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ADDITIONAL CHARACTERIZATION OF VADOSE AND PERCHED WATER IN THE K-65 AREA REVISION 1
MAY 28, 1993
RI/FS WORK PLAN ADDENDUM

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ADDENDUM

WORK PLAN ADDENDUM
to the
RI/FS Work Plan
Revision 3, March 1988

for

ADDITIONAL CHARACTERIZATION OF VADOSE AND PERCHED WATER IN THE K-65 AREA

WBS #40.03.05

Revision 1

Prepared by

Fernald Environmental Restoration Management Company
(FERMCO)
for the

Department of Energy
Fernald Environmental Management Project

May 28, 1993

WORK PLAN ADDENDUM
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WBS #40.03.05

1.0 INTRODUCTION

This work plan addendum presents a sampling and analysis plan for further investigations to characterize the presence, extent, and quality of vadose and groundwater in the glacial overburden immediately to the west of K-65 Silos 1 and 2. Assessment of the contamination in the unsaturated (vadose) zone of the glacial tills and an assessment of the probability of leakage into the subsurface from potential source areas, including the K-65 Decant Sump Tank, are also major objectives of this investigation. Results of the proposed work will be incorporated into the Operable Unit (OU) 4 Feasibility Study (FS) report and OU 5 Remedial Investigation (RI) reports. Results of previous investigations have been incorporated in the RI Report for OU 4, dated April 1993 (Revision 1); results, tables, and figures pertinent to the soils and perched groundwater near Silos 1 and 2 are presented in Section 4.0 of the OU 4 RI report.

The K-65 waste storage silos are large concrete storage structures built in 1951-52 at the FEMP. The silos are located south and west of the Waste Storage Area on the west side of the FEMP property. The cylindrical silos are approximately 80 feet in diameter, with walls approximately 26 feet high and domed roofs. The silos were constructed to provide storage for the residues resulting from processing pitchblende ore and concentrates to extract uranium content. The term "K-65" refers specifically to radium-bearing wastes generated during the uranium extraction process. Historical data indicate that the waste slurries in Silos 1 and 2 have settled to form a mud-like material that is a mixture of clay, silt, and sand-sized particles. Uranium concentration has been measured at approximately 1400 parts per million (ppm) in Silo 1 and 1800 ppm in Silo 2. An estimated 1.6 to 3.7 kg of radium is stored in the K-65 silos.

The K-65 silos were constructed with an underdrain system to collect any potential leakage through the floors. This underdrain system consists of an 8-inch thick layer of gravel with a series of drainage pipes beneath the floor which discharge into the decant sump tank. Access to the decant sump tank is by a 30-inch diameter vertical corrugated pipe.

By 1963, repairs to the deteriorated exterior surfaces and roofs of the silos had begun. After repairs to the walls were completed, an earthen embankment was built to the roof line of Silos 1 and 2 to provide relief from tensile stress within the walls, weather protection, a reduction in radon emissions, and increased shielding from penetrating radiation. To further reduce the risk of routine or catastrophic emissions of radon from Silos 1 and 2, the K-65 Silos Removal Action (Removal Action No. 4) involved the installation of a bentonite clay layer over the radium-bearing radioactive wastes. The Decant Sump Removal Action (Removal Action No. 5) was performed to remove and dispose of contaminated water from the tank.

2.0 Geology and Hydrogeology of Operable Unit 4

2.1 Geology of the K-65 Area Glacial Overburden

The Great Miami Aquifer, consisting of extensive deposits of sand and gravel, is the principal aquifer within the FEMP study area. The sand and gravel outwash was deposited in a broad U-shaped bedrock valley which ranges in depth from 120 to 200 feet.

In the K-65 area, the sand and gravel outwash is overlain by 5 to 10 feet of glacial till that is in turn overlain by 15 to 20 feet of lacustrine sediments. Figure 1 (Appendix A) shows the locations of three cross sections (shown individually in Figures 2, 3, and 4, Appendix A).

The till is an unsorted mixture of clay, silt, sand, and pebble- to cobble-size material with 70 to 80 percent of the material falling in the clay- to silt-size range. The till contains sparse, thin, and discontinuous lenses of sand and gravel.

The lacustrine sediments consist of a 5- to 10-foot thick coarse-grained deposit overlain by clay and silt deposited by streams and debris flows from the north. The unit is comprised of clayey silt, silt, sands with appreciable fine fractions, and clean sands with silty/clayey sand being the dominant lithology. The overlying outwash units were deposited by lower energy lacustrine depositional processes. The low-energy lacustrine sediments consists of clay, silty clay, clayey silt, silt, and find sand with silty clay the dominant lithology. A loess cap probably overlies the lacustrine strata; however, it cannot be readily distinguished from the low-energy lacustrine deposits using the Unified Soils Classification soil description/classification methods used during the RI/FS. Elsewhere on the site, where the loess cap can be distinguished, loess is a clayey silt approximately 3 feet thick.

Throughout the site, clays, silts, and sands near the ground surface are brown hued and deeper strata are gray hued. Gray clay, silt, and sand are weathered to brown hues as iron is oxidized by oxygenated waters infiltrating from the ground surface. Each cross-section (Figure 2, 3, and 4, Appendix A) shows a dashed line representing the maximum depth of occurrence for brown-hued strata. The dashed line is a qualitative measure of the maximum depth of weathering. The typical column depth (zone of active soil formation processes) is 40 to 55 inches.

Adjacent to the K-65 area, Paddys Run dissects the glacial overburden exposing the sand and gravel outwash of the buried valley at an elevation of approximately 550 feet MSL (see Figure 2 in Appendix A). The coarse grain outwash unit is exposed in outcrop on the steep bank west of the silos; however, on the majority of the bank, the outcrop is obscured by a thin veneer of alluvium, colluvium, and fill.

2.2 Groundwater Flow in the Operable Unit 4 Study Area

As discussed previously, the geologic setting of glacial overburden beneath Operable Unit 4 consists of a sequence of lacustrine deposits overlying till. The glacial overburden overlies highly permeable sand and gravel outwash deposits of the Great Miami Aquifer. The thickness of glacial overburden in the OU 4 Study Area varies from 0 to 30 feet.

Each of the geological units underlying OU 4 have distinct hydrogeologic characteristics that determine the movement of water and contaminants in the surface.

2.2.1 Glaciolacustrine Deposits

The meltwater lacustrine deposit encountered beneath the OU 4 distinctly grades upward from coarse to fine. Strata at the base of the lacustrine deposits are predominantly silty and clayey sands and vary from 5 to 20 feet thick. The sands appear to have substantial primary permeability. The depth of weathering extends 10 to 20 feet beneath the ground surface. The uppermost fine grain sediment is largely weathered and is also jointed. The entire lacustrine unit has good lateral and vertical hydraulic communication. Operable Unit 5 is currently interpreting hydrogeological data for the lacustrine unit elsewhere on site and will present quantitative hydrogeological parameters are a later date.

2.2.2 Till Deposits

Between the lacustrine unit and the aquifer is till: a dense clay that contains minor lenses of poorly sorted fine- to medium-grained sand and gravel, silty sand, and silt with layers of silty clay.

Dense, fine-grained tills are the most common aquitards in most of the glaciated United States. These fine-grained deposits have intergranular hydraulic conductivities that are very low, with values in the 10^{-7} to 10^{-5} feet per day (Heath 1983). Extensive deposits of clayey till can cause isolation in zones of near surface groundwater flow. At the FEMP, a series of slug tests of the coarser, perched water bearing zones within the till indicated hydraulic conductivities ranging from 1.6 feet per day in Well 1048 to 7.1×10^{-3} feet per day in Well 1079.

In the Great Plains region and in parts of the Midwest, deposits of clayey or silty till and glaciolacustrine clay have networks of predominantly vertical joints or fractures due to weathering. This jointing pattern in the Wisconsin till has also been noted in the area surrounding the FEMP (Brockman 1988). In the FEMP Study Area, the joints are commonly near vertical and have a polygonal expression with a typical maximum axial dimension of 18 to 25 inches. The joints are generally oxidized to a radius of 2 inches. Within the FEMP, fractures have been noted in the till during the RI/FS drilling program and field reconnaissance.

These fractures can impart an enhanced bulk hydraulic conductivity of up to 1000 times more than an unweathered till (Hendry 1988). As a result of increased lateral stresses caused by overburden loading and decreased weathering, the hydraulic conductivity of fractured till and clay decreases with depth.

From a hydrogeologic standpoint, the till deposits can be differentiated into a brown weathered zone and a gray unweathered zone (Barari and Hedges 1986, Hendry 1988, Cravens 1987) (Figures 2, 3, and 4). These studies indicate that infiltration is primarily limited to the weathered till. Although precipitation enters this upper zone, it does not act as a significant source of recharge to deeper aquifer zones because the majority of the water lost from till deposits is from evapotranspiration. In addition, some water is suspected to discharge laterally to small seeps or drainages.

2.2.3 Groundwater Flow

The lacustrine strata has good, but slow hydraulic communication with the underlying till aquitard. Groundwater within the lacustrine strata is predicted to flow at a lateral rate significantly greater than its downward rate; therefore, perched groundwater is likely discharging westward to the bank of Paddys Run and southward to the east-west drainageway immediately south of Silo 1 as shown on Figure 5 in Appendix A.

In the OU 4 Study Area, surveys have been conducted to look for seeps along Paddys Run adjacent to the silos and along small drainageways in the vicinity. No seeps have been noted recently; however, it is likely that the fill zones located between the silos and Paddys Run would intercept any seasonal seeps, preventing them from having a surface expression.

Groundwater flow in the Great Miami Aquifer under the K-65 silos is generally from west to east as depicted by the 2000-Series wells (Figure 6, Appendix A). The average hydraulic gradient for these wells is approximately 1 foot per 1000 feet; however, from January through May, sufficient rainfall is generated for water to flow in Paddys Run. When flow is present, significant infiltration from the creek into the Great Miami River Aquifer takes place. The area where infiltration is known to occur begins at a point north of Silo 4 and extends to the south to at least where Paddys Run crosses the southern FEMP property boundary (Willey Road). The southern limit of infiltration through the creek bed to the Great Miami Aquifer varies with seasonal fluctuations of the water table in the regional aquifer. The impact of this recharge on the water table under the K-65 silos is not completely documented; however, it is clear that the gradient for eastward flow can vary from 1 foot per 1000 feet to 3 feet per 1000 feet in the immediate vicinity of Paddys Run. The recharge mounding can also alter the direction of flow from east to northeast for short periods.

Figure 6 (Appendix A) show water table data from the 2000-Series wells, which are wells screened through the water table. The 3000- and 4000-Series wells are screened at deeper levels within the Great Miami Aquifer. Operable Unit 5 is currently analyzing water level data from clusters of wells completed at different depths to determine if significant vertical hydraulic gradients exist. Previous analyses have identified minor vertical gradients at some locations.

3.0 PREVIOUS INVESTIGATIONS

3.1 Subsurface Soils

The objectives of the silo subsurface soil sampling program were to determine the vertical and horizontal extent and verify the source of radiological and chemical contamination surrounding the silos. Low-angle slant borings and vertical borings were installed at selected down and up-gradient locations, and laboratory analyses were performed on samples. Summary results are presented in Figures 7 through 12, Appendix A and Table 1, Appendix B. Radiological analyses revealed that the principal constituents above background levels include: Pb-210, Po-210, Ra-226, Th-230, total Th, U-234, U-238, and total U.

3.1.1 The five slant borings and sample locations are shown in Appendix A, Figure 7. All borings except 1616 and 1618 were advanced only to the first perched water zone encountered. Boring 1616 was temporarily cased and advanced through the perched water zone to soils underlying the decant tank. Cross-sectional profiles are shown in Figures 7 through 12 (Appendix A); analytical results of the major contaminants, total U, Ra-226, and Pb-210 are also shown at the respective sample locations.

3.1.2 Additional glacial overburden subsurface samples were collected at various depths during installation of monitoring wells drilled around the silos and in trenches excavated west of the silos (Figure 13, Appendix A). The analytical results presented in the accompanying Table 2, Appendix B show that the radiological concentrations range from <0.05 to 15 pCi/g. The highest concentration, U-238 at 15.0 pCi/g, was detected in Well 1072 at a depth of 0-1.5 feet. Results from the slant borings and other subsurface soil samples indicate that contamination is confined principally to the area immediately under the silos or near the surface around the silos. Based on results from the slant borings, there is a general decrease in concentrations of Ra-226, Pb-210, and total U with depth.

3.2 Perched Groundwater

3.2.1 To supplement existing data and more accurately determine the nature and extent of groundwater contamination beneath the silos, six groundwater samples were collected from the slant borings. Results of radiological analyses performed at the contract RI/FS laboratory are presented in Appendix A, Figures 8 through 12. Of the detected radionuclides, Ra-226 was detected only once in Boring 1618; uranium was the most frequently detected constituent in most of the borings. Ra-226, Pb-210, and Po-210 were not detected in the perched groundwater downgradient of the silos. Total U was detected at a concentration of 439 µg/l and 276 µg/l in Boring 1616 and in Monitoring Well 1032, respectively. The 439 µg/l from Boring 1616 was rejected due to lack of proper QA/QC, but it should be noted that the split analyzed at the on-site laboratory of this same sample detected a concentration of 390 µg/l total U.

Sample splits of the slant boring water samples were submitted to the FEMP laboratory for duplicate total U analyses (Appendix B, Table 3). Many of the analytes were detected in concentrations consistent with the RI/FS laboratory results. However, the total U and individual isotope results from Boring 1617 differ dramatically from the other borings and from the results obtained by the RI/FS laboratory. Due to more stringent QA/QC protocols at the RI/FS laboratory, the FEMP laboratory analyses were disregarded at that time. Additional analyses are now proposed to clarify the discrepancy.

3.2.2 Perched water samples have been collected from five 1000-series monitoring wells located around the silos. Figure 14 in Appendix A shows the distribution of total U in these five wells. Well 1032, west of Silo 2, contains the highest concentration of total U at 258 µg/L and its highest individual isotope, U-238 (96.8 pCi/L, (Appendix B, Table 4); these uranium concentrations may be attributable either to silo/decant system leakage, historic spills, or to contaminated backfill encountered in the boring.

3.2.3 Possible leakage from the silos moving through the vadose zone into the groundwater may account for uranium detected in the shallow soils. However, Ra-226 has only been detected once (2.89 pCi/L) in the perched water at Location 4 in Boring 1618 located directly below the center of Silo 1. Radiological results of the slant borings are discussed in detail in Section 4.2.3 of the OU4 RI, April, 1993.

The silos are a unique source of large quantities of Ra-226; therefore, Ra-226 should be useful as an indicator of releases. The fact that Ra-226 has not been detected in surrounding wells suggests that migration from beneath the silos toward Paddys Run has not occurred. However, there are significant differences in the solubility of radium and uranium compounds found in the silos and the presence or absence of Ra-226 alone is inconclusive evidence of leakage. Additional sampling and analyses proposed below will further characterize Ra-226 as an indicator.

4.0 PROPOSED INVESTIGATIONS

4.1 Background and Summary

Previous monitor well installations and slant borings under the silos have indicated the presence of a prominent perched water-bearing zone encountered at an elevation of approximately 563 feet above mean sea level (MSL) or approximately 7 feet below ground surface (Figures 15 and 16, Appendix A). A lower perched zone at approximately 552 feet MSL was encountered in slant Boring 1616. Contamination detected in Boring 1616 could represent cross-contamination from the upper perched zone. Proposed work is intended to further evaluate this suspected lower zone.

This project will also evaluate discrepancies in total U and individual isotopic analyses on Boring 1617 obtained from the contract RI/FS and FEMP laboratories. Due to more stringent QA/QC procedures at the RI/FS laboratory, the FEMP analyses were originally considered inaccurate.

Data Quality Objectives for the proposed work are presented in Table 5 (Appendix B). The following investigation will be conducted in order to further characterize the vadose and perched water zones:

a) drill, install, collect, and analyze samples from two 1000-series piezometers in the uppermost perched water interval, in the K-65 silos area (No. 1891 and 1893, Figure 17, Appendix A). A contingency well will be installed at the location shown on Figure 17, Appendix A if total uranium concentrations in perched water samples from piezometer 1891 exceeds 20 ug/L.

b) collect a Hydropunch II(TM) water sample in the upper perched water zone at location (1892) west of the K-65 Decant Sump Tank (Figure 17, Appendix A). After cementing casing through the upper perched zone, drilling will continue to a possible lower perched water zone encountered during slant boring operations, or to an equivalent elevation if the zone is absent. Depending on the availability of perched groundwater, a piezometer or lysimeter will be installed to obtain a groundwater sample.

c) install and sample three lysimeters in the east bank of Paddys Run (Figure 17, Appendix A) to determine if contaminated vadose or perched water is entering the stream and, by inference, the Great Miami Aquifer. Borings for the lysimeter installations will be installed by hand augering. A technical specification summary demonstrating the installation methodology for the lysimeters is presented in Appendix C.

d) collect and analyze one round of groundwater samples from Monitoring Wells 1032 and 2032.

All drilling, sampling, and piezometer installations will be conducted according to procedures defined in Appendices D, J, and K, Draft Sitewide CERCLA Quality Assurance Project Plan (SCQ), dated September 22, 1992, and in Section 5 of the FEMP RI/FS Quality Assurance Project Plan (QAPP). When more specific or more stringent, the SCQ procedures will take precedence over the QAPP. Procedures for lysimeter installation and sampling are presented in the attached Appendix C.

Continuous soil samples will be collected in each boring and hand-augered location. All recovered samples will be radiologically field screened, stored in 500 ml glass jars, and archived for possible future analyses. Results of the radiological screening will be evaluated by FEMP CRU4 and CRU5 staff to determine if additional soil analysis is required.

Water samples collected from the various locations will be analyzed primarily for Ra-226 and U-238 contamination and fluorescein dye tracer placed in the K-65 Decant Sump in mid-1991 and October 1992 (TAL 40.03.05A, Appendix D). General Groundwater Chemistry, Limited Radiological, and Limited HSL analyses (TAL 40.03.05B, Appendix D) will be performed if sufficient water volume can be collected. All analyses will be performed at an approved RI/FS laboratory with the exception of fluorescein dye which is analyzed at the on-site laboratory. The prioritized order in which TAL 40.03.05B (Appendix D) samples are to be collected is noted in Table 6 (Appendix B).

4.2 Drilling, Hydropunch Sampling, and Installation Procedures

4.2.1 Piezometers 1891, 1893, and Contingency Piezometer

Two 1000-series piezometers, 1891 and 1893, will be installed. These piezometers, shown in Figure 17 (Appendix A), are located approximately 100 feet southwest and northwest of K-65 Silos 1 and 2 respectively. Total depth is anticipated to be approximately 12 feet below ground surface (+558 feet MSL) at the base of the upper perched water interval within the glacial till.

Soil boring will be installed using a truck-mounted drilling rig using hollow-stem augers; continuous samples will be collected by advancing a split-spoon sampler (minimum 2-inch ID) ahead of the auger bit. Soil samples will be screened and archived as described in Section 6.0 below for possible future analysis as determined by site CRU4 and CRU5 personnel. Borings will be converted to piezometers by installing 2-inch schedule 40 PVC screen (0.020 Slot) and riser. A 0.020 slot screen will facilitate flow from the perched zone into the well. To filter out fines, a uniform sand pack (10/20) will be placed around the screen. Screen length will be determined by the on-site geologist based on the thickness of the upper perched zone at each location. The length of the screen will be such that the water table and at least 80 percent of the water bearing unit is screened.

If total U concentrations exceed 20 ug/L in Piezometer 1891, a contingency piezometer will be installed southwest of Piezometer 1891 at the location shown in Figure 17 (Appendix A). Soil sampling, well installation, and groundwater sampling will be completed as described above.

4.2.2 Hydropunch Sampling, Boring 1892

At Location 1892, a drilling rig equipped with at least a 10-inch outer diameter hollow-stem auger will be used in conjunction with a Hydropunch II(TM) sampler to collect water samples within the upper perched water bearing zone beginning at approximately +563 feet MSL (Figures 2, 3, and 4, Appendix A); groundwater samples will be analyzed for parameters as previously stated. If adequate volume is available, additional analyses for secondary parameters will be performed. In order to maximize water recovery, the Hydropunch sampler will be operated in the hydrocarbon recovery mode. Continuous split-spoon samples will be collected ahead of the rotary auger, providing a pilot hole in the perched zone for the Hydropunch sampler. Samples of the glacial till will be archived as described in Section 6.0 below for possible future analysis.

