

Test Section Installation Instructions
Alternative Cover Assessment Program

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1. INTRODUCTION

This document describes installation procedures for test sections constructed for the Alternative Cover Assessment Program (ACAP). An ACAP test section is designed to simulate an earthen alternative cover for a waste containment facility. Each test section contains a lysimeter pan to collect percolation from the base of the cover; a collection system for surface runoff; and sensors to monitor hydrologic variables within the cover soils, percolation and runoff volumes, and meteorological data. This document is divided into seven main sections. These sections include this introduction and describe the following construction activities:

- installation of the lysimeter pan and associated plumbing,
- placement of the cover soils,
- installation of the surface runoff collection system,
- installation of the instrumentation, and
- vegetation.

Calibration, wiring, programming, and testing of the instruments and data collection system are not included in this document. Calibration and testing procedures are described in the Quality Assurance Project Plan (QAPP). Wiring of the instruments and programming are described in the Standard Operating Procedure for Datalogger Programming and Data Checking for ACAP Sites.

Protocols to check each system after installation are described in each of the main sections. The Resident Engineer (a member of the ACAP team designated on a site-specific basis) is responsible for construction of the test section. The Resident Engineer and Field Manager must approve changes or modifications to the construction protocols. When changes involve modification of a critical component of the test section, the entire ACAP team should be notified. Approval of such modifications by the entire team is necessary before implementation of such changes. ASTM standards are frequently referenced throughout this document. All referenced standards are included in Appendix I. Specification sheets for materials used during this project are in Appendix II.

2. LYSIMETER PAN

Locate the area where the test section is to be installed as specified by the site owner. The lysimeter pan should be located in the central portion of the test section, as shown in plan view in Fig. 1. Subgrade and cover soils are to be placed over the entire test section area. Geosynthetics are to be placed only in the monitoring area. The area where the test section is located should be stripped of topsoil and prepared to the grade required for the base of the lysimeter. Areas with soft materials should be over-excavated and replaced with new materials. These materials should be placed using methods described in Sec. 2.1.1. When filling is not required, the entire test section location should be proof-rolled until meeting the approval of the Resident Engineer.

2.1 Subgrade Preparation

2.1.1. Placement and Compaction

Subgrade for the lysimeter pan should consist of local soils. Moderately cohesive finer textured soils (% fines > 30% as per ASTM D 422) are preferred. The Resident Engineer shall approve subgrade soils before placement. When fill must be placed to achieve the desired base grade for the lysimeter pan, the fill must be placed in loose lifts having a thickness \leq 300 mm (12 in) or in accordance with instructions provided by the Resident Engineer.

For cohesive soils, compact the subgrade to a dry unit weight \geq 90% of the maximum dry unit weight per ASTM D 698. The compaction water content of cohesive subgrade shall be less than optimum water content (OWC) defined per ASTM D 698. Cohesionless soils should be densified to obtain a relative density > 90% per ASTM D 4253. At least four measurements of water content and dry unit weight shall be made at random locations in each lift to check compaction. ASTM methods D 2922, D 2167, or D 1556 shall be used. Soft regions or inadequately compacted regions identified by testing or by the Resident Engineer shall be re-worked until their condition meets the satisfaction of the Resident Engineer and the aforementioned compaction requirements.

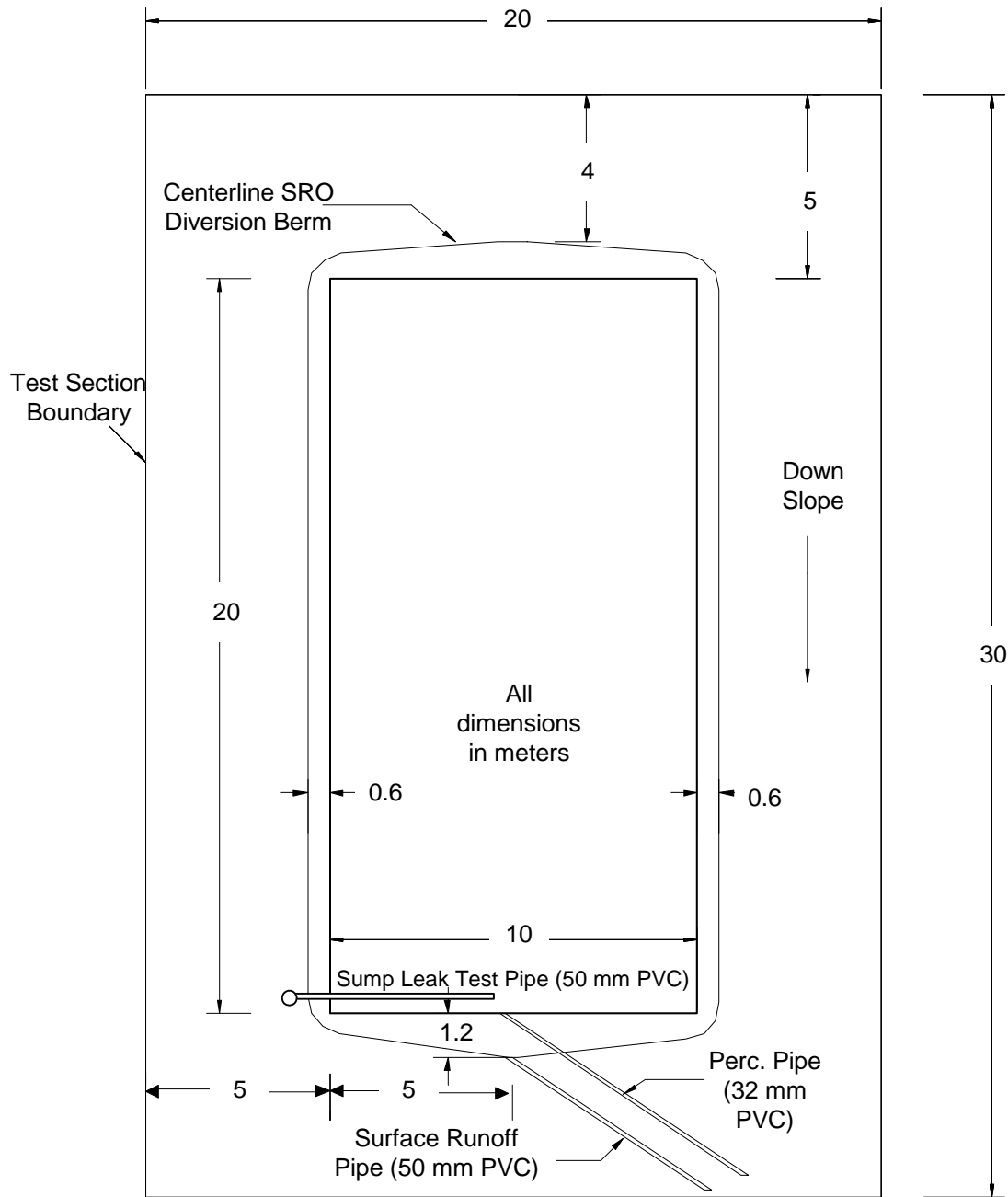


Fig. 1. Plan view of test section.

