SECTION 2G

SOIL-BENTONITE CUTOFF WALL

INDEX

1. General
2. Materials
3. Execution

1. GENERAL

1.1 Scope: This section covers the work necessary to furnish and install a minimum 30-inch-wide soil-bentonite cutoff wall around the hazardous waste disposal area at the location shown on the Drawings. The cutoff wall shall extend from the existing ground surface to a depth of at least 2 feet below the top of a stiff clay layer. Total depth of the wall will vary from about 30 feet to about 52 feet. The wall shall be installed using a slurry trench method of excavation.

1.2 Submittals: Submittals during construction shall be made in accordance with the GENERAL PROVISIONS. In addition, the following specific information shall be provided prior to construction:

1.2.1 Schedule and sequence of operations.

1.2.2 Drawing of the mixing plant or lagoon layout showing locations and sizes of all equipment, lagoons, tanks pumps, valves, hoses and supply lines.

1.2.3 Source of all imported material, including bentonite, soil admixture, or plastic fines.

1.2.4 Sample (50 pounds minimum) of imported soil admixture or plastic fines.

1.2.5 Soil-bentonite mix design and trial mix reports including trial moisture content, density, mix proportions, gradation, and permeability on at least 4 samples of the design mix, as specified hereinafter.

1.2.6 Certification of bentonite quality, showing compliance with API Standard 13A.

1.2.7 Certification of soil admixture quality including grain size analysis and Atterberg Limits of imported plastic fines.

1.3 Quality Assurances: The Contracting Officer shall have access to and have the right to inspect all batch plants, and supply facilities of suppliers, manufacturers, subcontractors, and contractors providing products included in these Specifications. Batch plants shall have current certification that all weighing scales have been tested and are within the tolerances as set forth in the National Bureau of Standards Handbook No. 44. Batch plant equipment shall be either semiautomatic or fully automatic.

1.4 Qualifications for Slurry Trench Construction: The Contractor or subcontractor shall be experienced in deep slurry trench construction, and the Contractor or subcontractor shall have sufficient competent personnel experienced in this type of construction and able to carry out the operations specified. The Contractor or subcontractor shall have experience in previous successful projects of soil bentonite slurry trenches using specialized slurry trench equipment to depths of 60 feet or greater. Also, a slurry trench specialist shall be employed by the Contractor or subcontractor and used to control the composition, mixing, placing, cleaning, and maintaining of the slurry.

1.5 Description of Stiff Clay Layer

1.5.1 The cutoff wall shall extend to a depth of at least 2 feet below the top of a stiff clay layer of the Kirkwood Formation. The Kirkwood Formation clay has been described by R.E. Wright Associates, Inc. as consisting generally of silt and clay, with a little fine sand. The color is dark grayish brown to dark gray. A typical standard penetration blow count in the stiff clay is 10 to 20 blows per foot. Sand contents of the stiff clay have been reported between 7 and 38 percent sand by weight (material coarser than the No. 200 sieve). Further descriptions of the stiff clay layer are given in the Borehole Logs in Appendix A.

1.5.2 The stiff clay (Kirkwood clay) shall be defined as material having a Unified Soil Classification of ML, MH, CL, or CH, with at least 50 percent of the material finer than the No. 200 sieve. The top of the stiff clay layer shall be defined as that elevation below which at least two feet of continuous stiff clay is encountered in the soil borings.

2. MATERIALS

2.1 Water: Clean and free from hazardous contaminants, oil, acid, alkali, organic matter, soluble salts, or other deleterious substances. Water is not available at the site; the Contractor

shall make all arrangements and pay all costs of obtaining suitable water.

2.2 Bentonite Clay Slurry: Slurry shall consist of a stable colloidal suspension of bentonite in water. Bentonite shall be pulverized premium-grade natural sodium bentonite meeting the requirements of the American Petroleum Institute's, "Specifications for Oil Well Drilling Materials", API Standard 13A. Admixtures shall be used only as specifically approved by the Contracting Officer at least 10 days prior to the slurry trench excavation. The slurry mixture shall meet the following requirements when tested in accordance with API Standard 13B:

2.2.1 Minimum 1 pound of bentonite per 2 gallons of slurry (Minimum 5.65%).

2.2.2 The plastic viscosity shall not be less than 15 centipoises at 20 degrees C as measured by direct-indicating viscometer nor less than 35 seconds Marsh Funnel reading.