After Hydropunch sampling has been completed, boring will continue to the underlying confining layer, and 8-inch ID steel casing will be cemented in place to the surface. After the cement has been allowed to cure for a minimum of 24 hours, 8-inch augers will then be used to drill through the depth of the suspected lower perched water interval (approximately +552 feet MSL), and either a 2-inch PVC piezometer or a 2-inch lysimeter will be installed; continuous soil samples will be collected and archived through the till. Final selection will be the responsibility of the FERMCO Manager, Field Program Development Section, depending on the volume of water found in the boring after it is left open overnight.

4.2.3 Lysimeter Installation

If water yield in the lower zone of Boring 1892 is determined to be inadequate for a conventional piezometer, a lysimeter will be installed at a depth corresponding to that of the suspected second perched water bearing zone. The lysimeter proposed for use during the monitoring and sampling period is a 2-inch diameter pressure vacuum soil water sampler as presented in Appendix C; the manufacturer may vary. This lysimeter consists of a micro-porous ceramic cup at the base which allows water entry through capillary forces, an 18-inch PVC cylindrical body with full-depth riser, and a PVC head. The head assembly attaches to the riser and connects sample and pressure ports to the lysimeter via 1/4-inch nylon tubing. The lengths of nylon tubing extend from the lysimeter body through the riser to the head at the surface and are used for vacuum extraction and pressure sampling. The sample tube extends from the head through the lysimeter to a point just in contact with the inside base of the lysimeter. The vacuum extraction tube extends into the lysimeter to a point approximately 3 inches below the inside of the cap.

Each length of nylon tubing will be clearly identified and attached to the proper fitting at the lysimeter head. Installation will be performed in general accordance to manufacturer's recommendations shown in the Appendix C. Specifically:

a) The lysimeter and associated tubing will be thoroughly decontaminated in accordance with standard procedures utilized for well screens prior to installation. After lysimeter and nylon tube decontamination, the ends of the tubing will be clamped off at the surface to avoid the inadvertent introduction of foreign material into the tubing. The lysimeter components will then be assembled and installed with full depth 2 inch PVC riser screwed onto the lysimeter body to house the nylon tubing. The tubing will be measured and cut to allow approximately a 2 feet stick-up at the surface.

   A 3 to 6 inch thick slurry of silica flour and distilled water will first be tremied into the open borehole. The lysimeter and riser will be gently lowered into the boring and secured at the surface to prevent floating.

b) Additional slurry will then be placed to 2-4 inches above the top of the ceramic tip of the lysimeter. At that point, 80/100 mesh sand will be poured to approximately 3-6 inches above the top of the lysimeter, followed by a column of Volclay grout to within three feet of surface; this grout seal will be placed with a tremie line and will prohibit shallow water from draining down into the lysimeter zone. The lysimeter head will then be connected to the tubing.

c) Finally, protective casing will be cemented in the boring to complete the installation according to RI/FS QAPP procedures used for 1000-series piezometers.

4.2.4 Paddys Run Lysimeters

Visible moisture has been observed seeping at approximately 5-6 feet below the top of the east bank of Paddys Run (approximately +550 feet MSL) adjacent to the silos. Three lysimeters will be installed along the east bank of Paddys Run (Figure 17) to determine if contaminated groundwater is migrating into the surface water and, subsequently, the Great Miami Aquifer. Topography along the creek precludes the use of a drilling rig. Therefore, a 6 inch hand auger will be used to drill a boring to a depth of 6 feet; soil samples will be collected, screened, and archived as described above. Two inch lysimeters will be installed with silica flour, 80/100 mesh sand and Volclay as described above. Because the locations are relatively inaccessible and untraveled, steel protective casing and final cement cap will not be installed; final backfill will consist of Volclay grout to surface. PVC tubing and locking lysimeter head will be installed to allow approximately a stick-up of 2 feet at the surface;.

4.2.5 Paddys Run Piezometer Installation

To determine water levels, a piezometer will be installed adjacent to each of the three Paddys Run lysimeters (1894, 1895, and 1896) to a depth of 6 feet. The borings will be installed using a 4-inch diameter hand auger; soil samples will be collected, described on a boring log, radiologically screened, and archived as outlined in Section 6.0. One-inch diameter Schedule 40 PVC well screen (0.020 slot) and riser will be installed in each boring. Well screens will be 1 foot in length. A uniform sand pack (10/20) will be placed around each screen to approximately 2-feet above the top of the screen. A 6-inch bentonite pellet plug will be placed on top of the sand pack and the remaining annular space will be backfilled to the surface with Volclay grout. The piezometers will be completed with an above ground locking protective cap and a 3-foot square concrete pad (per SCQ requirements). No groundwater samples will be collected for analysis from the three piezometers for this work plan. Samples may be collected in the future, if necessary.

5.0 PIEZOMETER DEVELOPMENT AND WATER SAMPLING

After final determination of the screen length and completion, all newly-installed piezometers will be developed by purging the wells dry or removing five casing volumes of water, as applicable. Perched water samples will be analyzed at a contract RI/FS laboratory for both the primary and secondary parameters presented above provided sufficient recharge is available. (Appendix E).

Trip blanks for Volatile Organic Compounds (VOCs) will be included with the post-development water samples collected (TAL 40.03.05C, Appendix D). In addition, rinsate and duplicate samples (one for every 20 samples or fraction thereof) will be collected and analyzed for all secondary parameters as specified in TAL 40.03.05B (Appendix D). When sampling has been completed, the wells will be incorporated into the site long-term groundwater monitoring program.

6.0 LYSIMETER SAMPLING

After satisfactory installation of each lysimeter, a vacuum hand pump will be attached to the pressure port of the lysimeter head and used to evacuate the lysimeter body to a pressure of approximately 18 inches of mercury. The lysimeter will then be allowed to equilibrate for a period of 24-48 hours. After that time, a positive displacement pump will be attached to the pressure port and will be used to pressurize the lysimeter, forcing collected water out through the sample line to a container at the surface. The process will be continued until enough water is collected to satisfy primary (TAL 40.03.05A, Appendix D) analyses, and secondary analytical requirements (TAL 40.03.05B, Appendix D) if an adequate water supply collects within 48 hours (Appendix E). One round of sampling will be conducted. All samples will be handled, documented, shipped and validated according to procedures defined in the SCQ.

7.0 SOIL SAMPLE ARCHIVING

Soil samples will be radiologically screened and archived according to the methods currently defined in the Advanced Sciences, Inc. Standard Operating Procedure No. FPP-404, titled "Archive Sample Management." In general, all split-spoon and hand-augered samples will be collected from a point immediately below surface vegetation to total depth. Samples will be placed into 500 ml glass jars, sealed with teflon lined lids, and stored in secure on-site containers for future use as determined by site CRU4 and CRU5 personnel.

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APPENDIX A

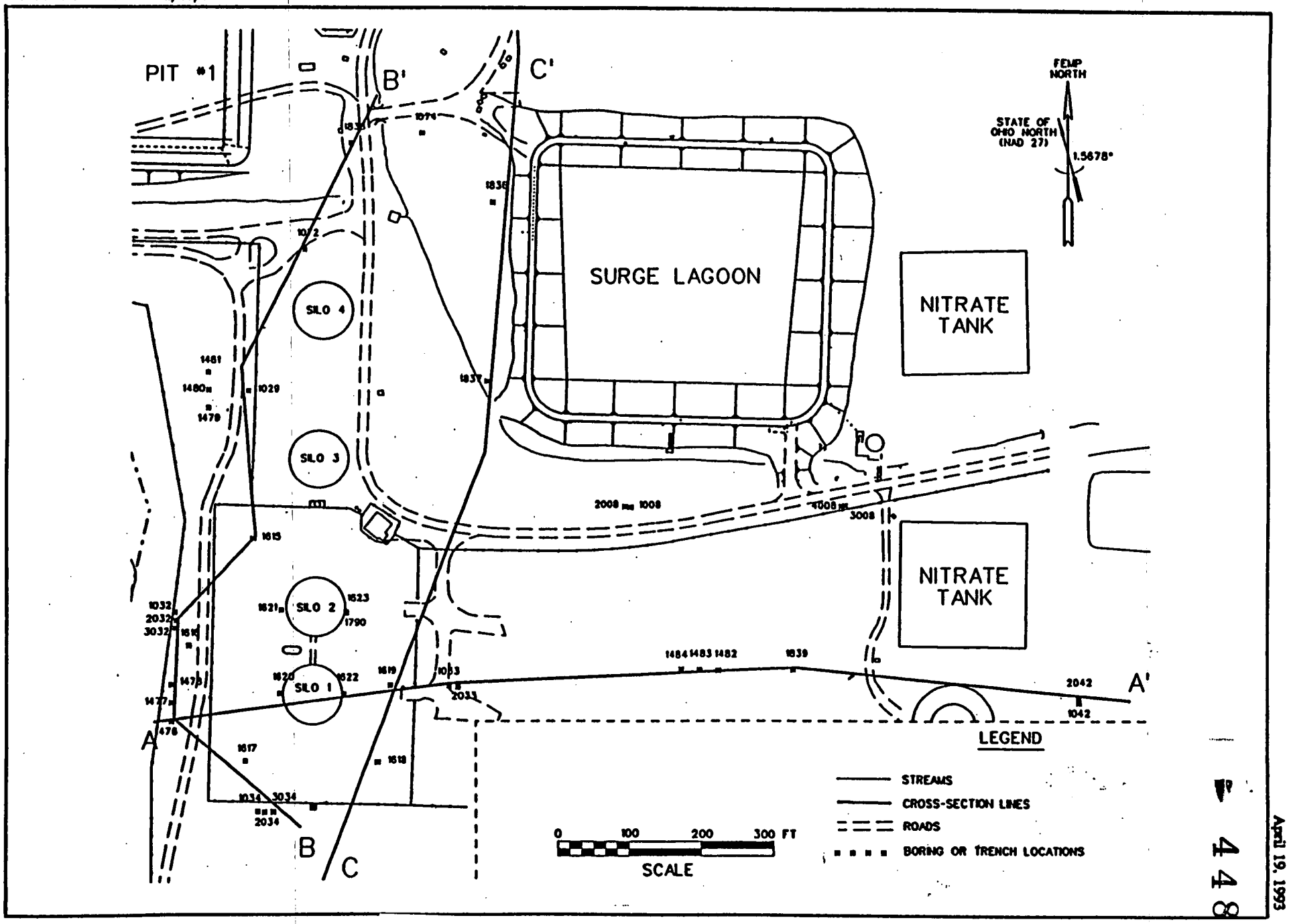


FIGURE 1 CROSS SECTION LOCATIONS

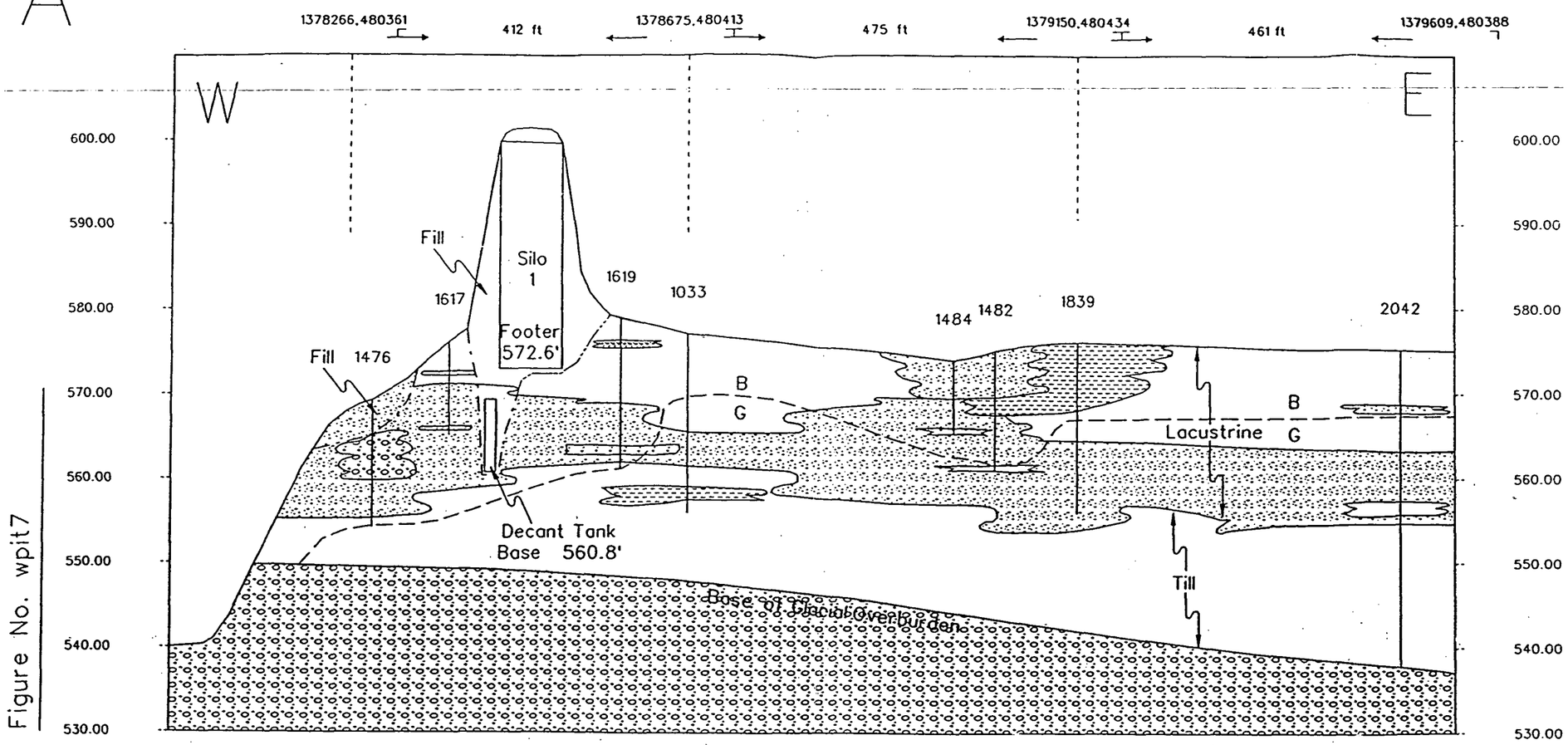


Figure No. wpit7

LEGEND:

- CLAY
- SILT
- SAND
- GRAVEL
- B / G — BASE OF WEATHERED HORIZON
- CONTACT OF FILL AND IN SITU STRATA

SCALE

100 0 100 200 Feet

NOTE: Boring numbers 1615, 1616, 1617, 1618, and 1619 were shallow angle borings; however, they are shown here as vertical borings. Subsurface correlations have been adjusted to account for their being angled borings.
Base elevations of Silo1 and the decant tank are as shown; however, the height of each structure is approximated. The nature of the backfill adjacent to the decant tank is unknown.

FIGURE 2
GEOLOGIC CROSS SECTION A-A'
K-65 AREA

409194-B-80 OU4 KNOX

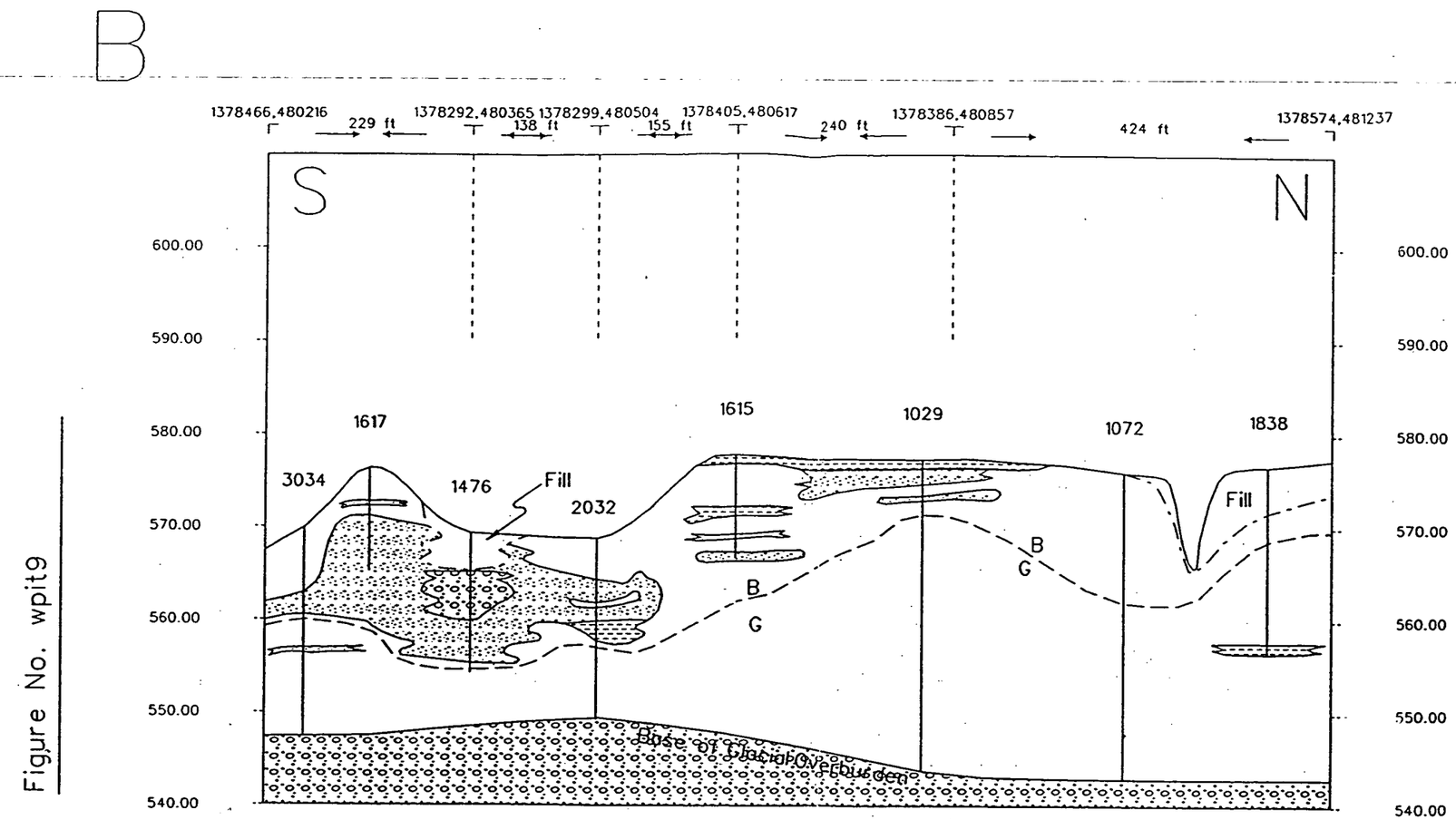


Figure No. wpit9

LEGEND:

- CLAY
- SILT
- SAND
- GRAVEL
- B / G — BASE OF WEATHERED HORIZON
- CONTACT OF FILL AND IN SITU STRATA

SCALE

100 0 100 200 Feet

NOTE: Boring numbers 1615, 1616, 1617, 1618, and 1619 were shallow angle borings; however, they are shown here as vertical borings. Subsurface correlations have been adjusted to account for their being angled borings.