The final lift of subgrade shall contain particles no larger than 12 mm (0.5 in) exposed on the surface. Ridges, depressions, equipment tracks, or other variations in the subgrade surface shall not exceed 12 mm (0.5 in). If such variations exist, they shall be smoothed and subsequently compacted by hand to the satisfaction of the Resident Engineer. The Resident Engineer shall approve the final surface of the subgrade before placement of overlying soils or geosynthetics.

2.1.2. Grading of Subgrade and Diversion Berms

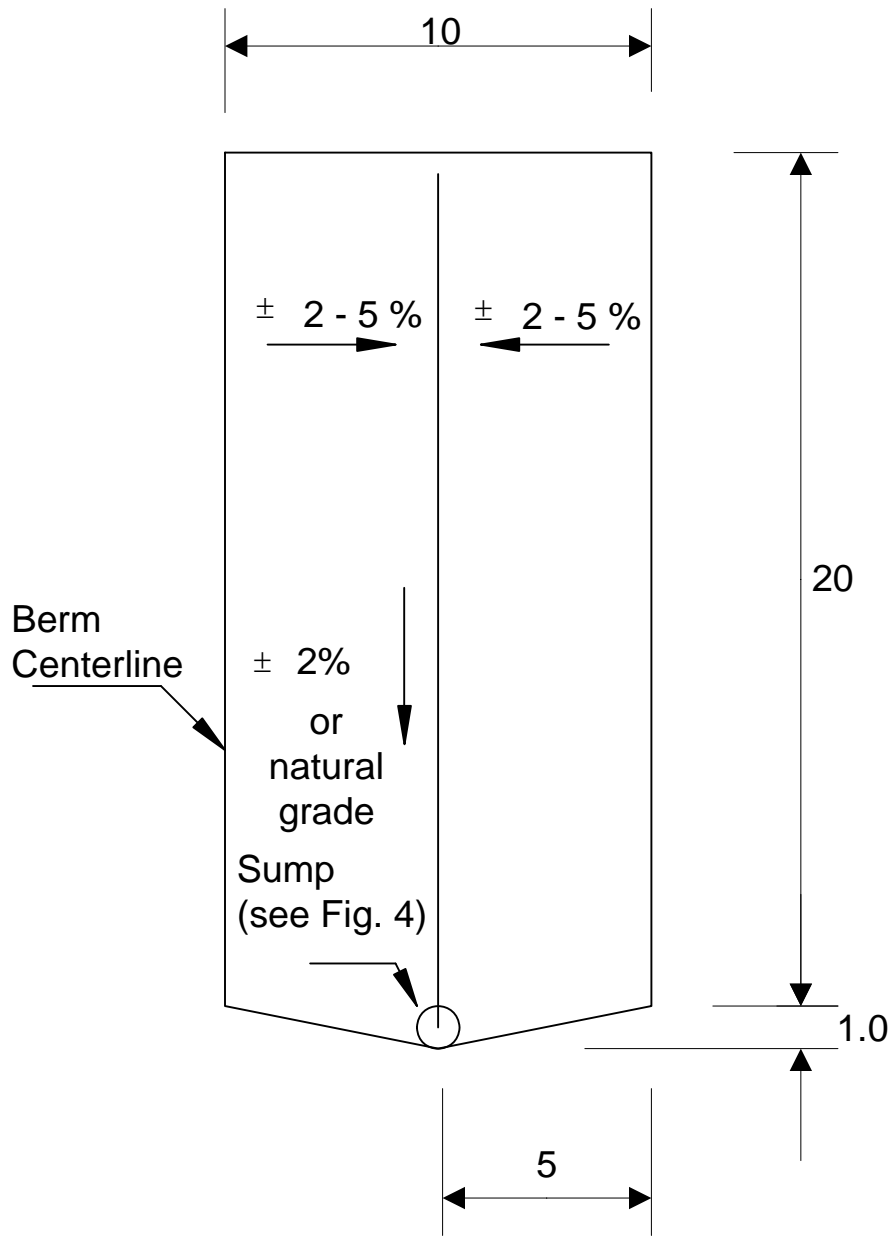
The surface of the subgrade in the monitoring area shall be sloped towards the centerline at a grade $\geq \pm 2\%$, but $\leq \pm 5\%$ as shown in Fig. 2. Centerline of the subgrade shall be sloped towards the sump at the natural grade and/or at a grade of $\pm 2\%$ (Note: \pm is used to indicate that these values refer to an average or an overall slope). Elevation of the center of the sump area shall be the lowest point in the monitoring area.

Perimeter berms can be constructed of subgrade soil along the periphery of the monitoring area (Figs. 2, 3) if desired by Resident Engineer and/or to facilitate installation of the lysimeter pan. Compaction and surface finish of the berms shall meet the same requirements as the subgrade soil as described in Sec. 2.1.1.