2.2.3 The filtrate loss shall not be greater than 20 milliliters in 30 minutes at 100 psi pressure as measured by a filter press.

2.2.4 The specific gravity shall be not less than 1.04.

2.2.5 Sand content shall be no greater than 10 percent by weight.

2.2.6 The Contractor shall perform all tests and furnish and maintain all testing equipment needed to verify compliance of the slurry with the applicable test of API Standard 13B. All costs of testing and quality control shall be borne by the Contractor.

2.3 Equipment for Mixing and Placing Slurry: Slurry shall be mixed in a continuous mixer and allowed to hydrate before introduction into the trench. Hydration is defined as the stabilizing of the viscosity and filtrate loss properties. The Contractor shall provide a suitable mixer, agitator, above ground storage tanks, pumps, valves, hoses, and supply lines as needed to provide continuous supply of slurry to the trench. Mixing of the slurry in shallow lagoons shall be permitted only in the eastern portion of the site where no hazardous waste materials are known to be buried. Contractor shall ensure that complete mixing and hydration is achieved using the lagoons. Submit a drawing of the plant layout to the Contracting Officer at least 10 days prior to start of mobilization.

2.4 Excavation Equipment: The Contractor shall provide equipment suitable for excavating soil materials and removing obstructions such as debris or tree roots to the maximum depths directed by the Contracting Officer. The backhoe, dragline, or clamshell shall be equipped with a bucket suitable for excavating a minimum 30-inch wide trench to a depth of at least 60 feet.

2.5 Soil Admixture

2.5.1 Excavated trench materials taken from below the groundwater table shall not be used for backfilling the trench.

2.5.2 Soil admixture shall consist of well graded material free from roots, debris, rocks larger than 3 inches, and other deleterious materials and shall be free from hazardous contamination. The soil admixture shall consist of at least 20 percent by weight of PLASTIC FINES, as defined hereinafter, and shall have a coefficient of uniformity greater than 4.

2.5.3 The Contractor shall have the option of using native site soils obtained from the required excavations above the ground water table on the site and supplemented with imported PLASTIC FINES to obtain the specified gradation, or of importing suitable soil admixture conforming to these Specifications. Mixing of soil materials, including native soils and imported PLASTIC FINES, shall be done using a pug mill, disc, harrower, or other means approved by the Contracting Officer to provide thorough, complete, mixing of soil types into a homogenous material.

2.6 Plastic Fines: Imported fine-grained material; smaller than the No. 200 sieve, having a Liquid Limit (ASTM D 423) greater than 20, and a Plasticity Index (ASTM D424) greater than 4. Imported material having suitable Atterberg Limits, but containing material larger than the No. 200 sieve shall be mixed with native site soils in sufficient portions so that the combined SOIL ADMIXTURE is at least 20 percent by weight smaller than the No. 200 sieve.

2.7 Soil-Bentonite Backfill

2.7.1 Material for backfilling the slurry trench shall consist of a mixture of soil admixture, bentonite, and water. Bentonite shall comprise at least 6 percent of the dry weight of the total backfill. Bentonite slurry removed from the trench may be used to prepare the backfill; however the proportion of dry bentonite shall NOT be adjusted to account for any Bentonite content of the slurry. At the time of placement, the backfill shall have a slump of 3 to 6 inches as measured in accordance with ASTM C 143,

and a density at least 15 pounds per cubic foot greater than that of the slurry.

2.7.2 Equipment for mixing and placing backfill shall be suitable earthmoving or grading equipment, such as bulldozers, disc harrowers, and/or blade graders to provide thorough, complete mixing of the bentonite and soil admixture.

2.7.3 The soil-bentonite backfill shall have a permeability less than one times ten raised to a power of (-7) centimeters per second (less than 0.103 feet per year) when tested in accordance with a modified ASTM D2435 and as specified under paragraph 2.9 herein. The Contractor shall increase the minimum specified proportions of imported plastic fines or bentonite as required to maintain this permeability. No additional payment shall be made for additional plastic fines or bentonite. At least 10 days prior to the start of slurry trench excavation, the Contractor shall submit results of tests conducted on at least 4 trial samples of the design mix including all tests described under Paragraph 2.8 MATERIAL APPROVAL, specified hereinafter.