FIGURE 3
GEOLOGIC CROSS-SECTION B-B'
K-65 AREA

409194-B-81 OU4 KNOX

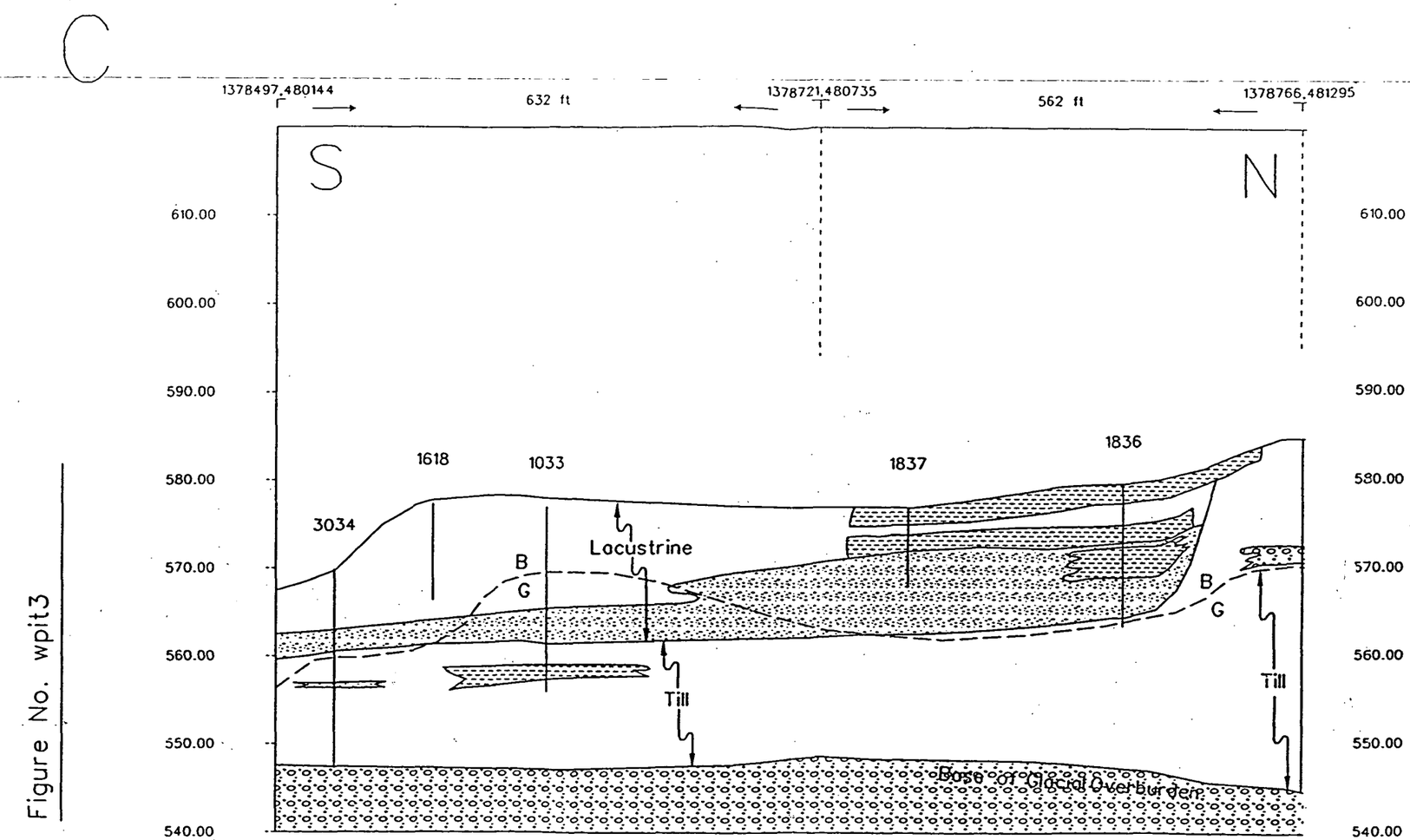


Figure No. wpit3

LEGEND:

- CLAY
- SILT
- SAND
- GRAVEL
- B / G — BASE OF WEATHERED HORIZON

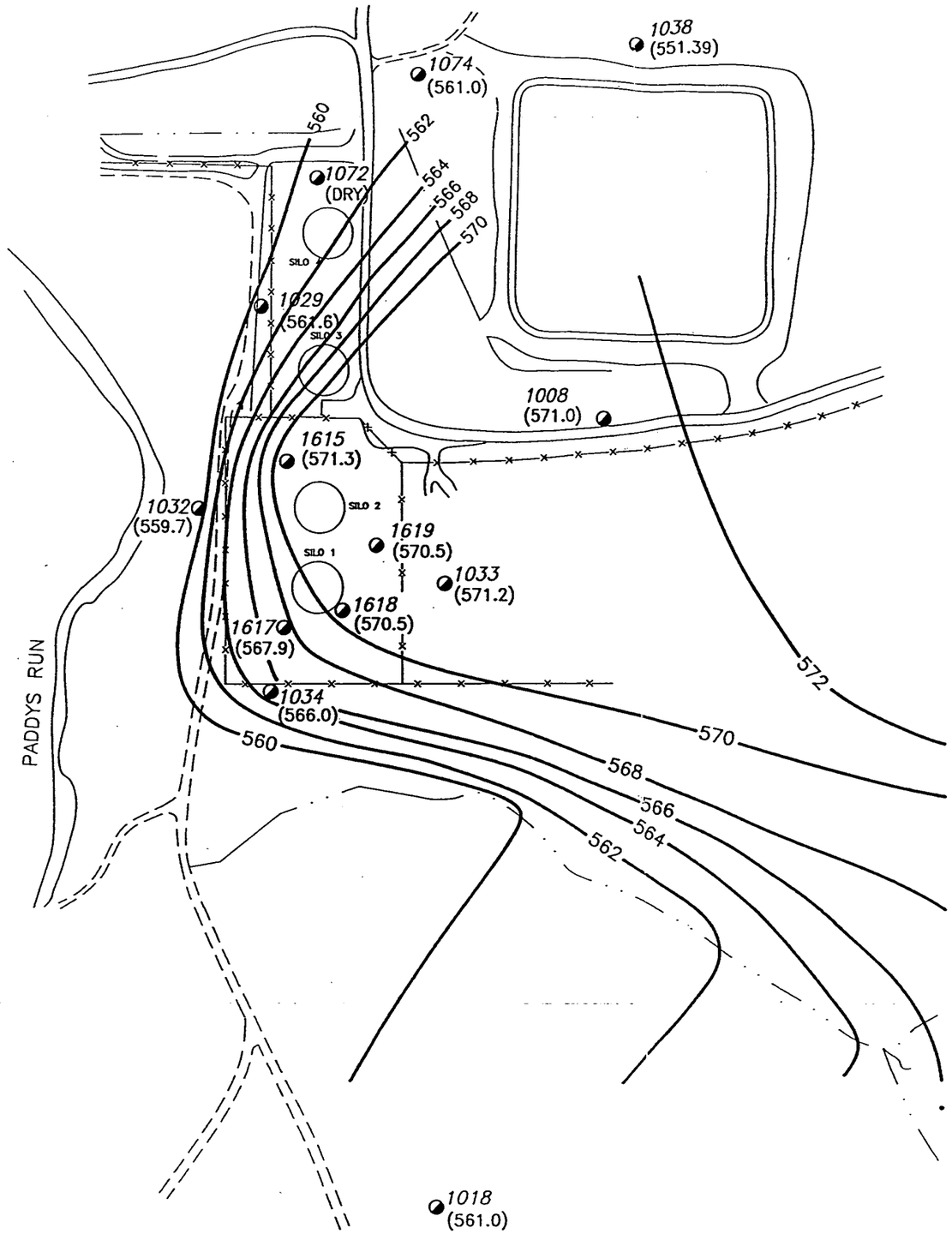
SCALE

100 0 100 200 Feet

NOTE: Boring numbers 1615, 1616, 1617, 1618, and 1619 were shallow angle borings; however, they are shown here as vertical borings. Subsurface correlations have been adjusted to account for their being angled borings.

FIGURE 4
GEOLOGIC CROSS-SECTION C-C'
K-65 AREA

409194-B-82 OU4 KNOX



N

LEGEND:

560	GROUNDWATER CONTOUR (INTERVAL=2 FEET)
—×—	FENCE
═══	ROADWAY
— · · —	DRAINAGEWAY
◐	WELL LOCATION
(571.2)	GROUNDWATER ELEVATION IN FEET

NOTE:

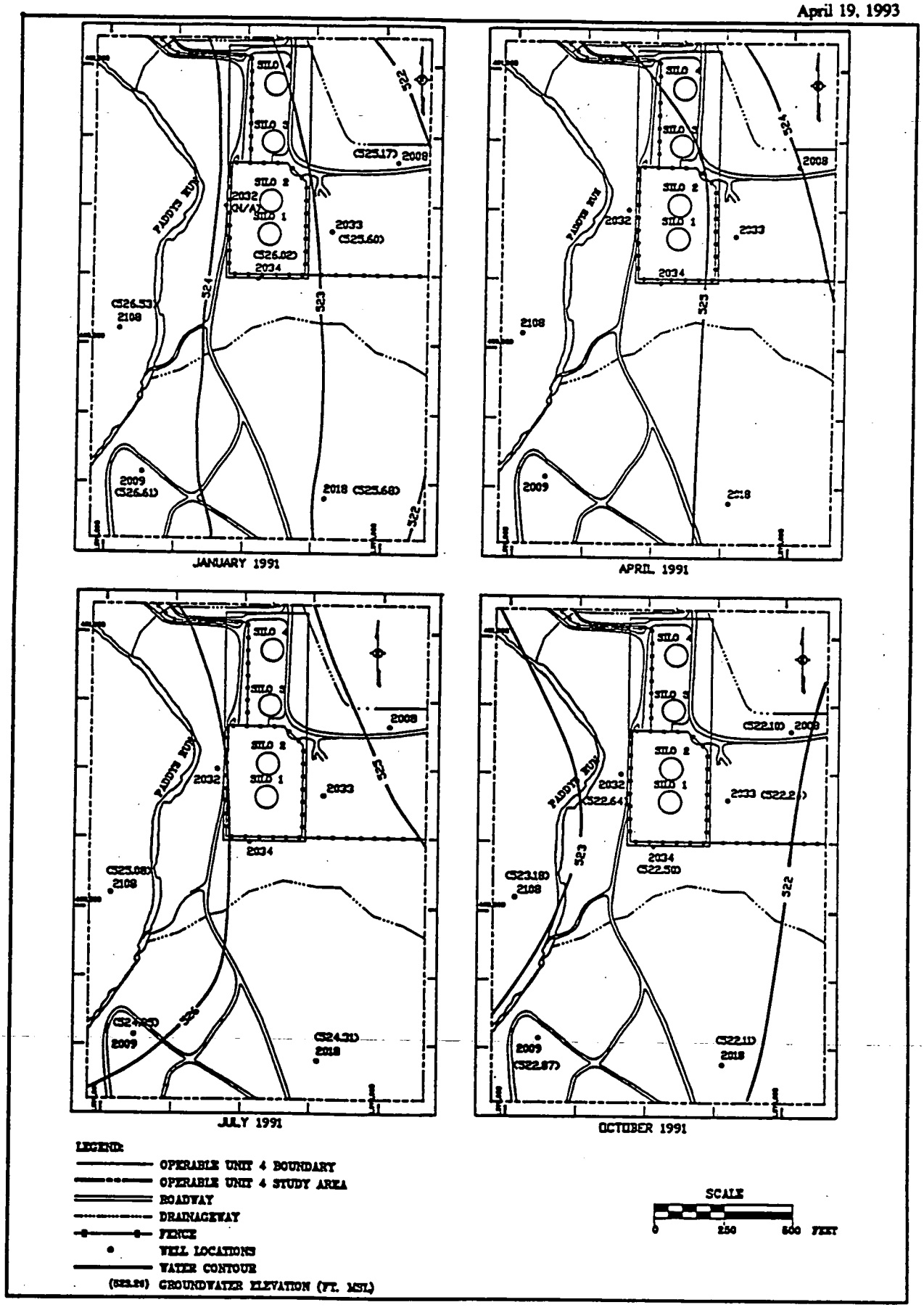
1. GROUNDWATER DATA FROM OCTOBER 1991, EXCEPT SLANT BORING DATA FROM AUGUST 1991.

SCALE:

0 200 400 FEET

409194-B-01 OU4 KNOX
40919401 03/06/93 4:50pm JAT

FIGURE 5
GROUNDWATER TABLE CONTOURS FOR OU4 AND SURROUNDING AREA



313327-A-131/OU4/KNOX/1-28-93

FIGURE 6 TYPICAL WATER TABLE CONTOURS BY QUARTER
2000 SERIES WELLS, 1991

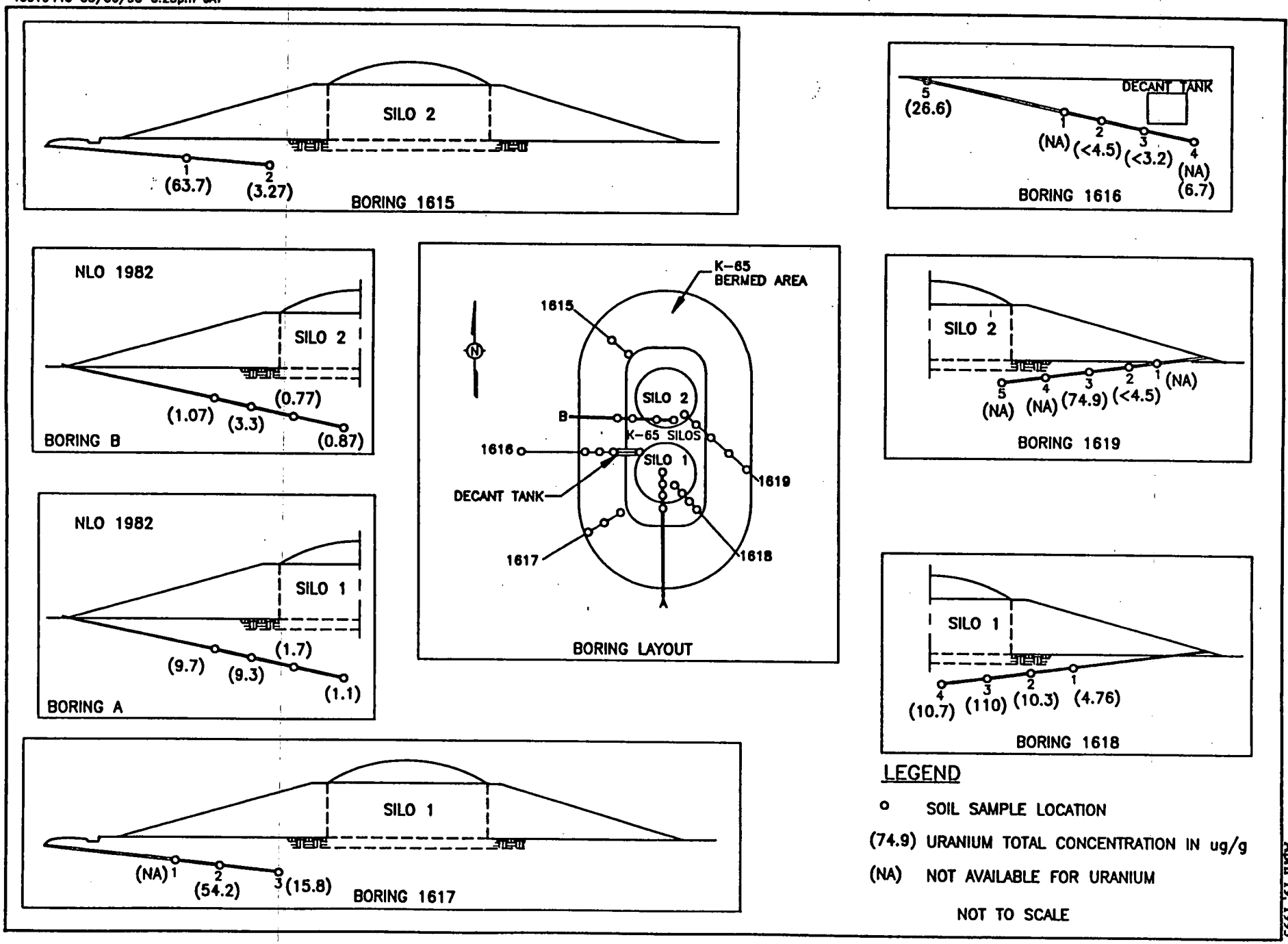
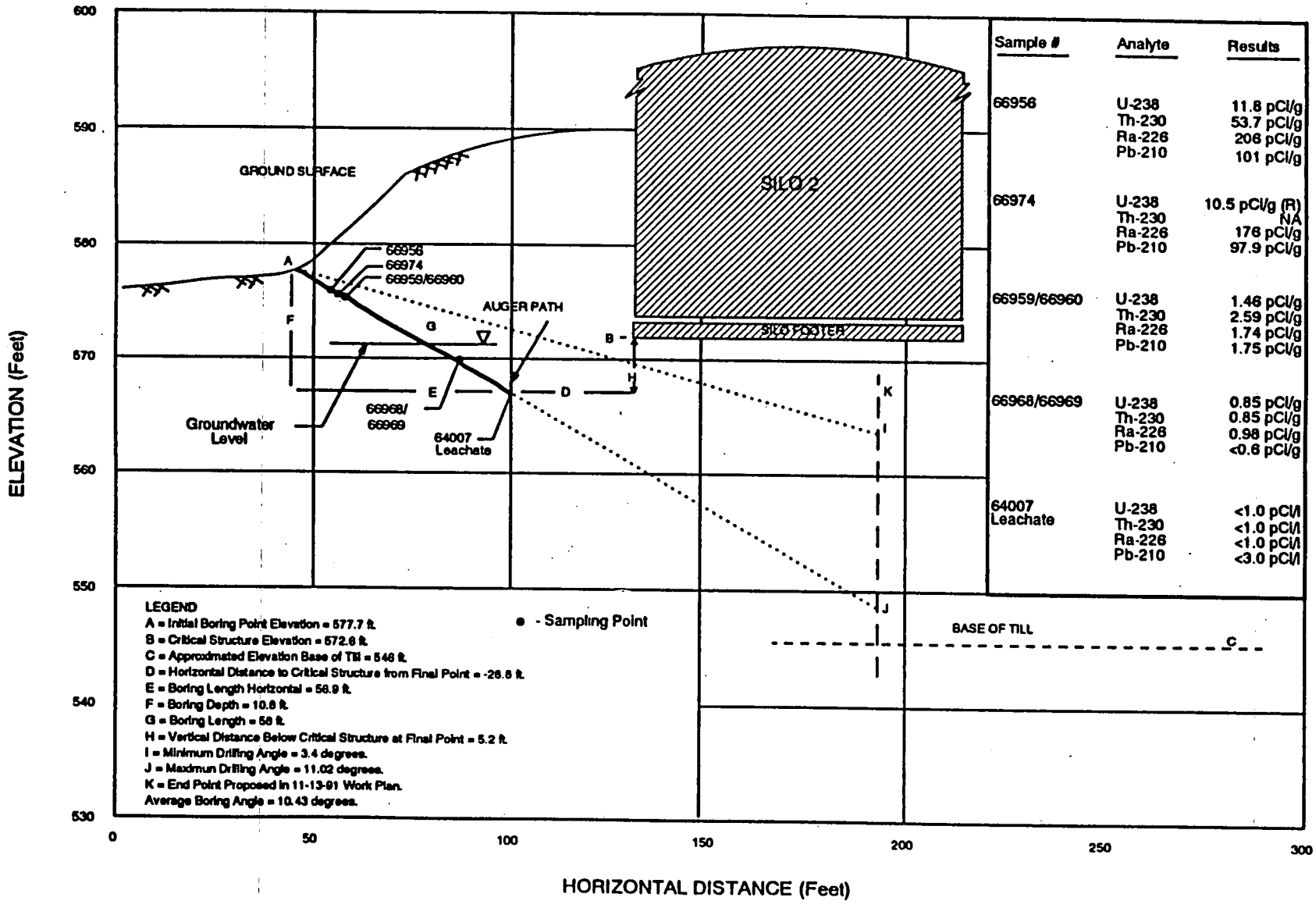
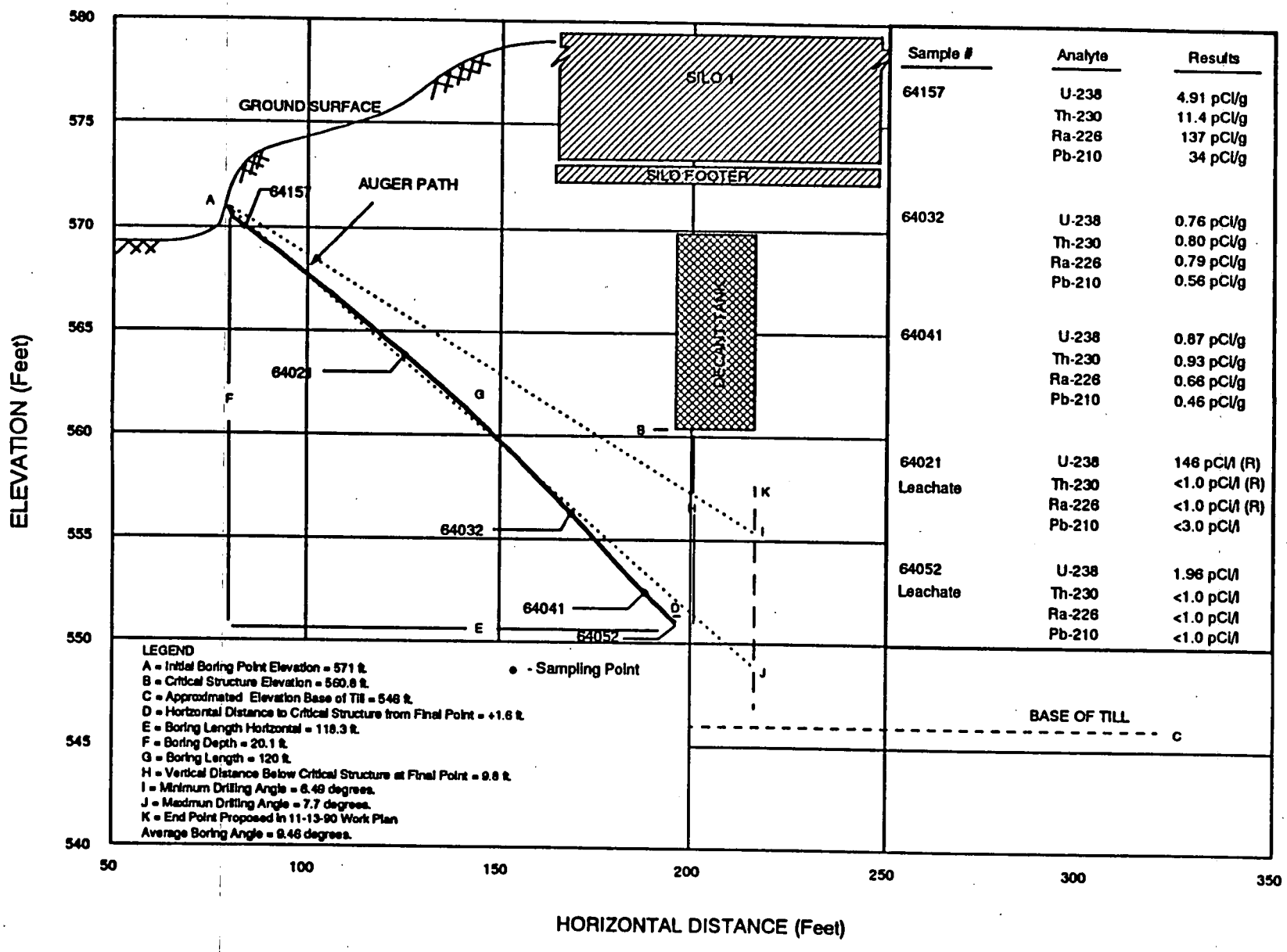