2.2 Sump Drainage Pipe

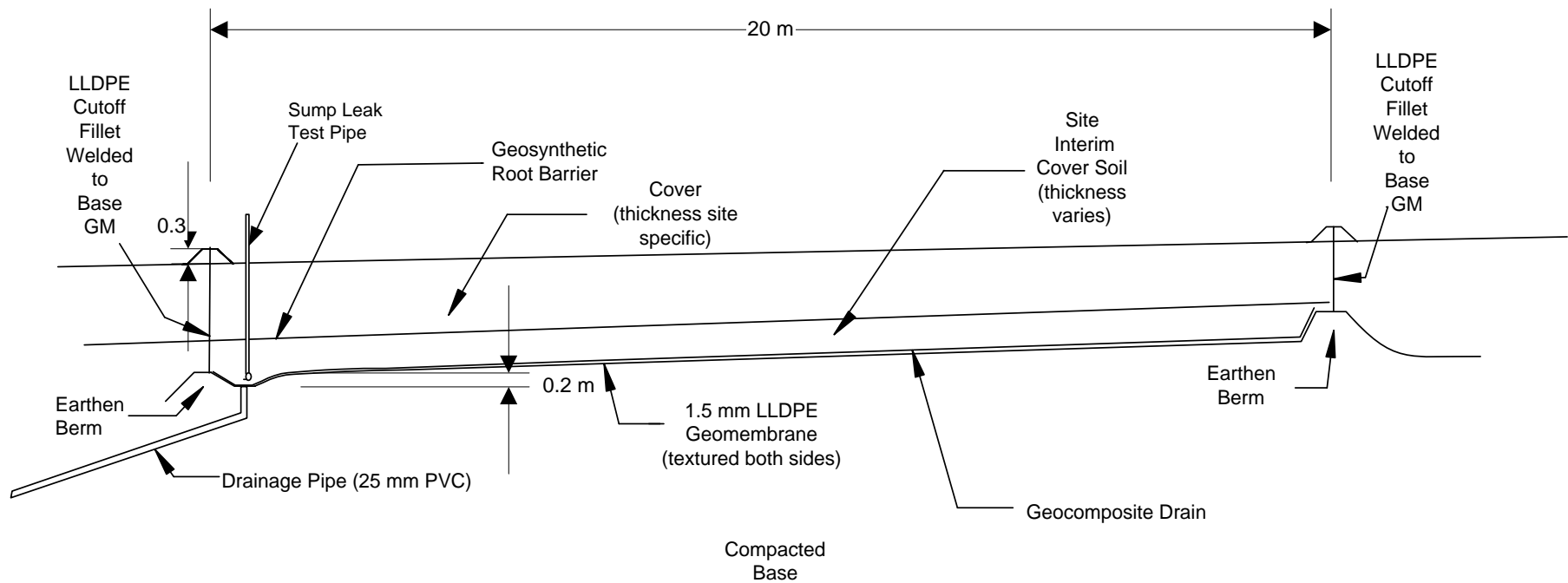
Schedule 40 PVC pipe [32-mm-diameter (1.25 in)] drains the sump as shown in Fig. 4. Install the pipe in a narrow trench extending from the lowest point in the sump through the bottom perimeter berm. Place a section of pipe long enough to daylight from the outer edge of the berm and ensure that the slope of the pipe is at least $\pm 2\%$. Solvent weld all PVC joints following instructions provided by the pipe manufacturer.

Compact subgrade soil on top of the trench to the satisfaction of the Resident Engineer. Leave an annulus along the riser in the center of the sump where the sump boot attaches.



All dimensions
in meters

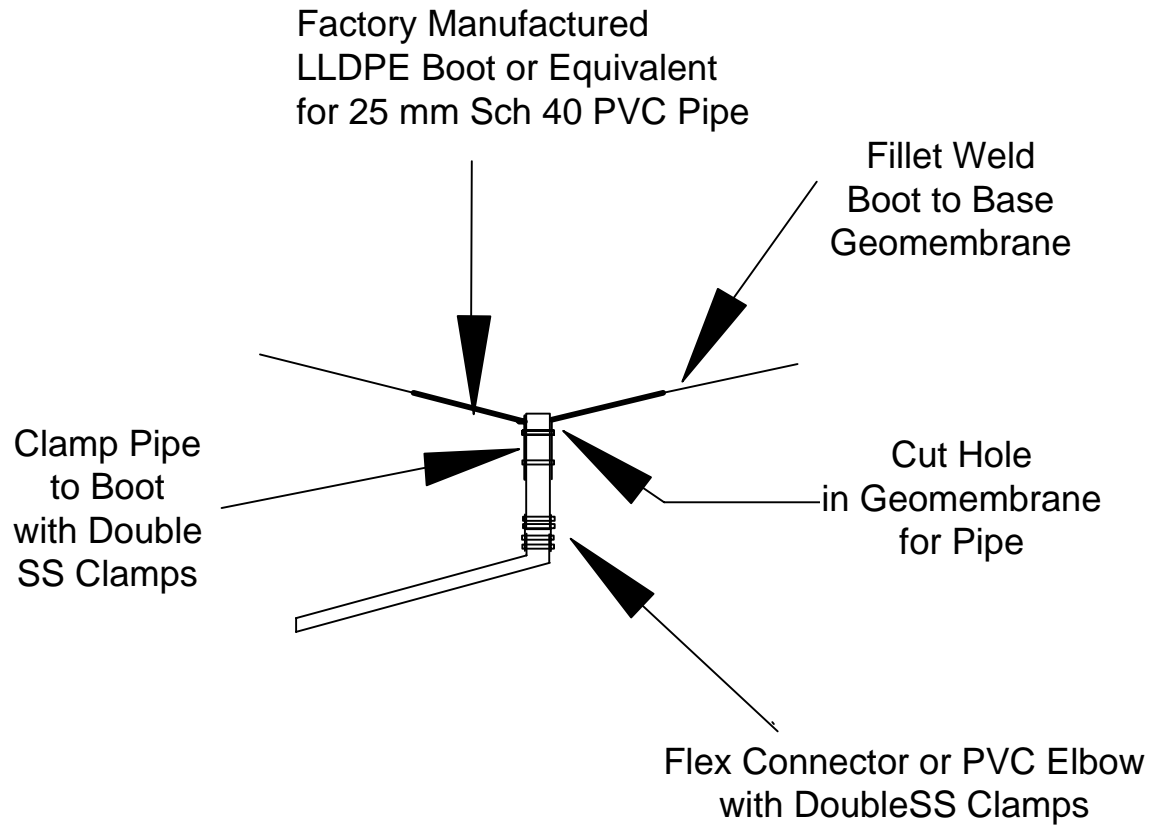
Fig. 2. Plan view showing grading of subgrade for lysimeter pan.