2.8 Material Approval

2.8.1 All tests necessary for the Contractor to locate approved sources of imported material shall be made by the Contractor. Certification that the material conforms to the Specification requirements along with copies of test results from an approved commercial testing laboratory shall be submitted to the Contracting Officer at least 15 days before the material is required for use. Samples of all imported materials shall be furnished by the Contractor to the Contracting Officer and shall be clearly marked to show the source and intended use on the project.

2.8.2 During construction, tests shall be made on the Soil Admixture prior to addition of dry bentonite and shall include gradation (ASTM D422), liquid limit (ASTM D423), plastic limit (ASTM D424), and moisture content (ASTM D2216). Three samples for testing shall be taken from each 325 cubic yards of material or each 100-foot section of slurry trench backfill, whichever is the lesser, or more often if variation in material properties is occurring or if the material departs from the Specification requirements.

2.8.3 Following approval of the Soil Admixture, tests shall be made on the Soil-Bentonite Backfill mixture prior to additon of water or slurry and shall include gradation (ASTM D422) and moisture content (ASTM D2216). Three samples shall be taken from each 325 cubic yards of backfill or each 100-foot section of slurry trench backfill, whichever is the lesser, or more often if

variation in material properties is occurring or if the material departs from the Specification requirements. Soil-Bentonite Backfill shall be mixed with water and/or slurry and introduced into the trench only after the results of this testing have been reviewed and approved by the Contracting Officer.

2.8.4 Tests shall be made on the completed Soil-Bentonite Backfill and shall include a slump test (ASTM C143), gradation including hydrometer test (ASTM D422), liquid limit (ASTM D423), plastic limit (ASTM D424), moisture content (ASTM D2216), and permeability (modified ASTM D2435). One sample shall be taken from each 100-foot section of slurry trench backfill or more often if variation in material properties is occurring or if the material departs from the Specification requirements. Results of the permeability testing shall be submitted by the Contractor no later than 24 hours following material sampling. If tests conducted by either the Contractor or the Contracting Officer indicate that the material does not meet the Specification requirements, material placement will be terminated until corrective measures are taken.

2.8.5 Tests shall also be conducted on samples of the bentonite clay slurry taken from the bottom of the slurry trench. Tests shall be conducted in accordance with API Standard 13B, and shall include Marsh Funnel reading, filtrate loss, specific gravity and sand content. Samples shall be taken from each 100-foot section of slurry trench or more often if variation in material properties is occurring or if the material departs from the Specification requirements.

2.9 Permeability Testing

2.9.1 Permeability tests shall be made by the Contractor on soil-bentonite slurry trench backfill samples prior to and during construction of the cutoff wall. Frequency of sampling and testing is specified in Paragraph 2.8 MATERIAL APPROVAL.

2.9.2 Test methods and apparatus shall be a modification of the standard one-dimensional consolidation test (ASTM D2435) using a fixed-ring consolidometer. The minimum sample diameter shall be 100 millimeters to minimize boundary effects. The sample height shall be between 30 and 50 millimeters. The porous stones on each face of the sample shall be replaced with a disposable filter medium consisting of fine sand (ASTM D1556, paragraph 2.2) and filter cloth. The filter cloth shall be a woven geotextile and have an effective opening size (E.O.S.) equivalent to the 70 to 100 sieves. The consolidomter shall be calibrated at the beginning of the work to determine flow rate of the apparatus without the specimen and shall be recalibrated

during construction as deemed appropriate by the Contracting Officer.

