willamette silt, the alluvium is composed of interconnected lenses of coarse sand and gravel derived from volcanic rocks and interspersed with fine sand and silt. Below a depth of about 15 m (50 ft), the coarser alluvial deposits grade into and interfinger with lenses of sand, silt, clay, and pebbles.

The younger alluvium contains materials that in most places yield large quantities of water to wells. These deposits consist of cobbles, coarse gravel, sand, and a small proportion of silt, and they have an average thickness of about 11 m (35 ft). In a few places (probably less than 10% of the

total outcrop area), the deposits contain so many fine particles interspersed with the sand and gravel that water is yielded slowly to wells. Although not extensive, these fine-grained deposits may locally impede the infiltration of water from the river. Such infiltration is necessary for some of the wells to sustain large withdrawals.

A geologic section crossing the Back Forty area is indicated in Figure 4. Based on data from drillers' logs of water wells, the distribution and thickness of various geologic units along this section are shown in Figure 5 (Frank 1972; Oregon Water Resources Department 1983). Evaluation of the well-log data shows that the Back Forty area is underlain by sand and gravel deposits interspersed with a mixture of sand, silt, and clay. In Well 11s/4w-12ccd, which is about 600 m (2000 ft) northwest of the Back Forty, the sand and gravel strata lie between a clay layer and shale of the Spencer Formation. Groundwater contained in these strata may be under confining pressure (Frank 1974).

REGIONAL GROUNDWATER MOVEMENT

The principal source of groundwater recharge in the area is infiltration of precipitation. Most of the precipitation evaporates, some is transpired to the atmosphere by vegetation, some runs off, and the rest infiltrates into the ground. Part of the water that infiltrates is retained as soil moisture, and the remainder percolates downward to the zone of saturation.

Groundwater in the area occurs under perched, confined, and unconfined conditions (Piper 1942; Frank 1974). Most of the wells that penetrate the consolidated rocks draw water from aquifers perched above the regional water table. A few of these wells produce water from the main saturated zone or from confined water bodies. The unconsolidated deposits of older and younger alluvia that underlie the valley plain are the most productive aquifers in the Albany area and are feasible for large-scale development of groundwater. Most of the groundwater in the alluvium is unconfined; however, at a few places groundwater in these deposits is confined seasonally. Many of the fine-sand strata lie between clay and silt layers in the alluvium and contain water

Figure 4. Selected Geologic Section Crossing the Back Forty Area.

Figure 5. Details of Geologic Cross Section of the Back Forty Area.

under a small confining pressure. In late winter and early spring, pressure builds such that water rises above the land surface in some wells. However, during much of the year water levels in the wells are typical of a water-table system.

Groundwater moves from areas of recharge to areas of discharge. The aquifers in the study area are recharged mostly during late autumn and winter, which are the seasons of greatest precipitation. Discharge from aquifers usually occurs through seeps and springs adjacent to or in stream channels, through evapotranspiration in areas where the water table is near the surface, and through pumping from wells. Discharge through seeps and springs helps to sustain the flow of the local streams.

A contour map showing the shape and slope of the groundwater table in the Albany vicinity is presented in Figure 6. The water levels were based on available well-log data, and the contours were drawn by connecting points on the water table that have the same elevations. It should be noted that groundwater levels in the unconsolidated alluvial deposits can generally fluctuate about 3 to 4 m (10 to 12 ft) during the year (Frank 1974).

It can be inferred from the contour map that in the study area, groundwater generally moves from the edges of the valley plain toward the Willamette River and in a downstream direction. In the Back Forty area, groundwater appears to be moving northwesterly towards the Calapooia River. The widely spaced contours in the Back Forty area also indicate that the slope of the water-table surface in the study area is gentle. This is probably due to a greater transmissivity of the materials in the site area through which the water is moving.