FIGURE 7 URANIUM CONCENTRATION IN SUBSURFACE SOILS UNDER SILO 1 AND 2



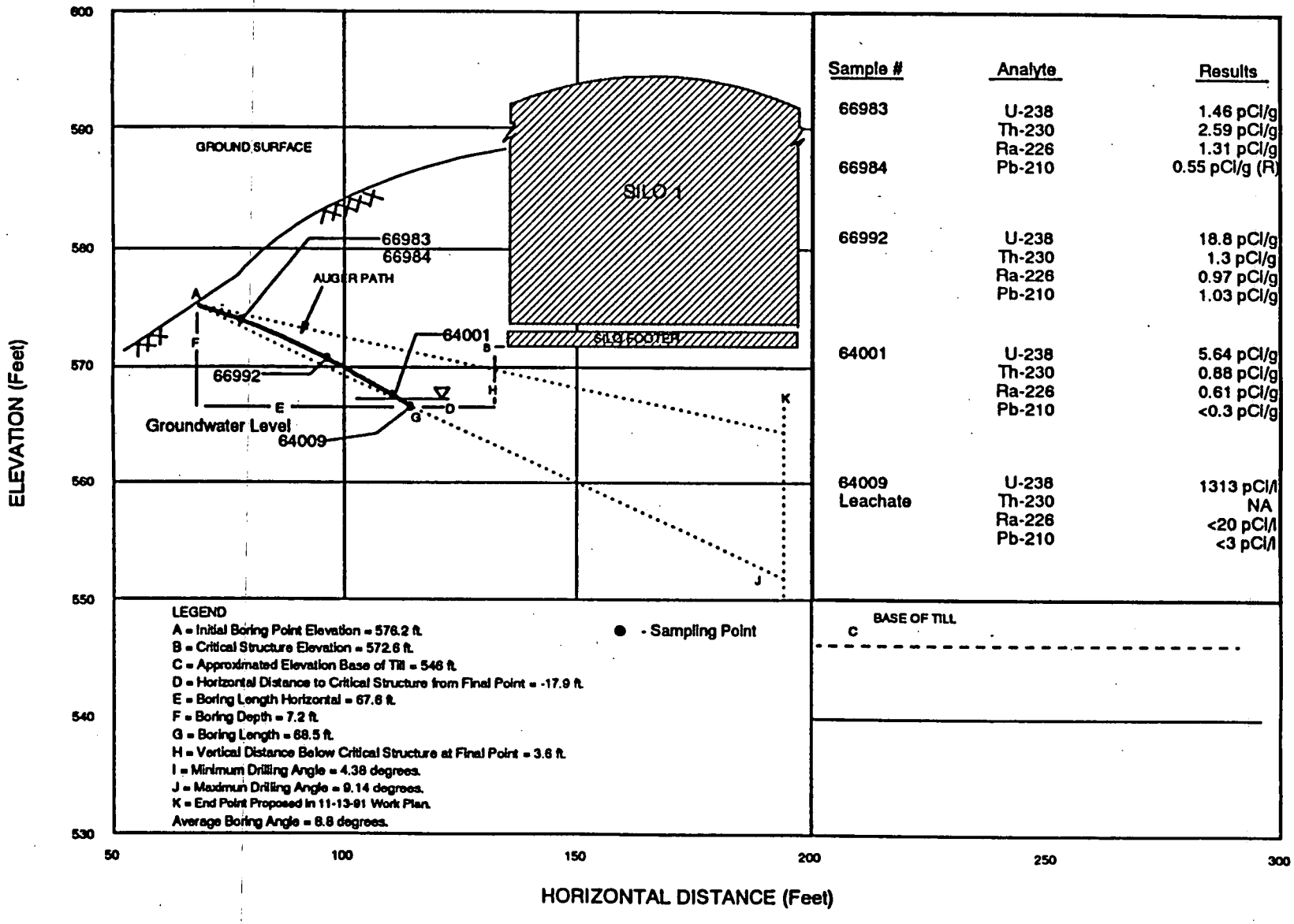
Sample #	Analyte	Results
66956	U-238	11.8 pCi/g
	Th-230	53.7 pCi/g
	Ra-226	206 pCi/g
	Pb-210	101 pCi/g
66974	U-238	10.5 pCi/g (R)
	Th-230	NA
	Ra-226	176 pCi/g
	Pb-210	97.9 pCi/g
66959/66960	U-238	1.46 pCi/g
	Th-230	2.59 pCi/g
	Ra-226	1.74 pCi/g
	Pb-210	1.75 pCi/g
66968/66969	U-238	0.85 pCi/g
	Th-230	0.85 pCi/g
	Ra-226	0.98 pCi/g
	Pb-210	<0.6 pCi/g
64007 Leachate	U-238	<1.0 pCi/l
	Th-230	<1.0 pCi/l
	Ra-226	<1.0 pCi/l
	Pb-210	<3.0 pCi/l

FIGURE 8 SLANT BORING 1615 (SILO 2)



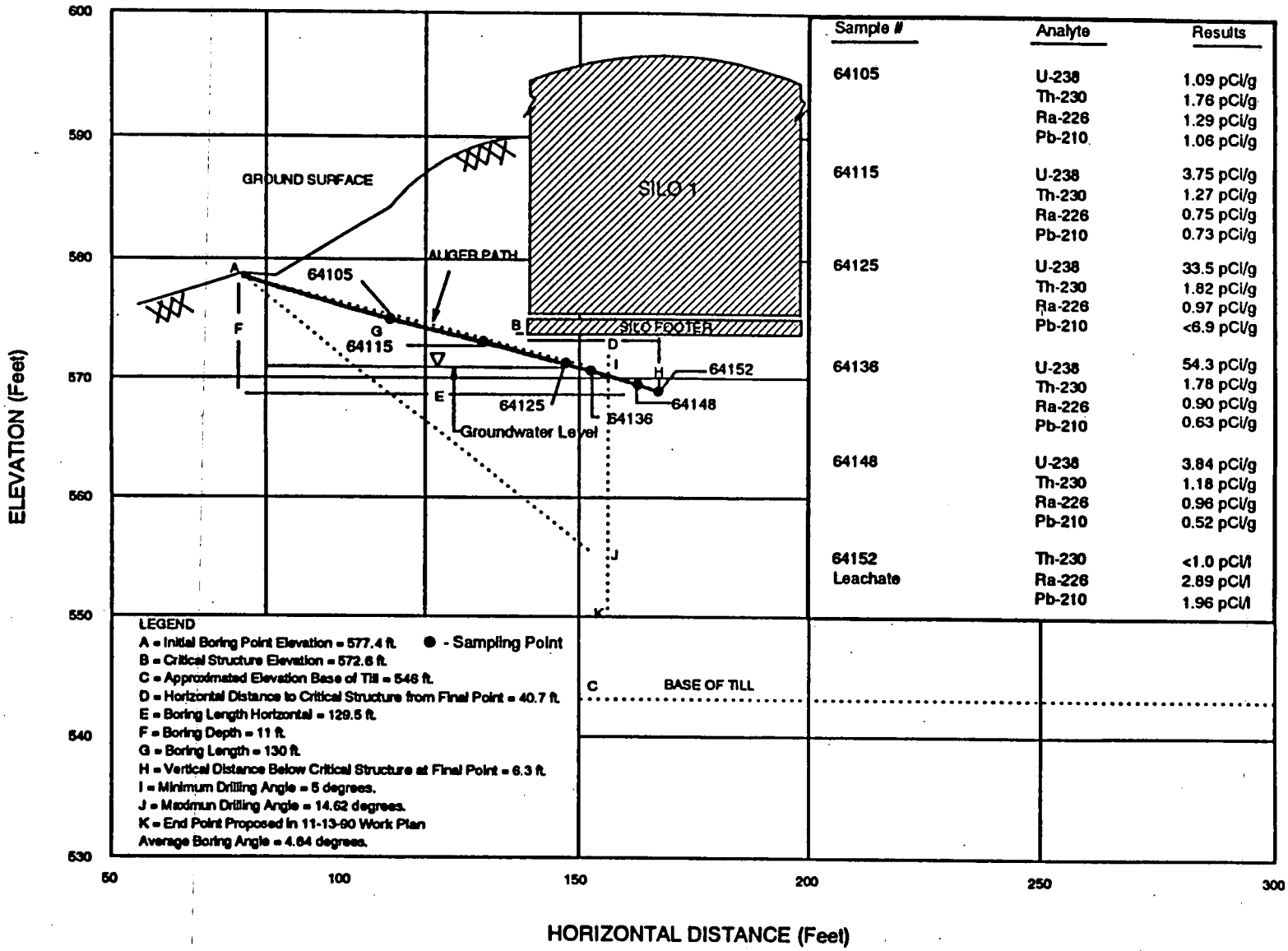
Sample #	Analyte	Results
64157	U-238	4.91 pCi/g
	Th-230	11.4 pCi/g
	Ra-226	137 pCi/g
	Pb-210	34 pCi/g
64032	U-238	0.76 pCi/g
	Th-230	0.80 pCi/g
	Ra-226	0.79 pCi/g
	Pb-210	0.56 pCi/g
64041	U-238	0.87 pCi/g
	Th-230	0.93 pCi/g
	Ra-226	0.66 pCi/g
	Pb-210	0.46 pCi/g
64021 Leachate	U-238	146 pCi/l (R)
	Th-230	<1.0 pCi/l (R)
	Ra-226	<1.0 pCi/l (R)
	Pb-210	<3.0 pCi/l
64052 Leachate	U-238	1.96 pCi/l
	Th-230	<1.0 pCi/l
	Ra-226	<1.0 pCi/l
	Pb-210	<1.0 pCi/l

FIGURE 9 SLANT BORING 1616 (SILO 1)



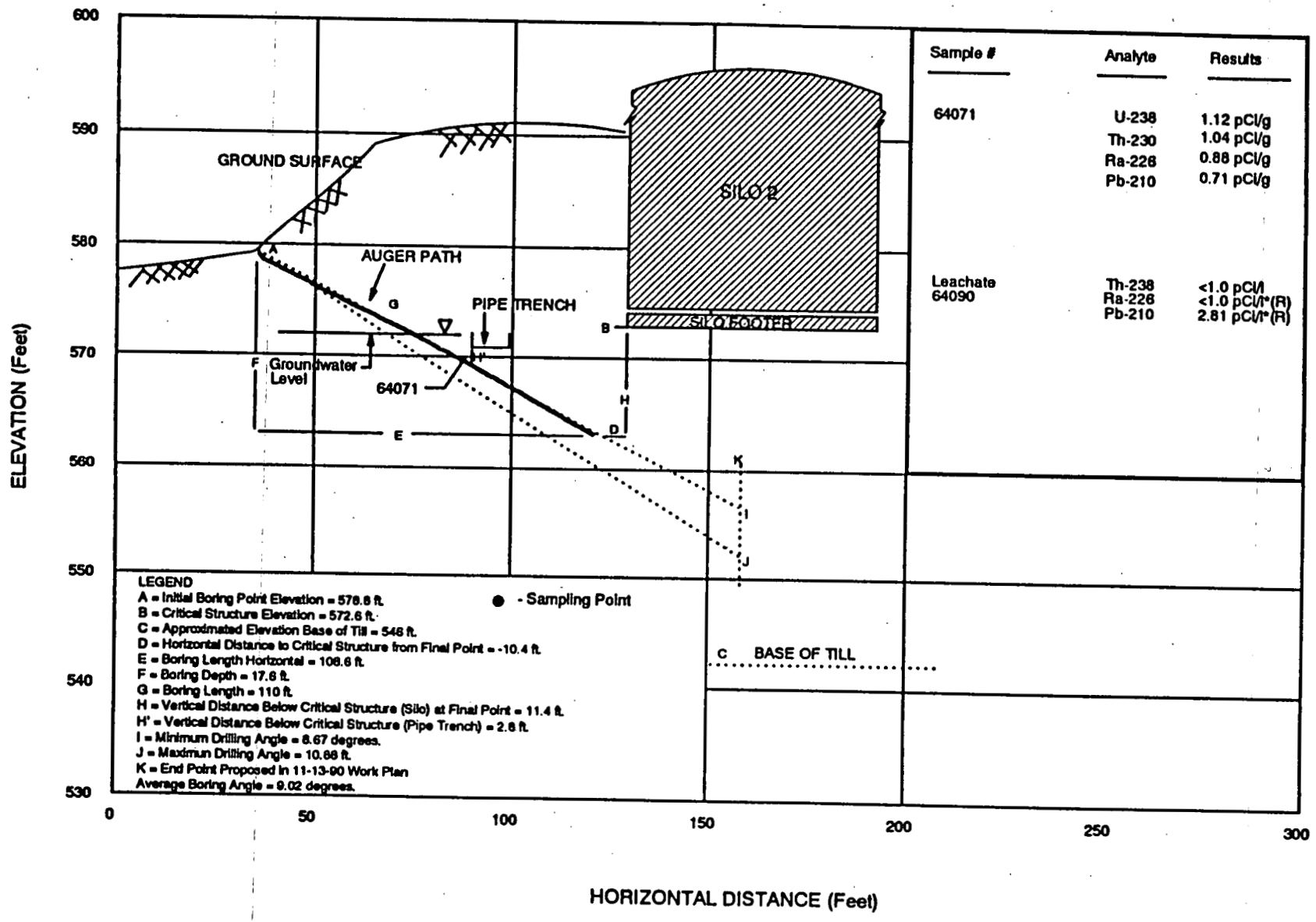
Sample #	Analyte	Results
66983	U-238	1.46 pCi/g
	Th-230	2.59 pCi/g
	Ra-226	1.31 pCi/g
66984	Pb-210	0.55 pCi/g (R)
66992	U-238	18.8 pCi/g
	Th-230	1.3 pCi/g
	Ra-226	0.97 pCi/g
	Pb-210	1.03 pCi/g
64001	U-238	5.64 pCi/g
	Th-230	0.88 pCi/g
	Ra-226	0.61 pCi/g
	Pb-210	<0.3 pCi/g
64009 Leachate	U-238	1313 pCi/l
	Th-230	NA
	Ra-226	<20 pCi/l
	Pb-210	<3 pCi/l

FIGURE 10 SLANT BORING 1617 (SILO 1)



Sample #	Analyte	Results
64105	U-238	1.09 pCi/g
	Th-230	1.76 pCi/g
	Ra-226	1.29 pCi/g
	Pb-210	1.06 pCi/g
64115	U-238	3.75 pCi/g
	Th-230	1.27 pCi/g
	Ra-226	0.75 pCi/g
	Pb-210	0.73 pCi/g
64125	U-238	33.5 pCi/g
	Th-230	1.82 pCi/g
	Ra-226	0.97 pCi/g
	Pb-210	<6.9 pCi/g
64136	U-238	54.3 pCi/g
	Th-230	1.78 pCi/g
	Ra-226	0.90 pCi/g
	Pb-210	0.63 pCi/g
64148	U-238	3.84 pCi/g
	Th-230	1.18 pCi/g
	Ra-226	0.96 pCi/g
	Pb-210	0.52 pCi/g
64152 Leachate	Th-230	<1.0 pCi/l
	Ra-226	2.89 pCi/l
	Pb-210	1.96 pCi/l

FIGURE 11 SLANT BORING 1618 (SILO 1)



Sample #	Analyte	Results
64071	U-238	1.12 pCi/g
	Th-230	1.04 pCi/g
	Ra-226	0.88 pCi/g
	Pb-210	0.71 pCi/g
Leachate 64090	Th-238	<1.0 pCi/l
	Ra-226	<1.0 pCi/l*(R)
	Pb-210	2.81 pCi/l*(R)

FIGURE 12 SLANT BORING 1619 (SILO 2)