2.9.3 The backfill sample to be tested shall be poured into the consolidometer ring and lightly tamped, rodded and/or vibrated to work voids out of the specimen. Determine the thickness of the test specimen to within 1 millimeter. Inundate the sample and filter media and keep saturated throughout the test. Apply a seating pressure of 100 grams per square centimeter (g/cm^2) to seat the extensometer, then apply a test pressure of 1,000 (g/cm^2) and maintain constant throughout the test. The test pressure shall be applied at a lighter load if the sample seems to shear during testing. Record the change in thickness of the sample at time increments of 0.10, 0.25, 0.50, 1.0 min., 4 min., 8 min., 15 min., etc., as specified in ASTM D2435. Plot the change in thickness readings versus the square root of time in minutes and determine 90 percent primary consolidation time and the coefficient of consolidation (cv) in accordance with the procedures described in ASTM D2435.

2.9.4 Calculate the permeability of the test sample by the following equation:

$$k = (dh/h)\ (w/dp)\ (cv)$$

where

k = Coefficient of permeability (cm/sec)

dh = Change in thickness of sample (cm)

h = Thickness of sample (cm)

w = Unit weight of water (g/cm^3)

dp = Change in pressure (g/cm^2)

cv = Coefficient of consolidation (cm^2/sec)

3. EXECUTION

3.1 Alignment: The alignment of the centerline of the soil-bentonite cutoff wall is indicated on the Drawings. The slurry trench excavation shall not deviate by more than 2 feet from this designated alignment unless specifically authorized in writing by the Contracting Officer.

3.2. Construction Sequence: Construction of the soil-bentonie cutoff wall shall proceed in such a manner that the upgradient section of the wall is completed before the downgradient section. This will prevent "damming" of contaminated groundwater at the site that could cause a significant rise in the groundwater table over the site during construction. The wall section between stations 0+00 and 9+00 must therefore be completed before the wall section between Stations 14+00 and 23+00. Once started, the wall construction shall proceed as a continuous operation in one direction.

3.3 Site Preparation: Prior to the start of the trench excavation, all fills or surface excavations shall be completed in accordance with Section 2C, EARTHWORK, to provide a grade at the top of the trench equal to or higher than the grade indicated on the Drawings. For Alternate B, compacted clay cover, a minimum 10-foot-wide by 12-inch thick compacted clay fill shall be placed along the centerline of the trench at the elevations shown, in accordance with Section 2C, EARTHWORK, prior to the trench excavation. The Contractor may make temporary modifications to the grading plan shown to construct temporary dikes or fills to accommodate the slurry trench excavation. Submit a plan showing any such modifications prior to the start of the trench excavation.

3.4 Borings

3.4.1 General: Borings shall be made to locate the top of the stiff clay layer as defined hereinbefore. Perform borings along the alignment of the slurry trench cutoff prior to slurry trench excavation. Borings shall be located at a maximum spacing of 100 feet as measured along the alignment of the slurry trench. Borings shall be completed to a point at least 400 feet in advance of the trenching operation at all times. If the elevation of the top of the stiff clay layer encountered in the soil borings differs by more than 2.0 feet between two adjacent borings, drill an additional boring equal distance between the other two. Payment for additional borings shall be made in accordance with the GENERAL PROVISIONS.

3.4.2 Drilling: Drilling equipment shall be a water or mud rotary type, approved by the Contracting Officer, which allows sampling of in-place native soil using bentonite slurry drilling fluid. At the time of sampling, the borehole shall be cleaned of drill cuttings and shall have a maximum of 6 inches of slough in the bottom of the borehole. Drilling shall be accomplished in accordance with the requirements of the SAFETY AND EMERGENCY RESPONSE PLAN for handling and disposal of contaminated materials.

3.4.3 Sampling: Sampling shall be performed by the Standard Penetration Test in accordance with ASTM D1586. Core catchers or other devices shall be used to ensure all samples are retained during sampler extraction from the borehole. The samples shall be placed in suitable containers as approved by the Contracting Officer and the container shall be clearly marked to indicate boring number, location, depth of sample, and date sample was obtained. Samples shall be taken continuously from a depth of five feet above the anticipated depth of the stiff clay layer to a maximum depth of four feet below the top of the stiff clay layer actually encountered. Following completion of the soil-bentonite cut-off wall construction, all samples shall be disposed of in the contaminated spoil disposal area.

3.4.4 Survey: The elevation of the ground surface at each boring location shall be determined within an accuracy of 0.1 feet. The location of each soil boring shall be determined within an accuracy of 2.0 feet.