Notes:

1. Base shall be approved fill (fines > 30%) compacted to >95% of max. dry unit weight based on ASTM D 698 and dry of optimum water content.
2. Smooth base before placing geomembrane. Eliminate all ridges, depressions, etc. > 25 mm in height. Remove all stones, etc. larger than 10 mm.
3. Place geomembrane in early morning and ensure good contact with all surfaces. No gaps shall exist between base and geomembrane.
2. Vertical cutoff sheets shall be fillet welded to base geomembrane
3. Geocomposite drain is geonet with non-woven geotextile heat bonded to both sides. Install using rub sheet.
4. Interim cover soil shall be placed on geocomposite drain from the edges. No equipment can travel on geomembrane or geocomposite drain. Once spread in 450 mm loose lift, compact to >85% of max. dry unit weight based on ASTM D 698.

Fig. 3. Cross-section of test section.



Notes:

1. Slope base of sump inwards to pipe
2. Pipe end shall be flush with surface of boot.
3. Silicone caulk connection between pipe and boot as well as pipe and flex clamp before tightening SS clamps
4. Sump must past leak test before geocomposite drainage layer is placed.

Fig. 4. Schematic of lysimeter sump.

Check the drainage pipe for leaks by installing a sight tube on the downstream end of the pipe (Fig. 5). Fill the pipe with water until it overflows at the upstream end. Cap the upstream end of the pipe with parafilm (or similar material) and a rubber band or tape. Pierce the parafilm cap with a needle to form a small hole for pressure equilibration. Place a similar cap on the top of the sight tube.

Monitor water elevations in the sight tube and in an identical adjacent sight tube with a sealed base for 40 min. Correct elevations in the sight tube plumbed to the sump using data collected from the adjacent sealed sight tube to account for solar, temperature, and barometric effects if necessary. The pipe is considered leak-free if the water elevation in the sight tube varies by ≤ 3 mm during the monitoring period and the water elevation has no discernable temporal trend. If this criterion is not met, determine the location of the leak, seal the leak to the satisfaction of the Resident Engineer, and then conduct the leak test again. Repeat this procedure until the criterion has been met satisfactorily and the Resident Engineer approves the pipe installation.

2.3 Geomembrane and Geocomposite Drain Installation

2.3.1. Deployment and Welding of Geomembrane

LLDPE geomembrane (GSE Ultraflex Textured VFPE or equivalent) is to be used to line the lysimeter pan. The geomembrane shall be textured on both sides and shall be at least 1.5 mm (60 mil) thick. High-density polyethylene (HDPE) or PVC geomembrane shall not be used.

Move the roll of geomembrane to the side of the lysimeter using a loader equipped with a gantry bar or similar equipment. Suspend the roll of geomembrane above the ground surface during movement and deployment onto the subgrade. If the geomembrane is wrapped, remove the wrapper once the roll has been transported to the top of the lysimeter. Unroll the geomembrane from the side of the lysimeter by hand and gently pull the geomembrane by hand across the lysimeter to the other side so that the edge of the geomembrane runs perpendicular to the slope.