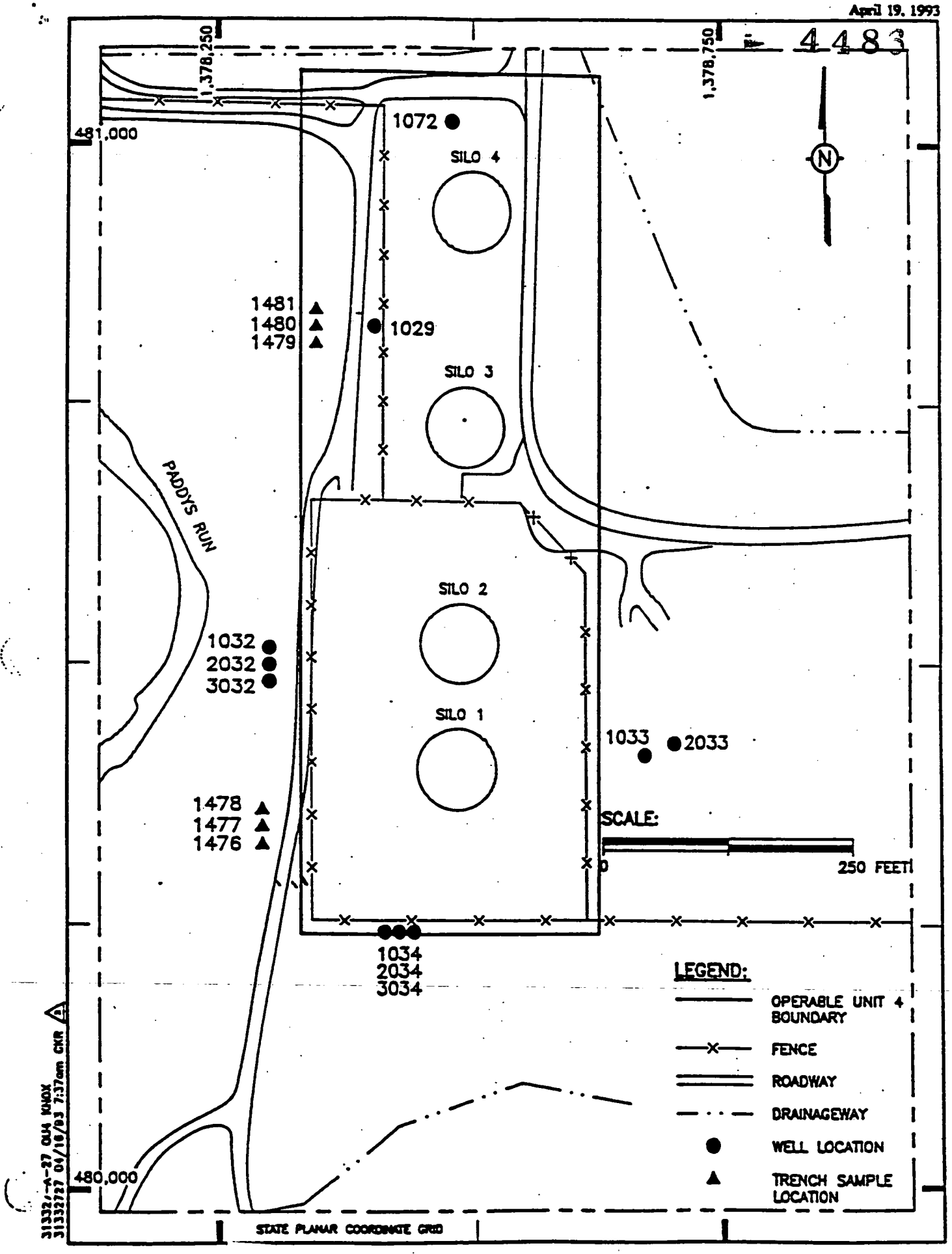


FIGURE 13 SUBSURFACE SOIL SAMPLING LOCATIONS

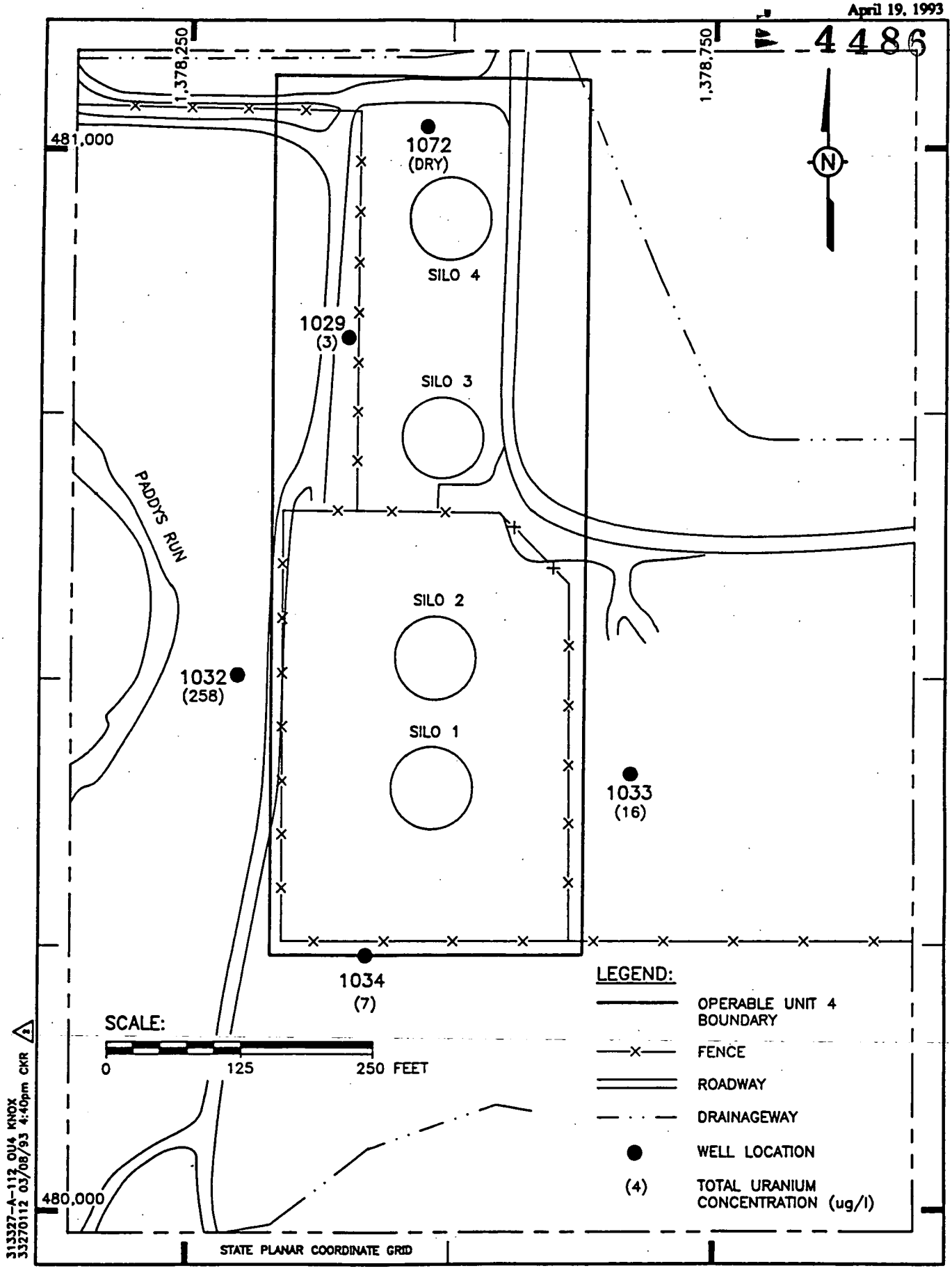


FIGURE 14 AVERAGE TOTAL URANIUM CONCENTRATION IN PERCHED GROUNDWATER (1988-1989)

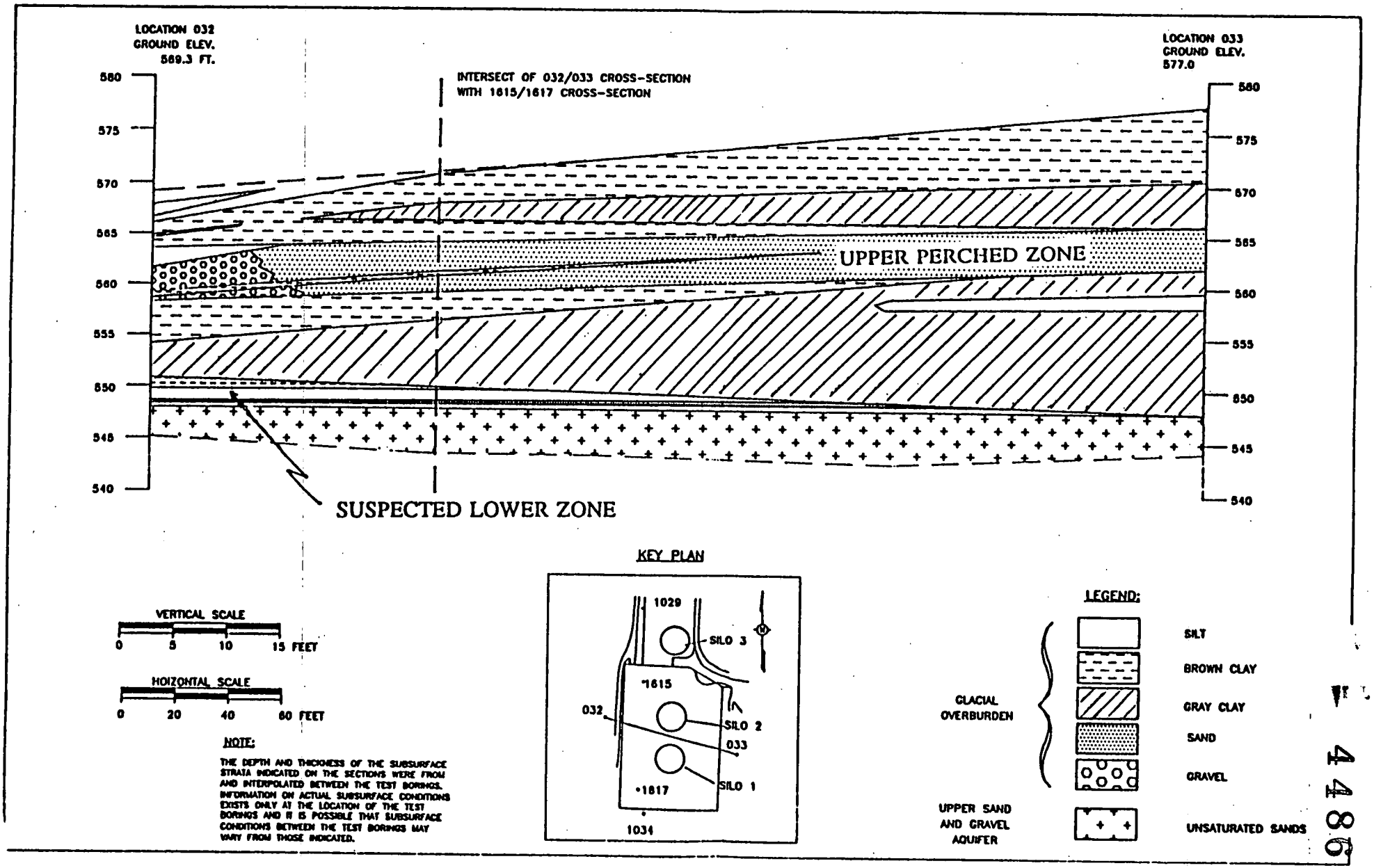


FIGURE 15 GEOLOGICAL CROSS SECTION OF LOCATION 032/033 IN THE K-65 SILO AREA

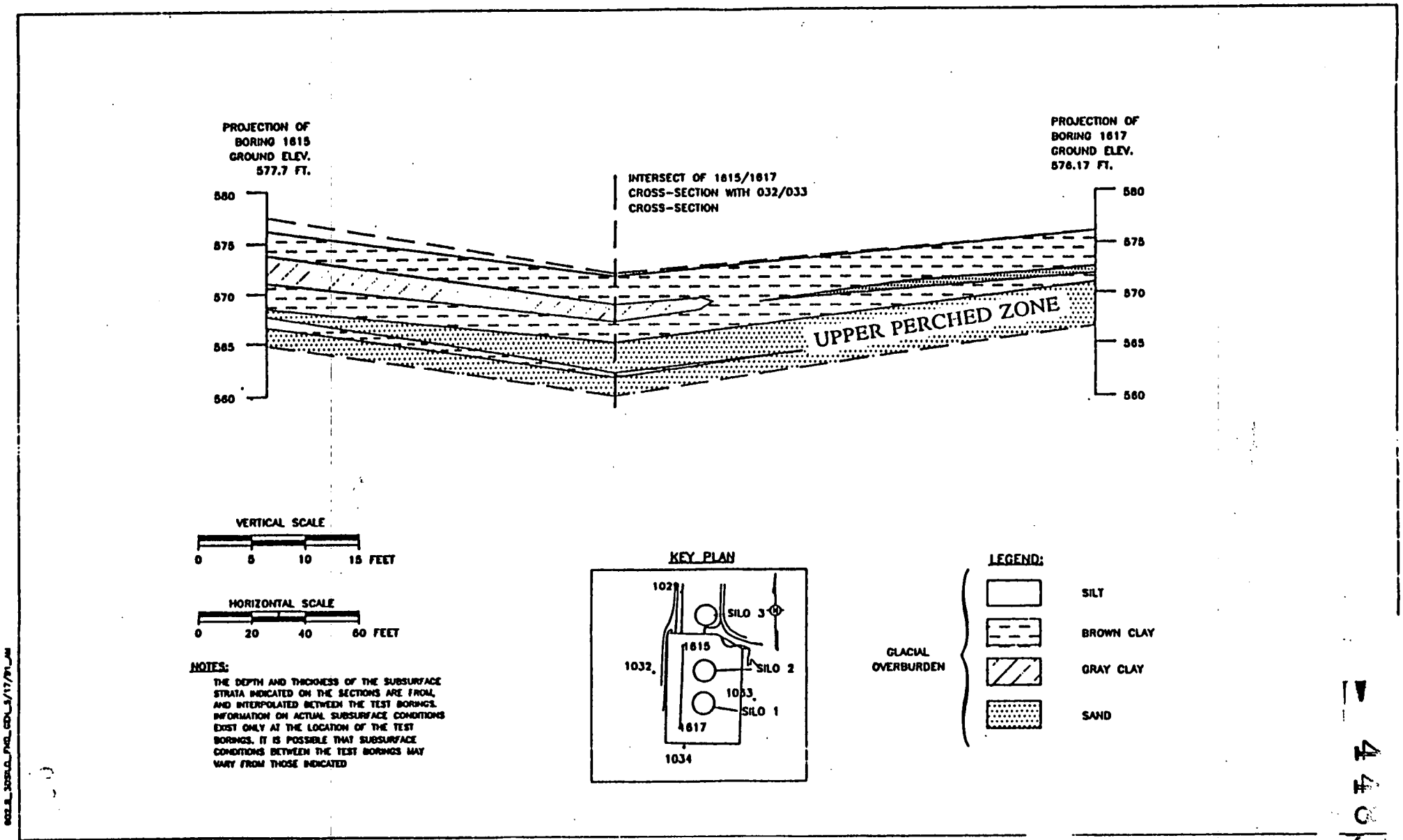


FIGURE 16 GEOLOGICAL CROSS-SECTION BORINGS 1615/1617 IN THE K-65 SILO AREA

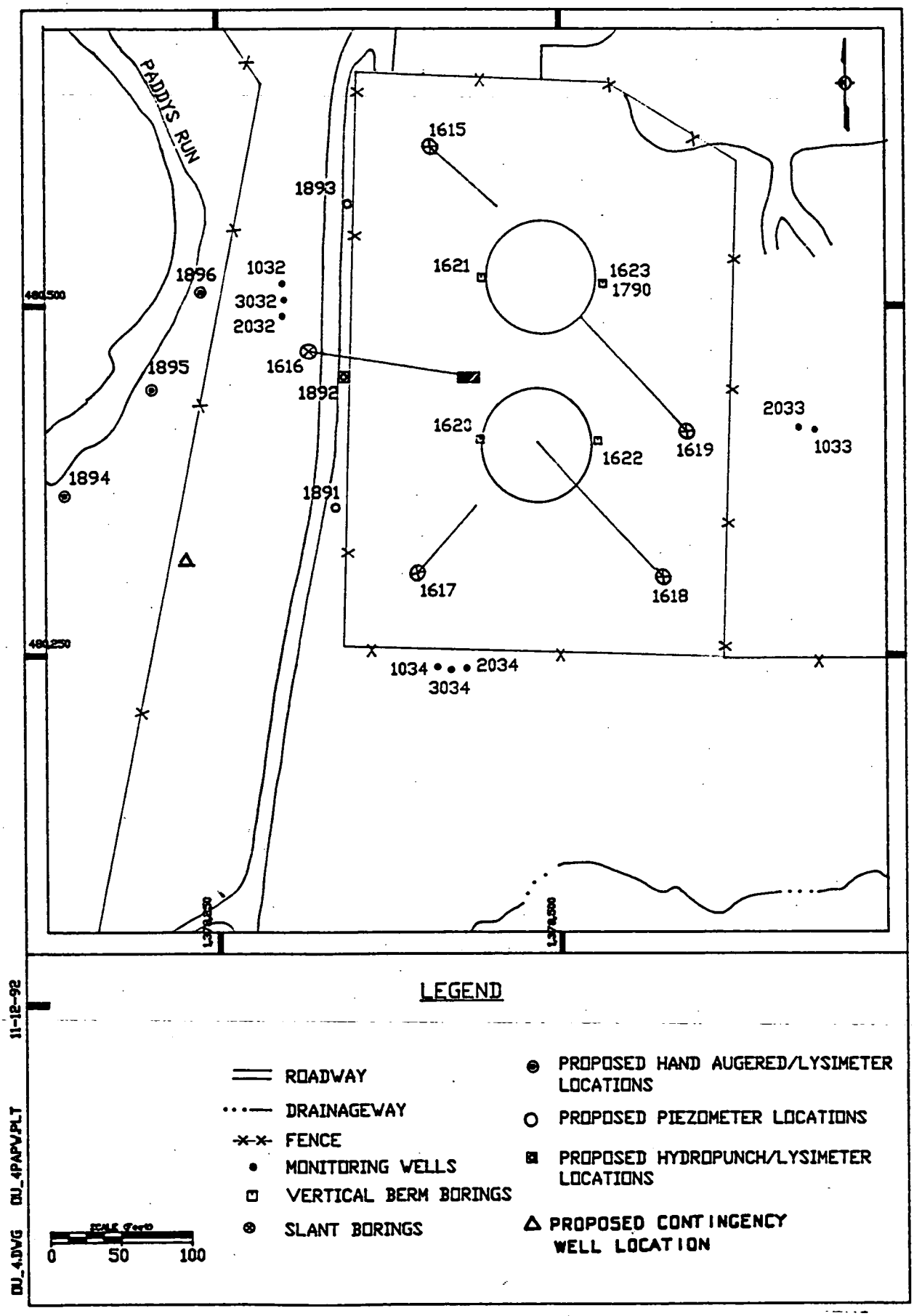


FIGURE 17 PROPOSED ADDITIONAL PERCHED WATER SAMPLE LOCATIONS

APPENDIX B

TABLE 1

RADIOLOGICAL CONSTITUENTS FOR K-65 SILO SUBSURFACE SOILS

COMPOUNDS (pCi/g)	FREQUENCY OF DETECTION	MEAN	RANGE	UTL*
Ac-227	4/17	5.03750	0.56-9.66	N/A
Pb-210	10/14	24.11400	0.52-101	2.23
Po-210	10/13	9.55180	0.938-62.6	2.23
Ra-224	11/15	1.08182	0.67-1.71	1.475
Ra-226	16/21	33.36869	0.613-206	2.613
Ra-228	12/21	0.86483	0.485-1.24	1.475
Sr-90	1/6	0.81600	0.816-0.816	N/A
Th-228	16/19	1.48988	0.768-2.06	1.475
Th-230	14/20	5.78871	0.8-53.7	2.109
Th-232	12/21	0.99950	0.62-1.5	1.668
Th-TOTAL	15/21	8.24267	3.34-13.6	N/A
U-234	18/19	14.88806	0.8-139	2.109
U-235/236	5/20	3.64660	0.853-9.92	0.097
U-238	18/19	16.23800	0.76-146	2.368
U-TOTAL	12/17	59.35667	1.51-110	N/A

* Upper Tolerance Limit

TABLE 2

SUBSURFACE SOIL RADIOLOGICAL RESULTS WITHIN OPERABLE UNIT 4 AREA

			Analytical Results (pCi/g)								
Well No.	Sample ID	Depth (ft.)	Ra-226	Ra-228	Tc-99	Th-230	Th-232	U-234	U-235/236	U-238	Total U *
Background			1.51	1.28	-	2.18	1.36	1.28	0.15	1.22	NA
1018	07311	3.0-4.5	1.1	<0.8	<0.9	1.8	0.8	1.0	<0.6	1.1	NA
1029	07407	13.5-15.0	0.6	0.5	<0.9	1.0	<0.6	<0.6	<0.6	0.6	NA
1032	07504	15.0-16.5	1.0	0.6	<0.9	1.6	0.7	2.1	<0.6	1.3	NA
1033	08854	1.5-3.0	1.3	1.1	<1.3	1.6	1.3	1.2	<0.6	1.4	NA
1072	08188	0.0-1.5	1.5	1.0	3.6	4.8	0.9	3.4	<0.6	15.0	NA
2032	32456	7.5-9.0	0.69	<0.5	<0.9	0.8	<0.6	NA	NA	NA	9.81 ± 2.7
2032	32465	25.0-26.5	0.59	<0.5	<0.9	1.4	<0.6	<0.6	<0.6	0.6	7.86 ± 2
2033	32766	40-40.5	0.53	<0.05	<0.9	1.17R	<0.6	<0.6	<0.6R	<0.6	4.72 ± 1.5
3032	33083	95.0-96.5	0.87R	0.41R	<0.9	1.75R	<0.6	0.94R	<0.6R	0.99	2.74 ± 1.08R
3034	08272	10.5-12.0	<0.3	<0.5	<0.9	0.9	0.6	0.6	<0.6	0.6	NA
3034	08279	21.0-22.5	0.7	0.6	2.1	3.8	0.7	0.8	<0.6	0.9	NA
3034	08295	95.0-96.5	0.6	<0.5	<0.9	0.7	<0.6	<0.6	<0.6	<0.6	NA