3.5 Slurry Mixing: The slurry shall be prepared in a mixer that achieves complete dispersion of the bentonite particles. All slurry shall be batched or continuously mixed. No slurry shall be mixed in the trench. After mixing, the slurry shall be allowed to hydrate completely before being introduced in the trench excavation. This may be accomplished by maintaining high speed circulation until hydration is complete, or by storing the slurry in a tank or pond with a low speed circulation system. The slurry shall be stored under essentially constant circulation until used. Circulation may cease overnight or on weekends when the addition of slurry to the trench is not necessary.

3.6 Slurry Trench Excavation:

3.6.1 Perform all excavation of every description regardless of the type, nature, or condition of the material encountered, as specified, shown, or required to accomplish the excavation. Excavate by the slurry method of excavation to a depth of two feet below the top of a stiff clay layer as indicated by the soil borings or by the nature of the materials being excavated, as required by the Contracting Officer. The entire depth of excavation shall then be carried along the trench line. The toe of the slope of the trench excavations shall not precede the toe of their backfill slopes by more than 100 feet nor less than 20 feet. The slurry trench excavation shall be constructed without undue interruption until complete.

3.6.2 If for some reason it is necessary for the soil-bentonite cutoff wall to be constructed in more than one continuous segment, some re-excavation of the previously constructed slurry trench will be necessary. This re-excavation

shall consist of backfill and slurry removal 10 feet perpendicular to the slope of the backfill for the full depth of the slurry trench. That portion of the soil-bentonite cutoff wall that is removed or overlapped shall be constructed at no expense to the Government.

3.6.3 Slurry shall be introduced into the trench at the time excavation begins. The level of the slurry in the open trench shall be maintained at all times no more than 1 foot below the working surface. Dilution of slurry by surface waters shall be prevented. The slurry shall be maintained at all times in the specified condition. To achieve this end, the slurry may require operations such as recirculation through shaker screens.

3.6.4 Material excavated from the slurry trenches that is suitable for use as SOIL ADMIXTURE may be stockpiled in approved areas for subsequent processing. Material excavated from the slurry trenches that is not suitable for use as SOIL ADMIXTURE shall be placed directly into trucks for hauling to the disposal area as specified hereinafter. No contaminated spoil shall be stockpiled adjacent to the trench.

3.7 Trench Bottom Cleaning and Sampling: Suspended sand and sediment which may settle out of the slurry or fall to the bottom of the trenches shall be removed by an airlift pump or other suitable equipment approved by the Contracting Officer. The airlift pump or other equipment shall be operated in such a manner to prevent removal of materials from the walls of the trenches. After the trench bottom has been cleaned, measure the actual excavated depth of the trench and take at least one sample of the native material in the trench bottom every 20 feet along the length of the slurry wall. Samples shall be obtained using a split-spoon sampler, clamshell bucket, or other approved method. Samples shall have a minimum length of 3 inches. After examining these samples, the Contracting Officer will either approve the termination of the excavation at the sampled points or require additional excavation. If additional excavation is required, then additional samples shall be furnished by the Contractor as specified above.

3.7.1 Prior to the introduction of soil-bentonite backfill into a section of the trench, the Contractor shall perform probings or soundings of the trench bottom at maximum 20-foot intervals. The elevation of the bottom of the slurry trench shall be recorded to within 0.1 foot. All sampling and probing shall be done in the presence of the Contracting Officer's representatives.

3.8 Backfilling

3.8.1 Mixing: Prepare and mix soil admixture as required to obtain the specified material properties and gradation. The prepared SOIL ADMIXTURE shall be mixed with dry bentonite powder in the proportions specified or required to obtain the specified permeability and blended by windrowing, by disk harrowing, by bulldozing or blading, or by other approved methods. Water or bentonite clay slurry shall be added to the dry mixed backfill in sufficient quantities to provide the specified slump of the backfill material. Mixing and blending shall be performed in such a manner as to produce slurry trench backfill. Excess slurry which may drain away from the mixing operations shall be diverted back into the trench. If bentonite clay slurry is not used to prepare the backfill mixture throughout the wall construction, then the slurry shall not be used to prepare the backfill mixture for the last section of the soil-bentonite cutoff wall to be backfilled. The backfill material shall be thoroughly mixed into a homogeneous mass, free from large lumps or pockets of fines, sand, or gravel. Occasional lumps of up to 6 inches in their largest dimensions will be permitted. The backfill material, just prior to placing, shall have a consistency that has the appearance of a "wet concrete with a slump of 3 to 6 inches."