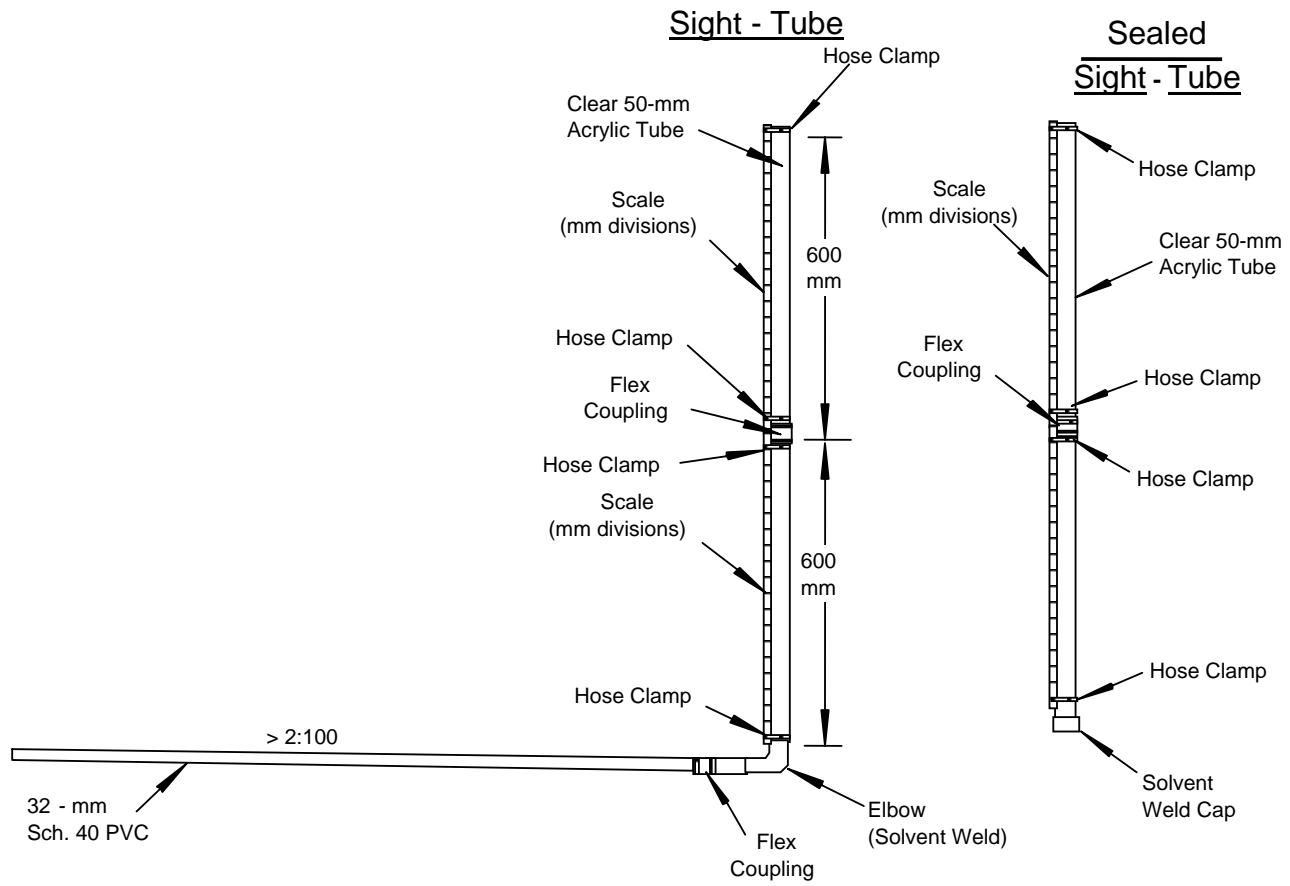


Fig. 5. Leak testing set-up

Extend the geomembrane at least 1 m past the top of the downslope, upslope, and side subgrade berms. The geomembrane can be extended farther, as needed, if the sidewall is to be part of the lysimeter pan. Cut the geomembrane from the roll and anchor it around the edge by covering the geomembrane with subgrade soil. Leave the geomembrane uncovered for a least 1 m along the interior edge (i.e., where the geomembrane panels will be welded).

Install adjacent strips of geomembrane to complete lining of the monitoring area using the same procedures employed for the first strip. Use an overlap of at least 150 mm and shingle the overlap downslope. Weld the two geomembranes using the dual-track hot wedge welding technique as per the instructions by the geomembrane manufacturer. Test welds should be performed at the beginning of any welding activities. Peel and shear destructive tests should be performed on test welds per the installer manual. No welding should be allowed until test welds are accepted by the Resident Engineer. Check the dual -Track welds for leaks using air pressure per ASTM D 5820. Check extrusion welds using a vacuum box supplied by the installer. Sweep the geomembrane and inspect the entire area of the geomembrane for defects. Repairs of any leaks or defects should be performed in accordance with the installer manual and to the satisfaction of the Resident Engineer. The geomembrane installation procedures may vary depending on the location of the test section and the topography of the adjacent terrain. The Resident Engineer along with the geosynthetic installer can adjust these procedures as needed.

2.3.2 Installation of Sump Boot

Locate the riser from the drainage pipe in the sump. Carefully cut the geomembrane around the periphery of the pipe so that the pipe penetrates into the sump area. Loosen the clamps at the flex connection and remove the riser pipe. Place a prefabricated sump boot over the riser pipe so that the top end of the riser pipe is flush with the surface of the sump (Fig. 4). Liberally smear silicon caulk (GE Silicon II or equivalent) between the boot and the pipe, and then clamp the boot to the pipe using two stainless steel hose clamps. Fill the surface groove between the riser pipe

and boot with caulk. Remove any excess caulk from the surface of the boot, and then allow the caulk to cure for at least 120 min.

After curing, insert the riser pipe into the flex connection. Adjust the elevation of the riser pipe so that the geomembrane rests flush against the subgrade, and then tighten the hose clamps securely. Backfill any open area surrounding the riser pipe with subgrade soil and form a firm surface for the geomembrane. Extrusion-weld the boot to the geomembrane deployed previously. Check the extrusion welds using a vacuum box per ASTM D 5641, or a spark test per ASTM D 6365. Identify and repair any leaks identified until the criteria in D 5641 are met and to the satisfaction of the Resident Engineer.

Leak test the geomembrane by installing and filling a sight tube on the downstream end of the drainage pipe using the same procedures described in Section 2.2 and shown in Fig. 5. Fill the bottom end of the lysimeter with water until the water surface covers the sump area. Place a clear 0.1-mm-thick (4 mil) polyethylene sheet over the water surface to prevent evaporation and to minimize fluctuations in the standpipe level caused by wind rippling.

Monitor water elevation in the sight tube and an identical adjacent sight tube with a sealed base for 40 min. If necessary, correct elevations in the sight tube plumbed to the sump using data collected from the adjacent sealed sight tube to account for solar, temperature, and barometric effects. The geomembrane is considered leak-free if the water elevation in the sight tube varies by ≤ 3 mm during the monitoring period and the water elevation has no discernable temporal trend. If this criterion is not met, determine the location of the leak, seal the leak to the satisfaction of the Resident Engineer, and then conduct the leak test again. Repeat this procedure until the criterion has been met satisfactorily and the Resident Engineer approves the pipe installation. After approval, remove the water from the lysimeter.

2.3.3 Deployment and Seaming of Geocomposite Drain

A geocomposite drainage layer shall be used for collecting percolation from the cover soils. The geocomposite drainage layer (GSE Fabrinet or equivalent) shall have non-woven polypropylene geotextiles on both sides, both of which are heat bonded to a polyethylene geonet in the interior. The geotextiles shall have a minimum mass per unit area of 200 g/m² (6 oz/yd²).

A rubsheet consisting of 0.1-mm-thick polyethylene (4 mil) may be used to facilitate installation of the geocomposite drain. If a rubsheet is used, unroll a 0.1-mm-thick (4 mil) polyethylene rubsheet over the area of the lysimeter on which the first sheet of geocomposite drain will be placed. Lightly anchor the rubsheet with soil on along the outside edge of the upper and lower berms. Move a roll of geocomposite drain to the top of the lysimeter by hand or using a loader equipped with a gantry bar or similar equipment. Suspend the roll above the ground surface while moving it and during deployment onto the geomembrane. If the geocomposite drain is wrapped, remove the wrapper once the roll has been transported to the top of the lysimeter. Unroll the geocomposite drain from the top of the lysimeter by hand and gently pull the geocomposite drain over the rubsheet by hand towards the base of the lysimeter. Extend the geocomposite drain to the top of the downslope, upslope, and side subgrade berms. Cut the geocomposite drain from the roll.

Anchor the geocomposite drain to the geomembrane. Gently move the rubsheet near the top of the lysimeter to expose 1 m of interface between the geomembrane and the geocomposite drain. Press the geocomposite drain against the geomembrane until the two geosynthetic layers lock together in a manner similar to hook-and-loop attachments often referred to as "Velcro." Once anchored, pull out the remaining rubsheet and press the remainder of the geocomposite drain against the geomembrane.

Install the remaining sections of geocomposite drain using the same procedure until the interior surface of the lysimeter pan is covered. If the overlap between the geocomposite drain is less

than 0.6 m, join the geonets in adjacent sections using plastic cable ties 1 m (36 in) on center. Pull strips on the cable ties shall be oriented upwards to minimize the potential for puncturing the geomembrane.