NA Not Analyzed
* Results reported in ug/g
R Rejected

TABLE 3

PERCHED GROUNDWATER RESULTS FROM THE WEMCO ON-SITE LABORATORY (OCTOBER 28, 1991)

Boring Number	1615	1615	1616	1616	1617	1618	1619	
Location Within Boring	57 ft.	57 ft.	48 ft.	120 ft.	68 ft.	130 ft.	110 ft.	
Parameters				Results				Units
Total Thorium	<400	<400	<400	<400	<400	<400	<400	µg/l
Thorium-230	3.0	<3.0	1.0	4.5	5.0	<10.0	2.6	pCi/L
Uranium-234	0.69	0.66	96.9	1.01	3400	280	100	pCi/L
Uranium-235	0.03	0.038	4.8	0.04	140.0	13	5.1	pCi/L
Uranium-236	0.017	0.018	0.25	0.01	<5.9	<0.54	<1.0	pCi/L
Uranium-238	0.66	0.73	129.6	0.797	3100	<280	110	pCi/L
Total Uranium by Laser	2.00	2.20	390	2.4	9240	840	330	µg/l
Radium-226	1.00	0.9	<3.40	<4.5	<3.3	6.50	<3.40	pCi/L
Lead	<6	<6	19.2	4.0	<6	<3	5.0	µg/l
Barium	310	307	226.1	291.0	57	<200	<200	µg/l

TABLE 4

PERCHED GROUNDWATER RADIOLOGICAL ANALYSES - RI/FS

WELL NUMBER	SAMPLE NUMBER	DATE	Th-228 (PcI/L)[a]	Th-230 (PcI/L)	TOTAL THORIUM (µG/L)[b]	U-234 (pCi/L)	U-238 (pCi/L)	TOTAL URANIUM (µg/L)
1029	3076	04/05/88	<1 J [c,d]	<1 J	NA [e]	1.7 J	1.4 J	3 R [f]
1029	3354	07/20/88	<1 J	<1 J	<2 J	1.4 J	<1 J	3 R
1029	3634	10/23/88	<1 [f]	<1	<3	1.2	<1	2 J
1029	3852	01/22/89	<1 J	<1	<4	1.7	<1	3 J
1032	3133	04/27/88	<1	1.6	NA	84.9	96.8	256 R
1032	3355	07/20/88	<1 J	<1 J	<5 J	61.3 J	70.5 J	196 R
1032	3635	10/23/88	<1	<1	<5	82.4	92.4	230 J
1032	3851	01/22/89	<1	<1	<4	76.1	88.8	276 J
1033	3220	05/22/88	<1	1.4	NA	3.7	3.5	11 R
1033	3567	08/24/88	<1	<1	3	3.3	3	9 J
1033	3773	11/20/88	<1	<1	<2	4.9	5	15 J
1033	3961	03/10/89	<1	<1	<2	7.1	8.2	23 J
1034	3122	04/25/88	<1 R	<1 R	NA	1.3 J	1.1 J	4 R
1034	3850	01/22/89	<1	<1	<3	1.2	1.1	3 J
1034	3356	07/20/88	<1 J	2.4 J	<4	2.6 J	1.8 J	10 R
1034	3636	10/23/88	<1	<1	<2	2.9	3.4	7.0 J
1072	8213	03/09/88	0.6 R	0.7	NA	0.6 J	0.8 J	4 R

a Results expressed in piciCuries per liter (pCi/L). Data are from RI/FS and are validated.
b Results expressed in micrograms per liter (µg/L). Data are from RI/FS and are validated.
c J - Estimated value
d < - Not detected. Number represents detection limit.
e NA - Not analyzed
f R - Results unusable

TABLE 5
DATA QUALITY OBJECTIVES FOR K-65 ADDITIONAL PERCHED WATER

Activities	Install 2 piezometers in upper perched zone; install 1 piezometer/lysimeter in suspected lower perched zone	Install three hand-augered lysimeters along Paddys Run
	One round of sampling in new locations and in MW 1032, 2032	Analyze for Ra-226, U-238, fluorescein dye, Limited Rad/HSL, and GWQ
Prioritized data uses	Data will be used to: 1) characterize nature and extent of contamination in the K-65 perched water and a suspected lower perched zone; 2) define the western extent of contamination, possible influx to Paddys Run, and possible leakage from K-65 silos/decant system; 3) evaluate discrepancies in analytical results from RI/FS and FEMP labs.	
Appropriate analytical level	Level E for radiological; Level D for HSL, VOC inorganics; Level C for GWQ	
Constituents of concern	Ra-226, U-238, fluorescein dye primary (TAL 40.03.05-A), limited HSL, GWQ, Limited Rad secondary (TAL 40.03.05-B)	
Level of concern	Documented in Preliminary Remediation Goals, Site-Wide Characterization Report (Draft), August 1992	
Required detection limits	Documented in Section D, Sitewide CERCLA Quality Assurance Project Plan (Draft), September 1992	
Critical samples	Perched water samples from upper zone Hydropunch and piezometers and from suspected lower zone lysimeter or piezometer	

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4486

TABLE 6
SAMPLING REQUIREMENTS

Parameter	Min. Vol.	Desired Vol.	Priority	Preservatives**	Filtered***
Ra-226/U-238	1 liter	1 liter	1	HNO3	yes
Fluorescein	40 ml	100 ml	1	none	no
Inorganics	2 X 1 liter	4 X 1 liter	2	4° C, HNO3	yes
VOC*	2 X 40 ml	3 X 40 ml	3	4° C, HCL	no
GWQ	3 X 1 liter	6 X 1 liter	4	4° C, H2SO4	no
Alkalinity	500 ml	1 liter	5	4° C, H2SO4	no
Full Rad	2 liter	4 liter	6	HNO3	yes
Misc. Rad	500 ml	1 liter	7	HNO3	yes

* Store all VOC samples at 4°C until analyses. If HNu readings of >5 units for >10 seconds are obtained or there is reason to suspect the presence of VOC's, then sample will be analyzed at RI/FS lab. Otherwise sample will be used for lower priority analyses.

** Samples will be acidified to a pH<2

*** Hydropunch sample may contain significant suspended silt; sample will be pre-filtered before final filtering at 0.45 microns.

APPENDIX C

TIMCO™ Lysimeters for Vadose Zone Monitoring

TIMCO™ Cup Type Lysimeter with Porous Ceramic Filter

Also Available in Tube Type Body in Teflon® or PVC

TIMCO™ Porous Ceramic Lysimeters

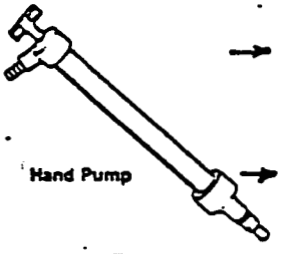
TIMCO'S™ Porous Ceramic Lysimeters are constructed similar to the TIMCO™ Porous Teflon® Lysimeters. Advanced machining techniques allow the ceramic filter to be threaded. This permits, for the first time, a totally adhesive and sealant free construction. Sealants, potential sources of contamination, are eliminated. The TIMCO™ Ceramic Filter Elements have a pore size of 0.446 micrometers by the mercury penetration porosimetry method (ASTM C-699).

The TIMCO™ Porous Ceramic Filter element may be easily removed from the body for decontamination or replacement if accidental breakage occurs. TIMCO™ uses Viton® O-rings in the flush threaded ceramic joints, to ensure a leak-free seal. The top plug is threaded to allow attachment of casing. If the lysimeter unit is located more than 20' (6M) below the ground surface, a TIMCO™ Deep Sampling Lysimeter will be required. Sample recovery in excess of 10 psi may damage the filter and/or silica pack and force the collected pore water sample out of the lysimeter, back into the soil. TIMCO™ recommends the use of its Select Silica Flour as a pack around the installed lysimeter.

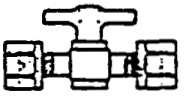
Porous Ceramic Lysimeters: Sizes Available with PVC Body	
Tube type	1.90" (48.3mm) x 17.5" (44.5cm)
Cup type	1.90" (48.3mm) x 17.5" (44.5cm)

Lysimeter Accessories

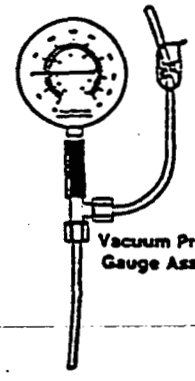
Silica Flour



Hand Pump

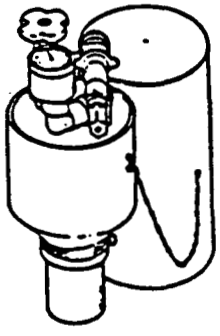


Teflon® Stopcock



Vacuum Pressure Gauge Assembly

Delrin® Stopcock



Lysimeter Head Assembly

TIMCO™ Lysimeter Accessory Items

Tubing

TIMCO™ provides tubing to connect the lysimeter to the surface. Usually 1/4" OD Teflon® or polyethylene is suitable.

TIMCO™ Select Silica Flour

Silica, 200 mesh (99.8% pure) is available in 50lb (23kg) plastic pails. Allow a minimum of 1 pail per installed lysimeter. Mix each pail with 2 gallons of distilled water to make about 6 gallons of silica slurry.

Vacuum Pressure Hand Pump

The pump is used to apply vacuum to the lysimeter during the pore water extraction phase. Pressure or vacuum is applied to deliver the sample to the surface.

Vacuum Pressure Gauge Assembly

When installed on the lysimeter vacuum/pressure tube, allows for constant monitoring during the pore water extraction phase. During the sample recovery phase, it will alert the user to potential over-pressurization.

Teflon® Stopcock and Delrin® Shut-Off Valves

Designed to allow easy sealing of the sample delivery and vacuum/pressure lines when not using a lysimeter well head assembly. The Teflon® stopcock is used with Teflon® tubing, the Delrin® shut off valve is used with polyethylene tubing.

Lysimeter Head Assembly

Designed for placement on the casing at the ground surface, it provides a neat and secure termination of the tubes from the lysimeter. A permanent vacuum/pressure gauge and taps for the vacuum/pressure and sample line are mounted beneath the weatherproof cap. Stopcocks and gauge assembly are not needed with Head Assembly.

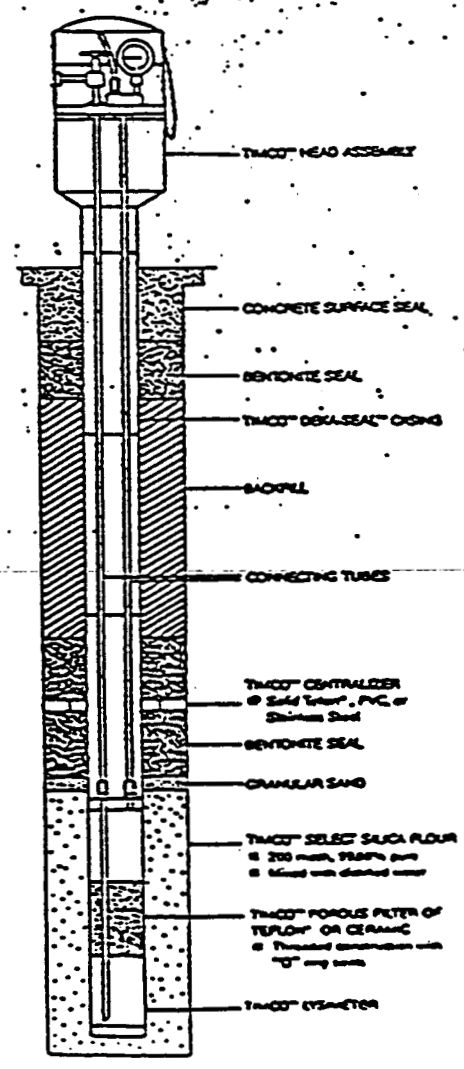
Operating Principles

The Timco(TM) Lysimeter System is designed for long term use in one location. are must be taken with the installation to ensure correct operation for a long eriod. The assembled system should always be checked for leaks prior to being at in the ground.

A Tube or Cup Type Lysimeter has an outside diameter of 1.9" or 2.375". These hould be placed in boreholes of at least 6" in diameter to allow for an adequate ilica slurry pack to surround the lysimeter.

The lysimeter has the vacuum/pressure outlet marked on the lysimeter top plug. his connection leads to the vacuum gauge on the head assembly. It allows a vacuum o be applied to the system, thereby creating a vacuum gradient between the inside f the lysimeter, the silica slurry pack, and the soil under investigation. The econd unmarked connection is the sample evacuation tube. This is connected to he head assembly sample line.

The specification of the silica flour used to surround the installed lysimeter s critical and should only be purchased from Timco. If a 6" borehole is used, single 50 lb. pail will be sufficient for each lysimeter installation. The flour s made into a slurry with distilled water before placement. The silica slurry s used to establish a continuum between the lysimeter and the surrounding soil. ince the Timco(TM) silica is not water soluble, it immediately begins to separate tself from the distilled water. When placed in the ground the water migrates nto the soil and establishes the continuity required for surface tension to be ransmitted in an outward direction upon application of a vacuum. This allows ny moisture attached to the soil particles to be drawn into the lysimeter through he silica pack.



TIMCO LYSIMETER MANUAL

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Assembling the Lysimeter

If properly installed, the typical lysimeter system will be expected to produce representative samples for several decades. It is therefore important to check out the system thoroughly before taking it to the installation site. Prior to installation the system should be pressure and/or vacuum tested to ensure it is leak free.

The lysimeter system components supplied by Timco are cleaned and packed in plastic bags. They have not been subjected to the rigorous decontamination procedures required for equipment used to obtain samples for subsequent micro-analysis of trace pollutants. If complete decontamination is required, see the section titled "Decontamination Procedures" and/or follow those specified for the specific job. Note that if the lysimeter body is decontaminated it will be necessary to pass at least 2 liters of distilled water through the porous section to ensure complete removal of the liquids used for the decontamination. After this procedure is completed the components should be bagged. Subsequent handling should be done in a clean area using sterile gloves.

The system components supplied are manufactured by Timco to satisfy the requirements of the order. Mixing these with components from other sources may lead to incompatibility problems resulting in leakage or failure of the lysimeter system.

1). Assembly of Tubing to Fittings.

Tubing, because of its slippery nature and rigidity, has to be specially grooved before a fitting is attached. Failure to do so will allow the tubing to slip out of the fitting and cause leakage. Timco normally grooves each end of the tubing supplied with the order. If the installation requires the tubing to be shortened the new end will need to be grooved using a special grooving tool available from Timco. The tool not only cuts the groove but also places the groove at the correct distance from the end of the tube.

2). Assembling the System.

As mentioned earlier, it is suggested that the complete system be assembled away from the installation site. This will allow for the assembly and testing under clean conditions. The assembled lysimeter may then be easily placed at the job site.

The assembly should begin with the attachment of the vacuum/pressure and sample evacuation lines to the lysimeter top plug. If necessary cut each to length, making certain cuts are clean and vertical to the horizontal length of the tubing. Follow the previous instructions for the grooving. Note that the Vacuum /Pressure outlet at the top of the lysimeter plug is marked with a "V". Make certain that the other end of the tube connected to this fitting is suitably marked or tagged. This will provide assurance that the tubing is correctly connected to the Timco Head Assembly.

If the installation is to involve threaded riser casing of appropriate length, assemble it at this time. Pass the two tubes from the lysimeter through the casing string. To complete the assembly attach the sample evacuation and vacuum/pressure lines to the bottom of the head assembly. The Timco Vacuum/Pressure Hand Pump is connected in the vacuum mode. The black female hose connector should be used to attach the end of the tubing to the hand pump (black end). The assembled system may now be tested for leaks.

Testing the System

Effective use of the lysimeter system requires that there be no air leaks. Two methods are described to check the assembled system for leaks.*

Pressure Testing

Completely immerse the lysimeter and the head assembly components, except for the gauge, in water. Connect the pressure outlet of the Timco Hand Pump to the vacuum/pressure line fitting on the head assembly. Apply 15 psi. of air pressure. Observe all connections for evidence of bubble leakage. The porous filter section should give off bubbles over its entire surface area. If leaks are observed in the tubing fittings, disassemble and check for correct assembly and retighten. Leaks at the fitting connections to the lysimeter body or the head assembly may be wrapped with Teflon(R) tape prior to reassembly. Leaks involving the body components of the lysimeter should be checked for cleanliness, particularly the surface that touches the O-Rings.

Vacuum Testing

The porous filter media of the lysimeter body is sealed off with a latex or flexible plastic membrane. Secure a seal by placing rubber bands over the membrane and securing it to the body of the lysimeter above the porous filter. Shut off the sample valve. Connect the vacuum inlet of the pump to the vacuum/pressure port on the head assembly, and apply a vacuum in excess of 20 inches of mercury. Shut off the vacuum valve. Note the vacuum reading on the gauge. Leave the system for several hours and then recheck the vacuum reading. A small drop of up to 3 inches of mercury may be expected. If a large drop is noted, check and retighten all connections as described above.

Prewetting the Porous Filter Media

Finally, before taking the assembled lysimeter system to the installation site, Timco(TM) recommends that the lysimeter body be placed in distilled water and a vacuum of about 15 inches of mercury be applied for 1 hour. This procedure prewets all surfaces of the porous filter media, eliminating any entrapped air in the filter media. The lysimeter should be installed with the body filled with distilled water if no riser casing is used. An empty, unsupported lysimeter will float on the wet silica slurry when placed in the borehole.

* NOTE — All Timco Lysimeters are tested at Timco prior to shipping. Fittings may loosen during transit.

TIMCO LYSIMETER MANUAL

Installation and Evacuation of the Shallow Lysimeter

The installation of a Timco Lysimeter System should be in accordance with the following procedure. It is suitable for depths of up to 20 feet. For greater depths a Timco(TM) Deep-Sampling Lysimeter should be used.

1). Borehole Preparation

The borehole must provide adequate space to allow the lysimeter body to be surrounded by the silica slurry pack. For a 2" diameter lysimeter use a 6" or larger borehole. The borehole must allow for at least a 1.5" thickness of silica slurry all around the porous filter of the lysimeter. If difficulties are anticipated in maintaining an open borehole, use casing to hold back the material. Immediately after installation of the silica pack and lysimeter pull back the casing and install a bentonite plug.

2). Mixing the Silica Flour Slurry

The Timco(TM) 200 mesh, 99.88% pure crystalline silica flour is mixed with distilled water using a ratio of 150 mls. water to 450 grams of silica flour. The Timco Silica Flour is supplied in a 50 lb. sealed pail. This will require about 2 gallons of distilled water to make the slurry and will be sufficient for a single lysimeter installation in a 6" borehole. Add the flour slowly to the distilled water with constant stirring. The mix must be completely blended and lumpfree. Constant stirring is essential as the silica is not water soluble and will settle if not agitated.

3). Placing the Silica Slurry Pack

Pour part of the silica slurry into the borehole to provide a bed for the lysimeter. A minimum of 4" depth for the cup-type lysimeter and 2" for the tube-type lysimeter. Depending upon the borehole diameter, between a quarter and a third of the total mix is usually sufficient

The Timco(TM) Lysimeter System should now be lowered into the borehole. Take particular care to make certain that the lysimeter body is centrally located within the borehole diameter. A minimum of 1.5" of silica slurry around the annular area of the unit is essential. Timco suggests Deka-Seal(R) casing be used for support and accurate placement. Centralizers will also assure correct placement.

The balance of the silica slurry should now be poured into the borehole to completely cover and surround the lysimeter body. Note that you must have the lysimeter in intimate contact with the silica slurry and the slurry must fill all voids in the bottom of the borehole. The Lysimeter should be supported at the surface with stakes for at least 2 hours until the silica sets.

A bentonite seal should be installed next, followed by tamped backfill. A second bentonite seal is suggested near the surface. Protection at the surface can be achieved with the Timco(TM) Lysimeter Head Assembly and a Timco(TM) Security Cover set in concrete.