3.8.2 Placing: The backfill shall be placed so that no pockets of slurry are present in the completed soil-bentonite cutoff wall. In order that this may be assured, the Contractor shall backfill continuously from the beginning of the trench in the direction of the excavation to the end of the trench. Placing operations shall proceed in such fashion that the top of the backfill below the surface of the slurry shall follow a reasonably smooth grade and shall not have hollows which may trap pockets of slurry during subsequent backfilling. To this end, the Contractor shall rod the face of the backfill below the surface of the slurry as necessary. The backfill shall not be dropped or deposited in any manner that will cause segregation. Free-dropping of backfill material through the slurry will not be permitted. Initial backfill shall be placed by lowering it to the bottom of the trench with crane and clamshell bucket until the surface of the backfill rises above the surface of the slurry. Additional backfill may then be placed by bulldozer in such manner that the backfill enters the trenches by sliding down the forward face of the previously placed backfill. To accomplish this, the bulldozer operation shall pile sufficient backfill on the edge of the existing backfill to cause a sliding action down the face of the existing backfill.

3.8.3 Time delays: If placement of the soil-bentonite backfill is stopped for a length of time exceeding two days, then

the backfilling operation shall be considered non-continuous and a portion of the previously placed backfill shall be re-excavated in accordance with Paragraph 3.6.2.

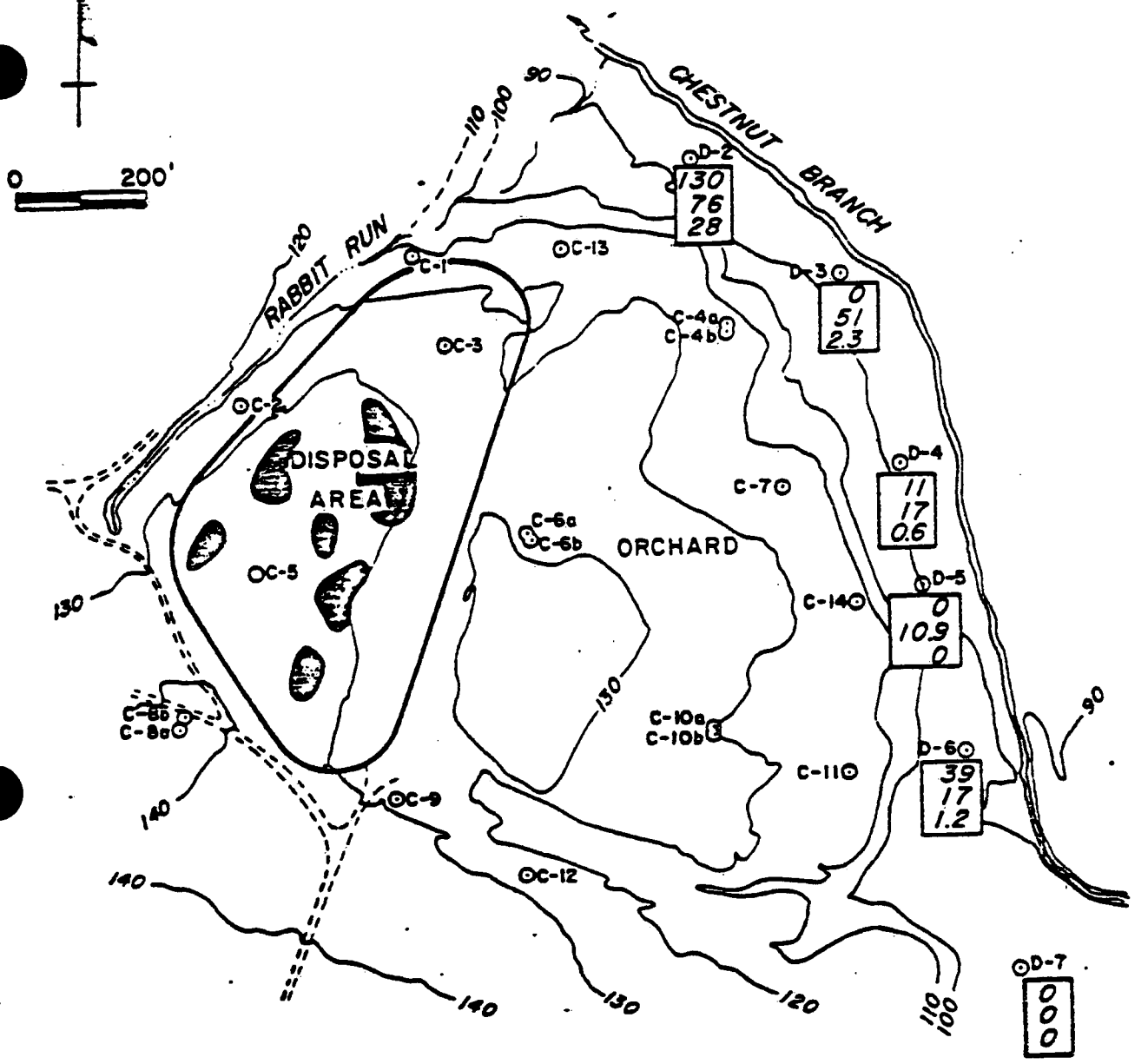
3.8.4 Mixing and placing during cold weather: Do not place frozen backfill into the trench. Do not mix soil-bentonite backfill when the ambient air temperature is less than 35 degrees Fahrenheit.