2.3.4 Sump Test Pipe

Install a sump test pipe at the downslope end of the lysimeter. This apparatus is not intended for quality control, but is to be used throughout the project to verify that the sump and/or the collection pipe are not clogged. One end of the pipe shall be placed on top of the sump and wrapped in geotextile. The other end of the sump test pipe shall exit the lined lysimeter area through a boot and then be extended vertically above final grade. All elbows and slip joints shall be solvent welded.

2.3.5 Sidewall Geomembranes

When appropriate, sidewall panels are to be constructed using the same geomembrane as the base of the lysimeter (Section 2.3.1). Two sidewall panels should be prepared that are 22 m long and at least 2 m wide (side panels) and another two panels should be prepared that are 12 m long and at least 2 m wide (top and bottom panels). The width of the panels depends on the thickness of the test section. In general, the panel width should be at least 300 mm wider than the thickness of the test section. These panels can also be an extension of the base liner and therefore do not need to be seamed to the base liner. Feasibility of the latter approach depends on the location of the test section and the topology of the surrounding area. The installer, with the approval of the Resident Engineer, can modify the layout as needed. The Resident Engineer shall determine the type of sidewall to be used (i.e., welded panels or base liner extension). When separate sidewall panels are to be used, center the panels along the edge of the top, bottom, and side berms of the lysimeter and place them flat with the top edge falling outside the monitoring area. Extrusion weld the panel to the bottom geomembrane along the crest of the berm to the satisfaction of the Resident Engineer. For each sidewall panel, extend the welds from corner to corner of the berm (see detail in Fig. 6).

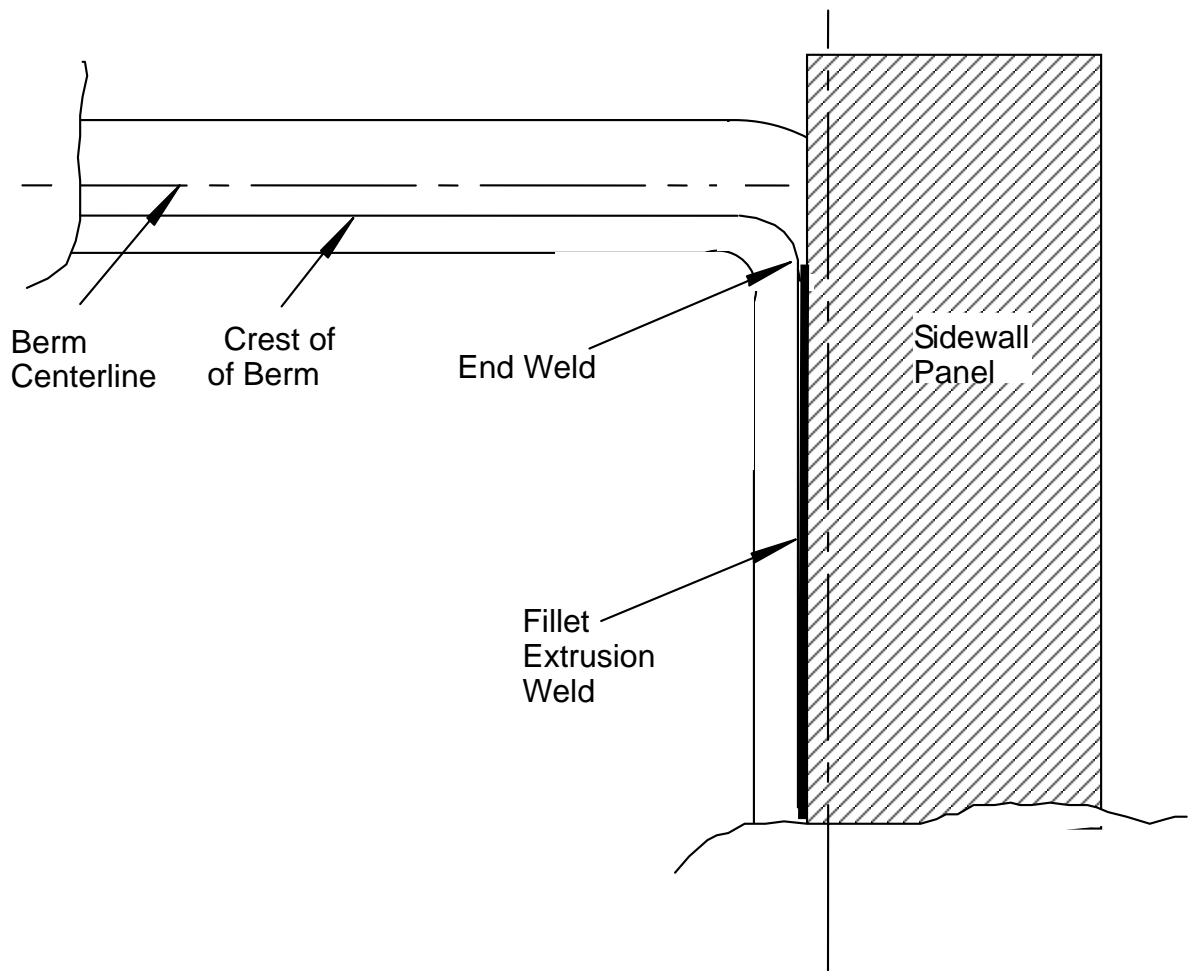


Fig. 6. Welds for sidewall geomembrane panels.

3. PLACEMENT OF COVER SOILS AND RELATED ACTIVITIES

Cover soils consist of those soils that comprise the cover profile being tested. The cover soils consist of interim cover soil, final cover soil, and a topsoil layer. The thickness of each of layer is specified in the cover design report submitted by the consulting engineer. A geosynthetic root barrier is also to be installed between the interim cover soil and the final cover soil.

3.1 Interim Cover Soil

When specified in the cover design, the interim cover soil used prior to placement of the final cover shall be the first layer of soil placed on the lysimeter. This soil shall be identified in the cover design report for the site. The Resident Engineer shall approve the interim cover soil before placement begins.