4). Activating the Lysimeter

If the lysimeter was filled with distilled water before installation, this should now be removed and discarded. Timco recommends the use of a two port rubber stopper in a collection flask. The flask should be of adequate size to hold the sample from a full lysimeter. This method is unlikely to disturb the silica pack and break the seal between the pack and the porous section of the lysimeter which would result in a lysimeter system failure.

1. Open the vacuum-pressure valve and the sample valve on the head assembly.
2. Attach the tube from the sample port on the head assembly to the hole in

rubber stopper. (Tube to protrude about 1" into the flask).

3. Attach the second tube from the flask to the vacuum-pressure inlet on the Timco Hand Pump. (Tube to be flush with the bottom of the rubber stopper).
4. Apply a gentle vacuum to the system, the distilled water will flow into the collection flask.

After removing the distilled water from the lysimeter, you are ready to activate the lysimeter to obtain a sample. If you start the activating procedure immediately after installation, it will be necessary to remove and discard the distilled water used to make up the silica pack. (Remove a water volume equivalent to approximately one third of that used to make up the slurry).* If the installation is left for a few days, the water in the silica pack will migrate into the surrounding soil and establish the continuity needed between the porous filter media and the soil. Samples collected in this situation should be considered representative. Use the following steps to activate the system.

1. Close the sample evacuation valve.
2. Connect the vacuum inlet of the Hand Pump to the vacuum-pressure port on the Head Assembly.
3. Apply a vacuum of 18-21 inches of mercury and close the vacuum-pressure valve.
4. When the gauge reads 10 inches of mercury or less, evacuation of water should be attempted. (Up to 24 hours may be needed).

* EXAMPLE: Using 2 gallons (7570 mls.) to mix the silica slurry would mean that the first .6 gallons (2271 mls.) of distilled water should be discarded.

5). Evacuating the Lysimeter with Pressure

The lysimeter body is pressurized and the sample is driven to the ground surface. A pressure of .44 psi is required for each foot of depth. For a 20' installation 9 psi will be needed to lift the sample. The time taken to accumulate a sample will depend upon the soil conditions. Sampling intervals separated by 48 hours or more are not uncommon. Use the following steps to evacuate the lysimeter.

1. Open the sample evacuation valve and the vacuum-pressure valve.
2. Connect the pressure outlet of the Timco(TM) Hand Pump to the vacuum-pressure port on the lysimeter head assembly.
3. Pressure should be increased gently until 9 psi is achieved. (If 9 psi were applied instantly, it is possible the silica pack would be damaged resulting in a lysimeter system failure).
4. Sample is forced up through the evacuation line and into a sample collection flask.

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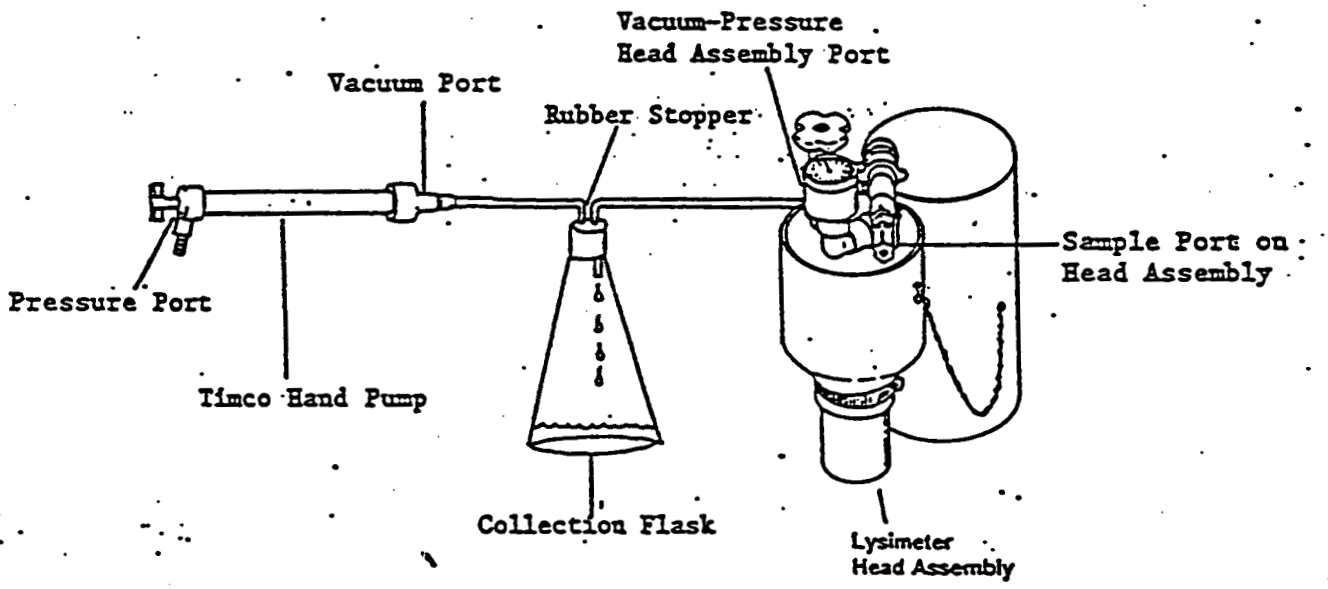
6). Evacuating the Lysimeter with Vacuum

This method is unlikely to disturb the silica pack and also reduces the possibility of sample aeration. Timco does not recommend this method for installations greater than 20 feet in depth. A two port rubber stopper in a collection flask is required. Use the following steps to evacuate the lysimeter.

1. Open the vacuum-pressure valve and the sample valve on the Head Assembly.
2. Attach the tube from the sample port on the Head Assembly to the hole in the rubber stopper. (Tube to protrude about 1" into the flask).
3. Attach the second tube from the flask to the vacuum-pressure port on the Timco(TM) Hand Pump. (Tube to be flush with the bottom of the rubber stopper).
4. Apply a gentle vacuum to the system, the sample will flow into the collection flask. (Flask to be of adequate size to hold the sample from a full lysimeter).



Cleaning and Decontamination

The following advice is provided by Timco. Timco can assume no liability and provides no guarantee that the procedures will ensure that a Timco product has been 100% cleaned. Timco does however believe that the procedures will give the proper purity characteristic required under state of the art conditions.

Teflon(R) & Ceramic Components

Step 1 - Disassemble all components.

Step 2 - Prepare a normal solution of Hydrochloric Acid. (120 g. concentrated HCL diluted in 1 liter distilled water).

Step 3 - Rinse all components in distilled water.

Step 4 - Submerge all components in this solution for 30 minutes minimum. Use a tool to remove from the solution. Soak in distilled water.

Step 5 - Resubmerge the components in clean water at least 2 more times to remove all traces of Hydrochloric Acid.

Step 6 - Timco believes an additional step of an Isopropyl Alcohol (IPA) bath and then another bath of Hydrogen Peroxide should render the equipment clean.

Step 7 - In all cases a final rinse in distilled, deionized water should ensure that the device is then suitable for representative sampling.

PVC Components

Step 1 - All products must be thoroughly cleaned of loose PVC particles, machining burrs and any other loose materials both inside and out. (Timco normally does this with all products shipped, but occasionally mistakes do happen).

Step 2 - Prepare a suitable Isopropyl Alcohol (IPA) bath which will allow total immersion of the product to be decontaminated.

Step 3 - Allow products to remain fully immersed for a period of no less than 10 minutes.

Step 4 - Remove products with clean surgical gloves to reduce chances of new contamination. Allow excess IPA to drain off.

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TIMCO MANUFACTURING, INC.

COMPLETE LINE OF GROUND WATER PRODUCTS

851 FIFTEENTH STREET, P.O. BOX 8
PRAIRIE DU SAC, WISCONSIN 53578
TOLL FREE: 1-800-236-8534
PHONE: 1-608-643-8534
FACSIMILE: 608-643-4275

FAX TRANSMITTAL SHEET

DATE: March 29, 1993

TO: Tom Anderson

ATTENTION: Tom Anderson

FAX NO: 513-738-9509

NUMBER OF PAGES: 1 (INCLUDING THIS TRANSMITTAL SHEET)

COMMENTS:

Dear Tom:

In response to your inquiry about installing lysimeters with wet silica flour vs. dry silica flour, we are unaware of any recent installations of lysimeters utilizing dry silica flour. The reasoning behind using wet silica flour is to establish good continuity between the soil under investigation and the filter media (ceramic or Teflon). We recommend once the silica slurry pack is in place and the lysimeter installed, an amount of water be removed from the silica pack, so that you do not have excess water in tight soil conditions (please see enclosed instructions from our instruction manual).

There was a time when dry silica flour was used, but it appears through much experimentation, it does not work as well as wet silica flour.

If you have further questions or need clarification please do not hesitate to call.

Sincerely,

Mark O'Donnell
Marketing/Sales Manager

TIMCO™ LYSIMETER MANUAL

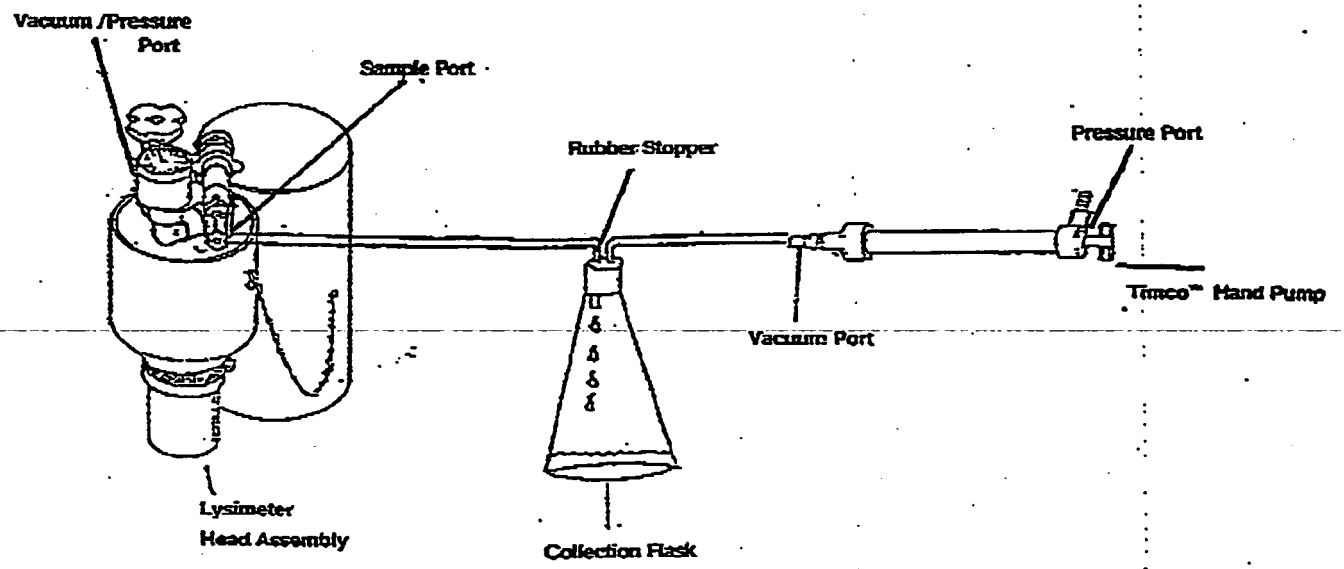
1. Close the vacuum/pressure valve and open the sample valve on the head assembly.
2. Attach the tube from the sample port on the head assembly to the hole in the rubber stopper. (Tube to protube about 1" into the flask.)
3. Attach the second tube from the flask to the vacuum/pressure inlet on the TIMCO™ Hand Pump. (Tube to be flush with the bottom of the rubber stopper.)
4. Apply a gentle vacuum to the system, the distilled water will flow into the collection flask. (See illustration)

5.) Evacuating the Lysimeter

After removing the distilled water from the Lysimeter you are ready to charge the Lysimeter to obtain a sample. If you start the charging procedure immediately after installation, it will be neccesary to discard the distilled water used to make up the silica pack. (*Remove a water volume equivalent to approximately one third of that used to make up the slurry.) If the installation is left for a few days, the water in the silica pack will migrate into the surrounding soil and establish the continuity needed between the porous filter media and the soil. Samples collected in this situation should be considered representative.

1. Close the vacuum/pressure valve and open the sample valve on the head assembly.
2. Continue applying a gentle vacuum to the Lysimeter until a reading of 18-21 inches of mercury is reached. Quickly close the sample port.
3. When the gauge reads 10 inches of mercury or less, evacuation of water should be attempted. (Up to 24 hours may be needed.)

*Example: Using 2 gallons (7570 mld.) to mix the silica slurry would mean that the first .6 gallons (2271 mls.) of distilled water should be discarded.



Sample capacity:	1.9" Cup-Type	400 MLS
	1.9" Tube-Type	550 MLS

APPENDIX D

ADDITIONAL PERCHED WATER CHARACTERIZATION IN THE K-65 AREA

PRIMARY GROUNDWATER SAMPLES

TAL 40.03.05 A

FEMP RI/FS – RADIOLOGICAL – ANALYTICAL PARAMETERS

	RADIOLOGICAL	Pay Item
1	Radium 226	114
2	Uranium 238	120

ADDITIONAL PERCHED WATER CHARACTERIZATION IN THE K-65 AREA

SECONDARY GROUNDWATER SAMPLES / FIELD BLANKS / RINSATES

TAL 40.03.05 B

FEMP RI/FS - LIMITED HSL - ANALYTICAL PARAMETERS

	INORGANICS	Pay Item
1	Aluminum	50
2	Antimony	
3	Arsenic	
4	Barium	
5	Beryllium	
6	Cadmium	
7	Calcium	
8	Chromium (Total)	
9	Cobalt	
10	Copper	
11	Cyanide	
12	Iron	
13	Lead	
14	Magnesium	
15	Manganese	
16	Mercury	
17	Molybdenum	
18	Nickel	
19	Potassium	
20	Selenium	
21	Silicon	
22	Silver	
23	Sodium	
24	Thallium	
25	Vanadium	
26	Zinc	

	VOLATILE ORGANICS	
1	1,1-Dichloroethane	47
2	1,1-Dichloroethene	
3	1,1,1-Trichloroethane	
4	1,1,2-Trichloroethane	
5	1,1,2,2-Tetrachloroethane	
6	1,2-Dichloroethane	
7	1,2-Dichloroethene (total)	
8	1,2-Dichloroethylene	
9	1,2-Dichloropropane	
10	2-Butanone	
11	2-Hexanone	
12	4-Methyl-2-pentanone	
13	Acetone	
14	Benzene	
15	Bromodichloromethane	
16	Bromoform	
17	Bromomethane	
18	Carbon disulfide	
19	Carbon tetrachloride	
20	Chlorobenzene	
21	Chloroethane	
22	Chloroform	
23	Chloromethane	
24	cis-1,3-Dichloropropene	
25	Dibromochloromethane	
26	Ethylbenzene	
27	Methylene chloride	
28	Styrene	
29	Tetrachloroethene	
30	Toluene	
31	Total xylenes	
32	trans-1,3-Dichloropropene	
33	Trichloroethene	
34	Vinyl acetate	
35	Vinyl chloride	

FEMP RI/FS - GENERAL GROUNDWATER QUALITY - ANALYTICAL PARAMETERS

	GENERAL CHEMISTRY	Pay Item
1	Ammonia	143
2	Chloride	
3	Fluoride	
4	Nitrate	
5	Phenols	
6	Phosphorus (total)	
7	Sulfate	
8	Sulfide	
9	Total Organic Carbon (TOC)	
10	Total Organic Halogens (TOX)	
11	Total Organic Nitrogen (TON)	

	MISC. GENERAL CHEMISTRY	
1	Alkalinity	134

FEMP RI/FS - RADIOLOGICAL - ANALYTICAL PARAMETERS

	RADIOLOGICAL	
1	Cesium 137	56
2	Neptunium 237	
3	Plutonium 238	
4	Plutonium 239/240	
5	Radium 226	
6	Radium 228	
7	Ruthenium 106	
8	Strontium 90	
9	Technetium 99	
10	Thorium 228	
11	Thorium 230	
12	Thorium 232	
13	Total Thorium	
14	Total Uranium	
15	Uranium 234	
16	Uranium 235/236	
17	Uranium 238	

	MISC. RADIOLOGICAL	
1	Gross alpha	19
2	Gross beta	
3	Lead 210	110

ADDITIONAL PERCHED WATER CHARACTERIZATION IN THE K-65 AREA

TRIP BLANKS

TAL 40.03.05 C

FEMP RI/FS - LIMITED HSL - ANALYTICAL PARAMETERS

	VOLATILE ORGANICS	Pay Item
1	1,1-Dichloroethane	47
2	1,1-Dichloroethene	
3	1,1,1-Trichloroethane	
4	1,1,2-Trichloroethane	
5	1,1,2,2-Tetrachloroethane	
6	1,2-Dichloroethane	
7	1,2-Dichloroethene (total)	
8	1,2-Dichloroethylene	
9	1,2-Dichloropropane	
10	2-Butanone	
11	2-Hexanone	
12	4-Methyl-2-pentanone	
13	Acetone	
14	Benzene	
15	Bromodichloromethane	
16	Bromoform	
17	Bromomethane	
18	Carbon disulfide	
19	Carbon tetrachloride	
20	Chlorobenzene	
21	Chloroethane	
22	Chloroform	
23	Chloromethane	
24	cis-1,3-Dichloropropene	
25	Dibromochloromethane	
26	Ethylbenzene	
27	Methylene chloride	
28	Styrene	
29	Tetrachloroethene	
30	Toluene	
31	Total xylenes	
32	trans-1,3-Dichloropropene	
33	Trichloroethene	
34	Vinyl acetate	
35	Vinyl chloride	