3.9 Cleanup: After completion of backfilling operations, all remaining excavated material and slurry shall be removed from the working surfaces. The slurry shall be disposed of within the designated disposal area or in a location on site as otherwise approved by the Contracting Officer. Spread the slurry over the surface of the ground to facilitate desiccation and mix with the surface soils to improve its stability.

3.10 Disposal of Excavated Material: Material removed from the slurry trench excavation below the groundwater table shall be considered contaminated and shall be disposed of in the designated area shown on the Drawings. Excavate a pit below the level of the proposed cover, but at least 2 feet above the groundwater table. Deposit excavated material into the trench and cover with at least 4 inches of uncontaminated soil daily. To facilitate placement of the 4 inches of cover, mix the excavated material with soil or peat as necessary. Do not allow surface water to flow into the pit nor direct runoff out of the disposal area. Maintain accurate records of the actual horizontal and vertical extent of the deposited material, and mark the limits of the disposal area with stakes and fluorescent tape at 10-foot spacings throughout construction until placement of the cover is complete.

* * * * * *

PH.120/14



Explanation

Acids and Base/Neutrals
Aromatics
Halogens

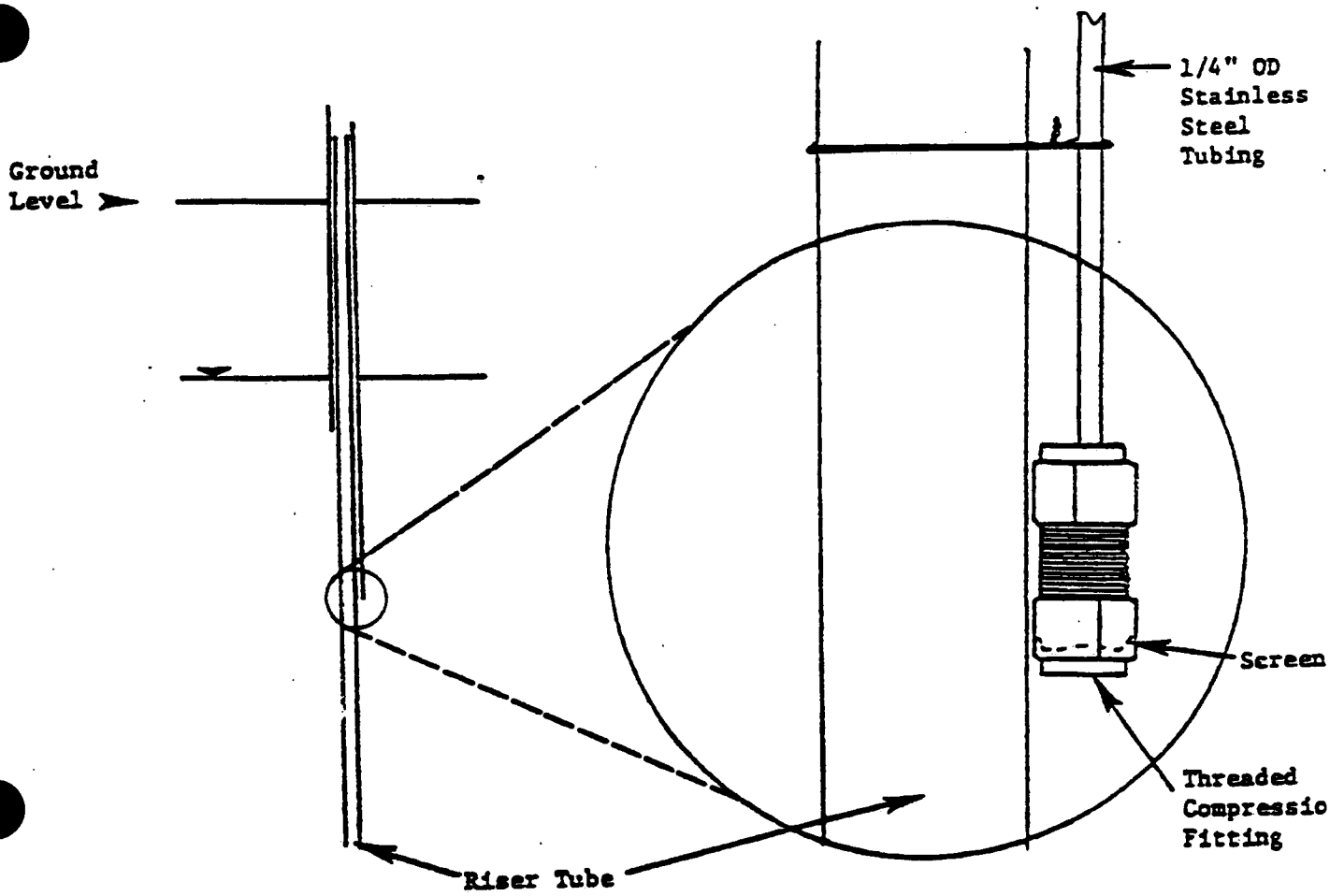
Figure 18. Organic-compound fractions in marsh-well samples, in parts per million. Drum-disposal areas are shaded.

If the average concentration of organic compounds being discharged from the embankment by the Lower Cohansey is 150 ppm, the rate of chemical discharge from the Chestnut Branch embankment through the Lower Cohansey is approximately 0.3 gpd.