Place the interim cover soil around the outside edge of the lysimeter directly adjacent to the sidewall geomembrane. Place interim cover soil inside the lysimeter boundaries. Work from the top end of the slope in a loose lift thickness ≥ 450 mm (18 in) or as specified in the cover design. Gradually extend the soil layer from the top berm, along the side berms, and then downward to form a working platform for equipment. At no time shall motorized equipment contact the geosynthetics in the base of the lysimeter. Collect four grab samples (12 kg, 26 lb) from random locations for laboratory analysis.

Compact soil on both sides of the sidewall geomembrane with a motorized hand tamper (jumping jack) to ensure a tight interface between the soil and geomembrane. Compact the remaining interim cover soil using lightweight equipment until the interim cover soil has a dry unit weight in excess of 85% of the maximum dry unit weight per ASTM D 698 (cohesive soil) or D 4253 (cohesionless soil) or the dry unit weight specified by the consulting engineer. Check the dry unit weight in at least four randomly selected locations inside the lysimeter boundaries using D 2922, D 2167, or D 1556. Ensure the soil is firm enough for placement of subsequent layers as per direction of the Resident Engineer. Place soil outside the lysimeter area using similar methods.

Collect two 200-mm-diameter block samples using ASTM D 4220 and two thin-walled tube samples. If the soil conditions preclude sampling with these methods, note the conditions and indicate that hydrological tests should be conducted using soils from the grab samples.

3.2 Seaming the Sidewall Geomembrane

Locate one end of the sidewall geomembrane that is welded to the bottom berm, or that is an extension of the bottom liner. Excavate soil placed at the corners and in the vicinity of the end of the geomembrane. Clean the surfaces of the geomembrane carefully, and extrusion weld the sidewall geomembrane at the corners (Fig. 7). Extend the weld from the lysimeter to the top of the interim cover soil. Repeat this procedure for the other end of the sidewall geomembrane welded to the bottom berm, and then for the two ends of the sidewall geomembrane welded to the top berm. Extrusion weld the two downslope corners as far up as practical.

Do not weld the upslope corners until the soil has been placed inside the lysimeter area. The upslope side of the lysimeter should be used for access in and out of the lysimeter for placement of the cover soil. While placing soil, the sidewall liner at the upslope side of the test section should be protected from being damaged by equipment traffic. The geomembrane should be sandwiched between two layers of non-woven geotextile. A layer of sand at least 200 mm thick should be placed on top of the geotextile to serve as an additional cushion against puncture. The sand layer is removed when the sidewall is to be raised into vertical position.

3.3 Root Barrier Layer

Place the root barrier layer (Reemay Biobarrier or equivalent) directly on top of the interim cover soil with minimum wrinkling. Panels of the root barrier shall be placed parallel to the slope of the test section. Overlap the root barrier panels about 25 mm, and ensure that the herbicidal nodules are oriented upwards. Anchor the root barrier layer along the upslope and downslope ends of the lysimeter area adjacent to the vertical geomembrane comprising the sidewall of the lysimeter.

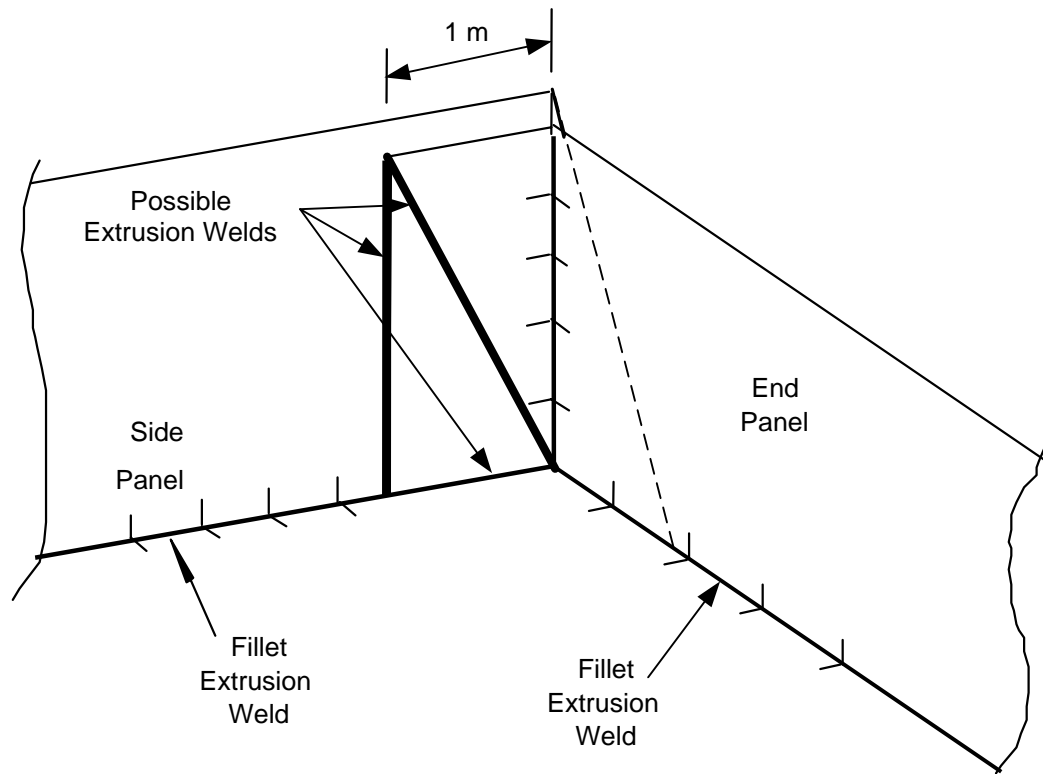


Fig. 7. Welding of sidewall geomembranes.

Ensure that the root barrier layer is not contacting the geocomposite drainage layer or the bottom geomembrane in the lysimeter.

3.4 Final Cover Soils

Place the final cover soils following methods (i.e., lift thickness, compaction water content, percent compaction, etc) described in the cover design report submitted by the consulting engineer for the site. If the consulting engineer specifies no methods, use the methods described in Sections 3.4.1- 3.4.3. Methods to be used near the edges of the lysimeter are described in Sec. 3.5.