ADDITIONAL PERCHED WATER CHARACTERIZATION IN THE K-65 AREA

SAMPLES TO BE ANALYZED ON-SITE

TAL 40.03.05 D

FEMP RI/FS - MISCELLANEOUS - ANALYTICAL PARAMETERS

MISC. PARAMETERS

1		Fluorescein Dye

APPENDIX E

FIGURE 3

ADDITIONAL PERCHED WATER CHARACTERIZATION IN THE K-65 AREA

HYDROPUNCH II SAMPLING / PIEZOMETER / LYSIMETER

LOCATION No. 1892

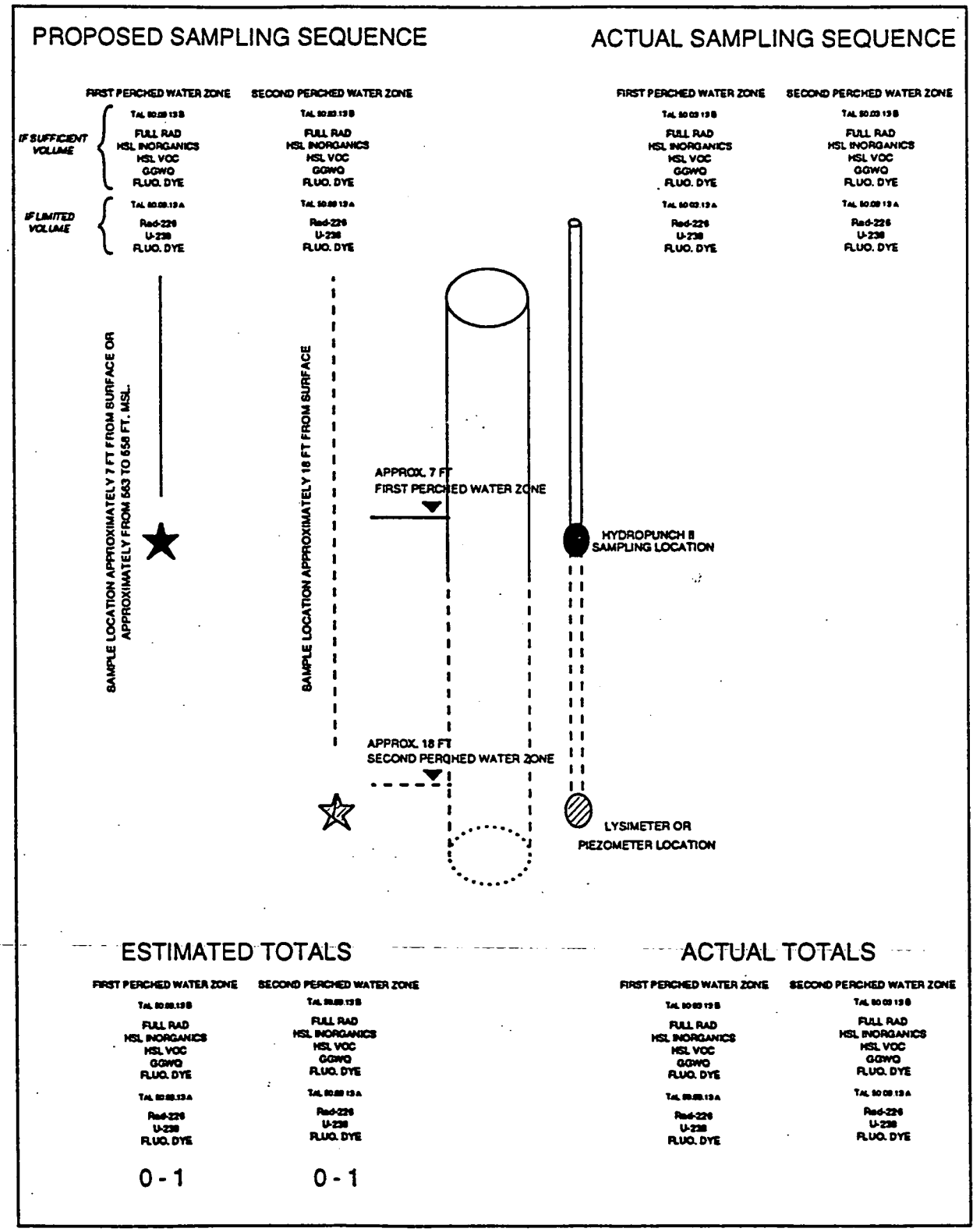


FIGURE 4

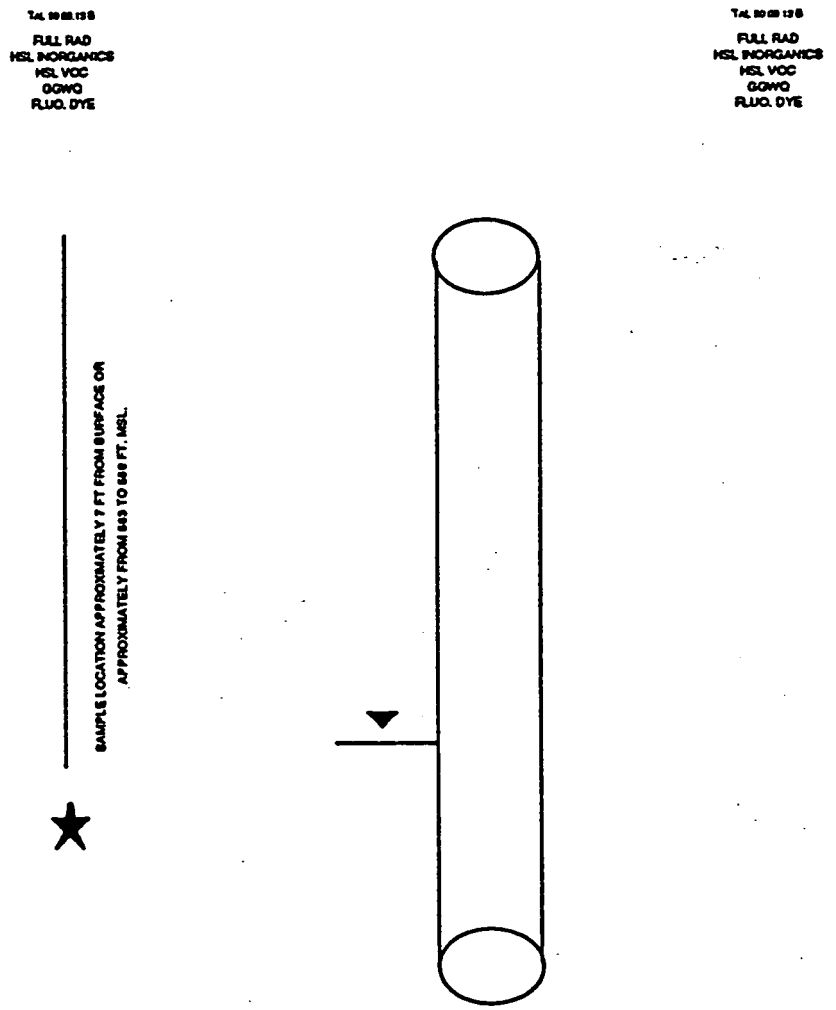
ADDITIONAL PERCHED WATER CHARACTERIZATION IN THE K-65 AREA

PIEZOMETERS

LOCATION No. 1891

PROPOSED SAMPLING SEQUENCE

ACTUAL SAMPLING SEQUENCE



ESTIMATED TOTALS

ACTUAL TOTALS

FULL RAD
HSL INORGANICS
HSL VOC
GGWQ
FLUO. DYE

FULL RAD
HSL INORGANICS
HSL VOC
GGWQ

1

FIGURE 5

ADDITIONAL PERCHED WATER CHARACTERIZATION IN THE K-65 AREA

PIEZOMETERS

LOCATION No. 1893

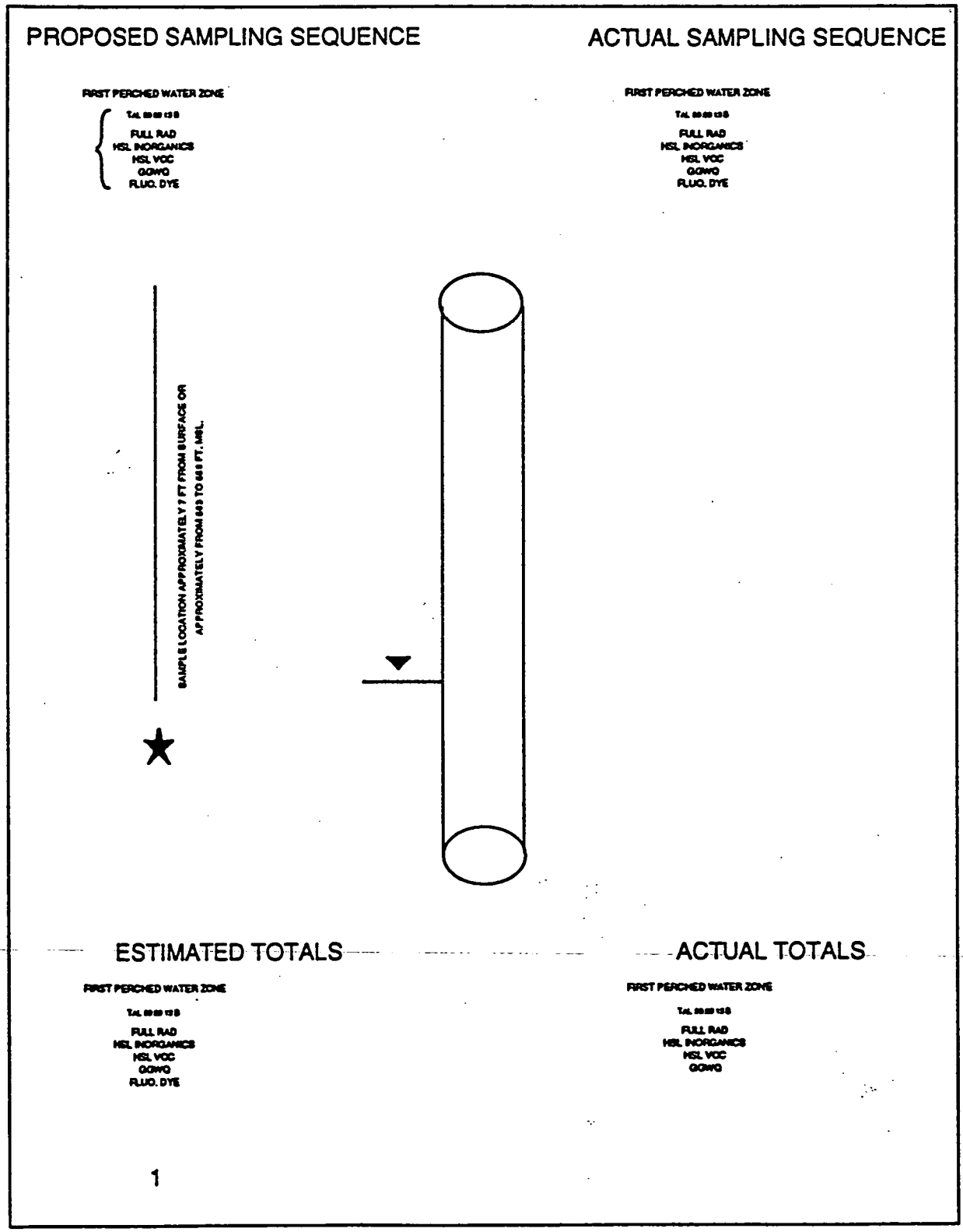


FIGURE 6

ADDITIONAL PERCHED WATER CHARACTERIZATION IN THE K-65 AREA LYSIMETERS

LOCATION No. 1894

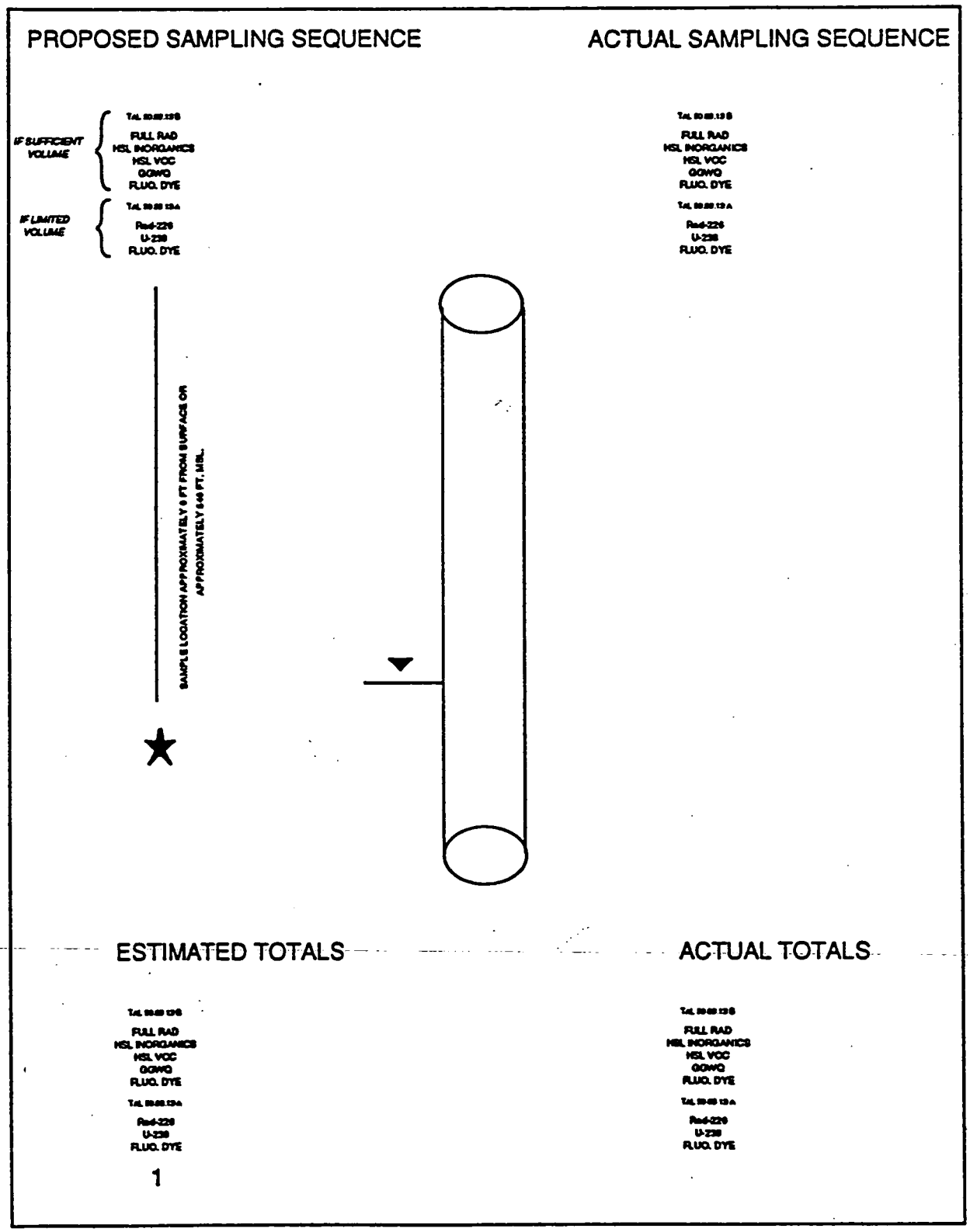


FIGURE 7

ADDITIONAL PERCHED WATER CHARACTERIZATION IN THE K-65 AREA

LYSIMETERS

LOCATION No. 1895

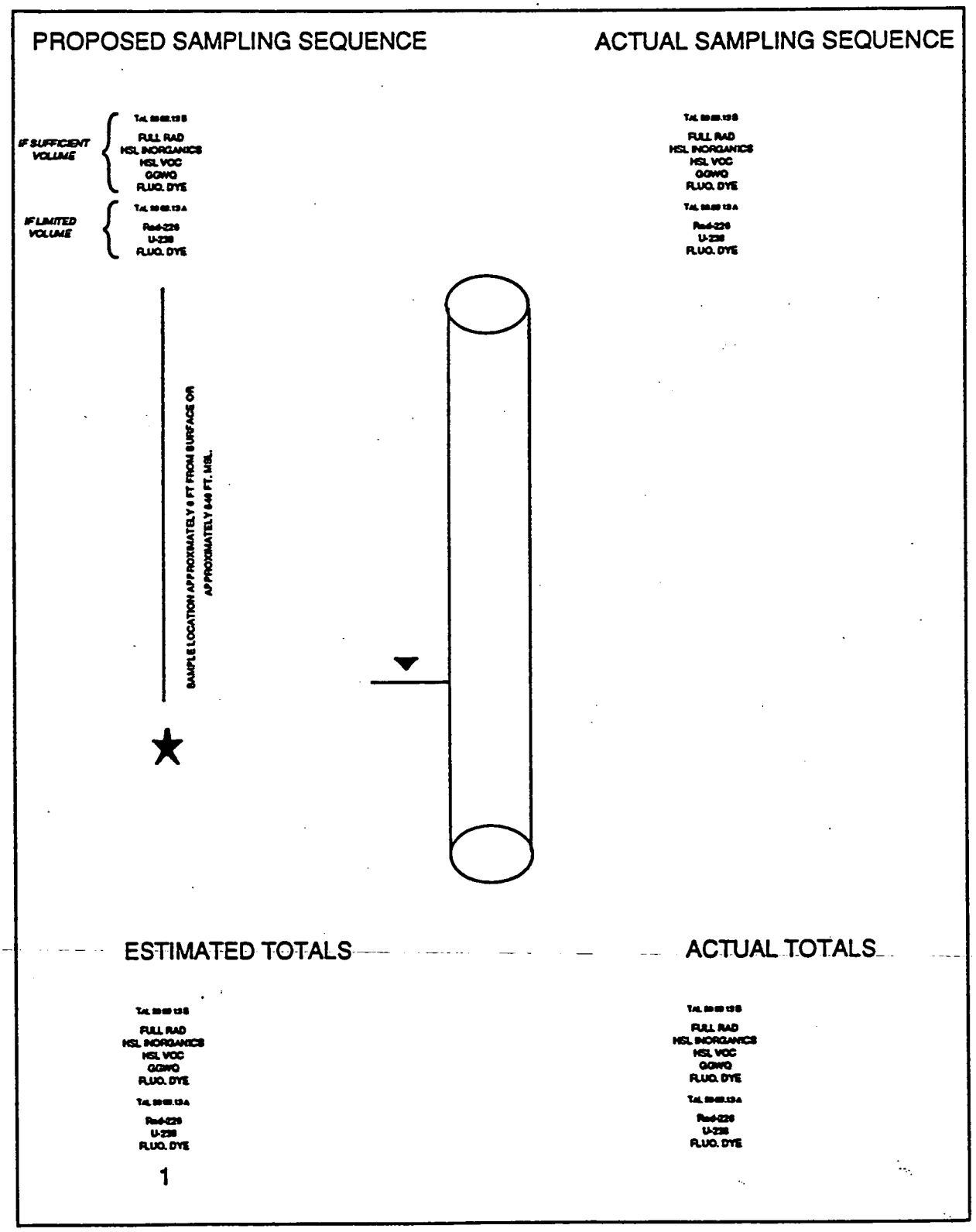
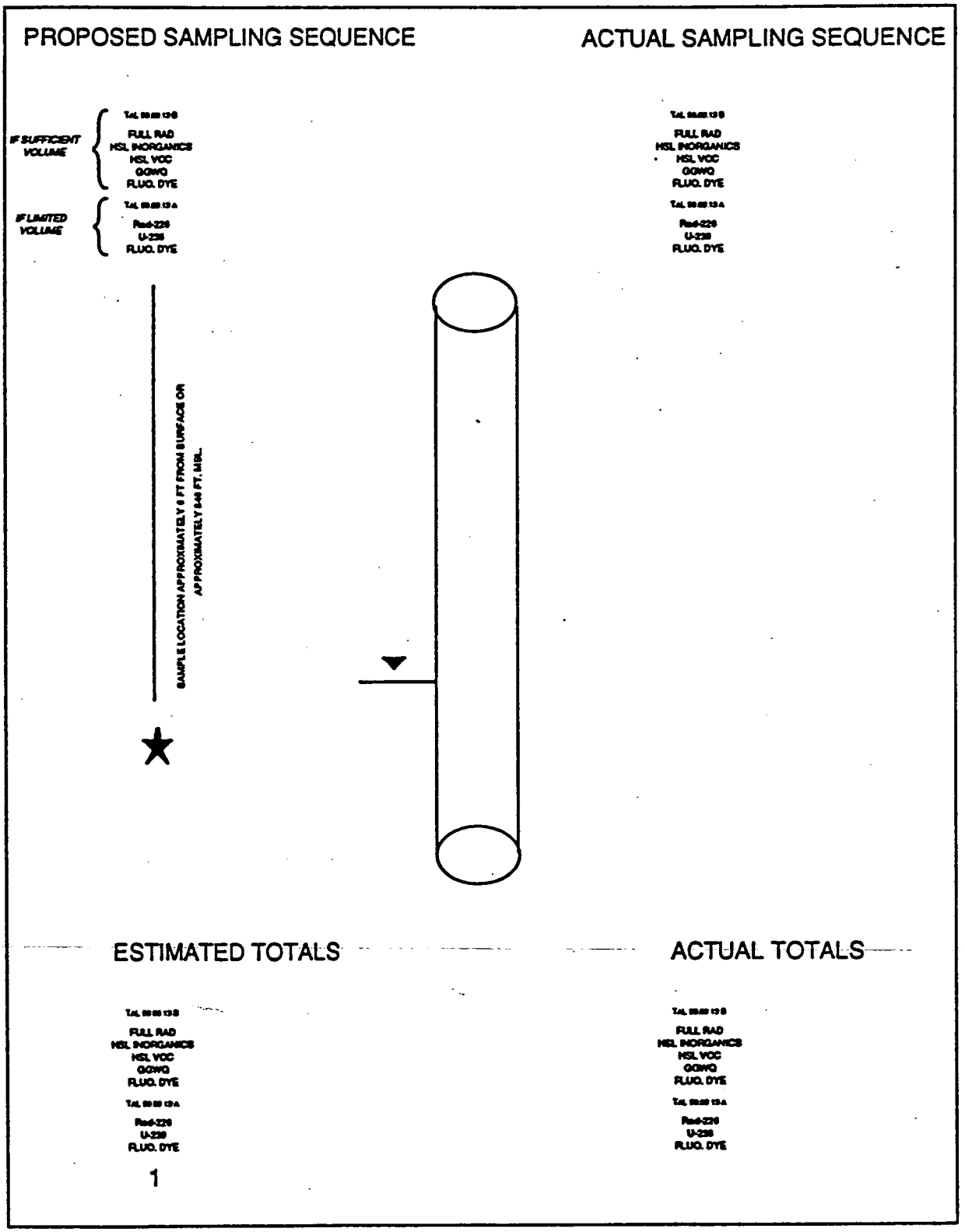


FIGURE 8

ADDITIONAL PERCHED WATER CHARACTERIZATION IN THE K-65 AREA

LYSIMETERS

LOCATION No. 1896