If it is assumed that the groundwater flowing down through the Kirkwood Clay has a total organic concentration of 225 ppm (based on the estimated average concentration in the Lower Cohansey as a whole), the rate of chemical flow through that unit is approximately 0.6 to 0.9 gpd.

In addition to the discharge of organic compounds by way of the embankment and through the Kirkwood Clay, the compounds are discharged into Rabbit Run. The chemistry of the Rabbit Run discharge was investigated twice in 1980, as set forth in the previous REWAI report. Those analyses, however, are not indicative of the chemistry of the actual seepage into Rabbit Run, mainly due to volitalization. The same situation is responsible for the fact that the concentration of organics in the surface water of the Chestnut Branch swamp is less than that in the Cohansey groundwater. The ratio of the average observed groundwater concentration to the marsh surface-water concentration (as described in the previous REWAI report) has been applied to the observed Rabbit Run concentration. Thus, the Rabbit-Run seepage concentration of organics is estimated to be 12 ppm.

Flow measurements made as part of the previous REWAI investigation indicate that Rabbit Run discharges at 30 to 75 gpm (gallons per minute). If half of this total discharge is assumed to originate from the contaminated groundwater south of Rabbit Run, the mass flux of chemicals by way of the stream is approximately 0.2 to 0.6 gpd.



Detail of Multi-Level Sampler Tube

(by John Bee, Technical Assistance Team)