LOCAL GROUNDWATER MOVEMENT

A network of drain tiles was installed in the Back Forty area in 1967 by the U.S. Soil Conservation Service for an Albany High School project (Fig. 7). On the average the tiles are about 1.2 m (4 ft) below the ground surface. The

Figure 6. Water-Level Contours in the Albany Area.

tiles are arranged such that part of the percolating water is drained from south to north and is intercepted by a collecting drain tile near the contaminated area. The collecting drain tile extends from east to west and discharges at an outfall along Queen Avenue, with some leakage at a ditch along Broadway street (Fig. 8). Near-surface flow in the Back Forty area is controlled by the drain tiles and, for most of the area, is from south to north. Part of the water that infiltrates through the contaminated area (Fig. 7) could flow toward the main tile drain (because of the low hydraulic

Figure 7. Distribution of Drain Tiles in Back Forty Area.

Figure 8. Tile Field Outfall Location.

head there) and be collected by the drain tiles. Water that is not intercepted by the drain tiles will continue to percolate downward to the groundwater system.

To evaluate groundwater flow characteristics in the Back Forty area, 15-cm (6-in) boreholes were drilled at each corner of the Back Forty property (Fig. 9) in July 1983. The results of the drilling indicated that groundwater at the site occurs in sand and gravel strata and is confined by the overlying clay and silt layers. Three boreholes (Nos. 7-S151, 7-S153, and 7-S154) were drilled to a depth of 4.6 m (15 ft). Subsurface water was first encountered in these three boreholes at a depth about 2.7 to 4.3 m (9 to 14 ft) below the existing grade level. Because of the confining pressure, the water level in these three holes rose gradually and in about one day reached a static level ranging from 0.9 to 2.0 m (3 to 6.5 ft) below grade level. Borehole 7-S152 in the southwestern corner was drilled to a depth of 7.6 m (25 ft) without encountering subsurface water. A small amount of water was observed in the hole the day after drilling. However, this water was believed to be caused by the subsurface seepage of infiltrating water rather than the local groundwater flow. A similar situation was observed in an adjacent hole (No. 7-S166) about 15 m (50 ft) east of borehole 7-S152.

After the boreholes were drilled, ground surface and equilibrium water levels were determined by transit using the reference elevation of 68.68 m (225.34 ft) MSL at a bench mark located at the northwest corner of the U.S. Bureau of Mines property (Fig. 8). The survey results at boreholes 7-S151, 7-S153, and 7-S154 are shown in Table 2. Using the static water levels in three boreholes, the groundwater contours and flow direction were delineated as shown in Figure 9. The results indicate that groundwater in the Back Forty area flows southwesterly from the contaminated area through the southern portion of the Back Forty with a hydraulic gradient of approximately 0.8%. This local groundwater flow direction is different from the regional flow direction, which is to the northwest, as shown in Figure 6 for the Albany area. This type of deviation is not unexpected because a nearby water body, such as the Calapooia River, can significantly influence the direction of local groundwater flow.

Figure 9. Hydraulic Gradient and Location of Boreholes in the Back Forty Area.

**Table 2. Ground and Water Surface Elevations
in Three Boreholes in the Back Forty Area**

Borehole Number† ¹	Ground Surface Elevation (ft MSL)	Water Surface Elevation (ft MSL)
7-S151	217.36	210.94
7-S153	216.79	209.95
7-S154	217.86	215.11

†¹ See Figure 9 for locations.

SUMMARY

Based on the existing hydrogeological data available in the literature and the groundwater measurements conducted in this study, hydrogeological characteristics at the Back Forty site can be summarized as follows:

1. The area is in the alluvial plain of the Central Willamette Valley.
2. Surface runoff in the area is drained primarily by the Willamette and Calapooia Rivers.
3. The unconsolidated deposits of older and younger alluvia are the most productive aquifers in the area.
4. Surface drainage from the waste disposal area is to the south, at least to the ditch that parallels the disposal area, which in turn drains to the west.
5. The near-surface flow at the Back Forty site is controlled by the drain-tile system beneath the site and, for most of the area, is in the direction south to north.
6. Part of the water that infiltrates through the contaminated area might flow in a southerly direction and be collected by the drain tiles.

7. Groundwater at the site occurs in sand and gravel strata and is confined by the overlying clay and silt layers, which are about 3 to 9 m (10 to 30 ft) thick.
8. Groundwater at the site flows southwesterly from the contaminated area through the southern portion of the Back Forty and toward the Calapooia River.

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