3.4.1 Cohesive Final Cover Soils

Adjust the moisture content of the soil, if necessary, prior to placement in the monitoring area. Soils that are too wet shall be spread in thin layers outside the monitoring area and disked intermittently until the water content of the soil is at least 1 percentage point dry of optimum water content per ASTM D 698. Water may be added to soils that are very dry to control dust. However, no cover soil in the monitoring area should have water content exceeding 1 percentage point dry of optimum water content per ASTM D 698.

Place cohesive cover soils in loose lifts no thicker than 450 mm by pushing the soils downslope from the bottom or the top of the test section using a front-end loader, bulldozer, scraper or other suitable equipment that would ordinarily be used for construction of a full-scale cover. Check the loose lift thickness on a regular basis. Re-grade the soil if necessary. After grading, collect four grab samples (12 kg, 26 lb) from random locations in the lift for laboratory analysis.

Compact the cover soil using the method described by the consulting engineer. If no method is specified, use a tamping foot compactor, rubber tire compactor, bulldozer tracks, or another technique approved by the Resident Engineer until the soil has a dry unit weight in excess of 85% of the maximum dry unit weight per ASTM D 698 (cohesive soil). Smooth drum compactors shall

not be used. Ensure compaction is uniform. Check the dry unit weight in at least four locations inside the lysimeter area using D 2922, D 2167, or D 1556. Also, collect two 200-mm-diameter block samples from the lift using ASTM D 4220 and two thin-walled tube samples from the lift. Fill in the excavations caused by the sampling activities with the same final cover soil and compact the soil using motorized hand tamper (jumping jack) to ensure equal compaction in all location of test section. The Resident Engineer shall approve each lift of cover before subsequent lifts are placed.

3.4.2 Cohesionless Final Cover Soils

Cohesionless soils that are too wet shall be spread in thin layers outside the test section and disked intermittently until the water content of the soil is acceptable for placement according to the Resident Engineer. Place cohesionless cover soils in loose lifts no thicker than 450 mm (18 in) by pushing the soils downslope from the top of the test section using a loader, bulldozer, scraper or other suitable equipment that would ordinarily be used for construction of a full-scale cover. Check the loose lift thickness on a regular basis. Re-grade the soil if necessary. After grading, collect four grab samples (12 kg, 26 lb) from random locations in the lift for laboratory analysis.

Densify the cover soil with the method specified by the consulting engineer. If no method is specified, use a vibratory compactor or bulldozer tracks, or another technique approved by the Resident Engineer until the soil has a dry unit weight in excess of 85% of the maximum dry unit weight per ASTM D 4253. Ensure compaction is uniform by applying an even number of passes across the entire test section. Check the dry unit weight in at least four locations inside the lysimeter area using D 2922, D 2167, or D 1556. Also, collect two 200-mm-diameter block samples from the lift using ASTM D 4220 and two thin-walled sampling tube samples from the lift. If sampling is not possible due to soil conditions, note these conditions and indicate that hydrologic tests should be conducted on soil from the grab samples. Fill in the excavations caused by the sampling activities with the same final cover soil and compact using a motorized

hand tamper (jumping jack) to ensure equal compaction in all location of test section. The Resident Engineer shall approve each lift of cover before subsequent lifts are placed.

The thickness of each lift should be verified using surveys of the bottom and top of each lift. The thickness of each lift should be on average (± 50 mm) equal to that specified by the Resident Engineer or the consulting engineer. The overall thickness of each component of the final cover (interim cover, gas collection layer, etc), should be at least equal to that specified by the cover design report.

3.4.3 Interfaces Between Layers of Different Texture

In cover designs that employ layers of different texture, soils at the textural interface shall be placed using the method specified by the consulting engineer. If no method is specified, place the soil in a manner that minimizes mixing of the two soils at their interface. The method to be used shall be approved by the Resident Engineer. The method should be similar to that to be used in the construction of the full-scale cover at the facility.

A geotextile may be used as a separating layer. Non-woven geotextiles shall be used that have a mass per unit area of at least 130 g/m^2 (4 oz/yd^2) and an apparent opening size (per ASTM D 4751) $< 0.6 \text{ mm}$ if the finer textured soil contains less than 50% fines or $< 0.3 \text{ mm}$ if the finer textured soil has more than 50% fines. The geotextile shall be anchored at the upslope and downslope ends of the lysimeter area adjacent to the vertical geomembrane comprising the sidewall of the lysimeter (see Fig. 7).

3.5 Compacting Adjacent to the Sidewall Geomembrane

Place cover soil around the inside and outside edges of the lysimeter directly adjacent to the sidewall geomembrane. Compact soil on both sides of the sidewall geomembrane with a motorized hand tamper (jumping jack) to ensure a tight interface between the soil and geomembrane. After each lift of cover soil has been compacted, excavate a narrow trench

adjacent to the geomembrane sidewall by hand as shown in Fig. 8. Fill this narrow trench with powdered bentonite (CETCO Super Gel-X or equivalent) and then cover the bentonite with a thin layer of the soil excavated from the trench.

3.6 Topsoil (Vegetative Layer)

Place the topsoil layer following the method specified by the consulting engineer. If no method is specified, the topsoil layer should be a layer 150 mm to 200 mm (6 to 8 in) thick consisting of material that will support plant growth and allow water infiltration. If available, topsoil that has been removed from the borrow area should be used. The vegetative layer can consist of other material that is available on site and is approved by the Resident Engineer. Seeding of the topsoil layer should be conducted following the re-vegetation plan prepared by the consulting engineer.

The topsoil layer should be placed with minimal compaction. Measure the dry unit weight in at least four locations inside and two locations outside the lysimeter area using D 2922, D 2167, or D 1556. Collect four grab samples, two 200-mm-diameter blocks using ASTM D 4220, and two thin-walled tube samples. Fill in the excavations caused by the sampling activities with the same soil and compact using hand shovels to ensure equal compaction in all locations of the layer. If sampling is not practical due to the soil conditions, note the conditions and indicate that hydrological tests should be conducted using soil from the grab samples.

4. SURFACE RUNOFF COLLECTION BERMS

4.1 Diversion Berms

Construct berms for surface runoff collection along the edge of the lysimeter as shown in Fig. 1. Place soil on either side of the sidewall geomembrane as shown in Fig. 9. Compact with a motorized hand tamper and/or with construction equipment such as a loader until the soil is firm. Slope the swale along the bottom berm at $\pm 2\%$ to ensure flow to the centerline of the test section.

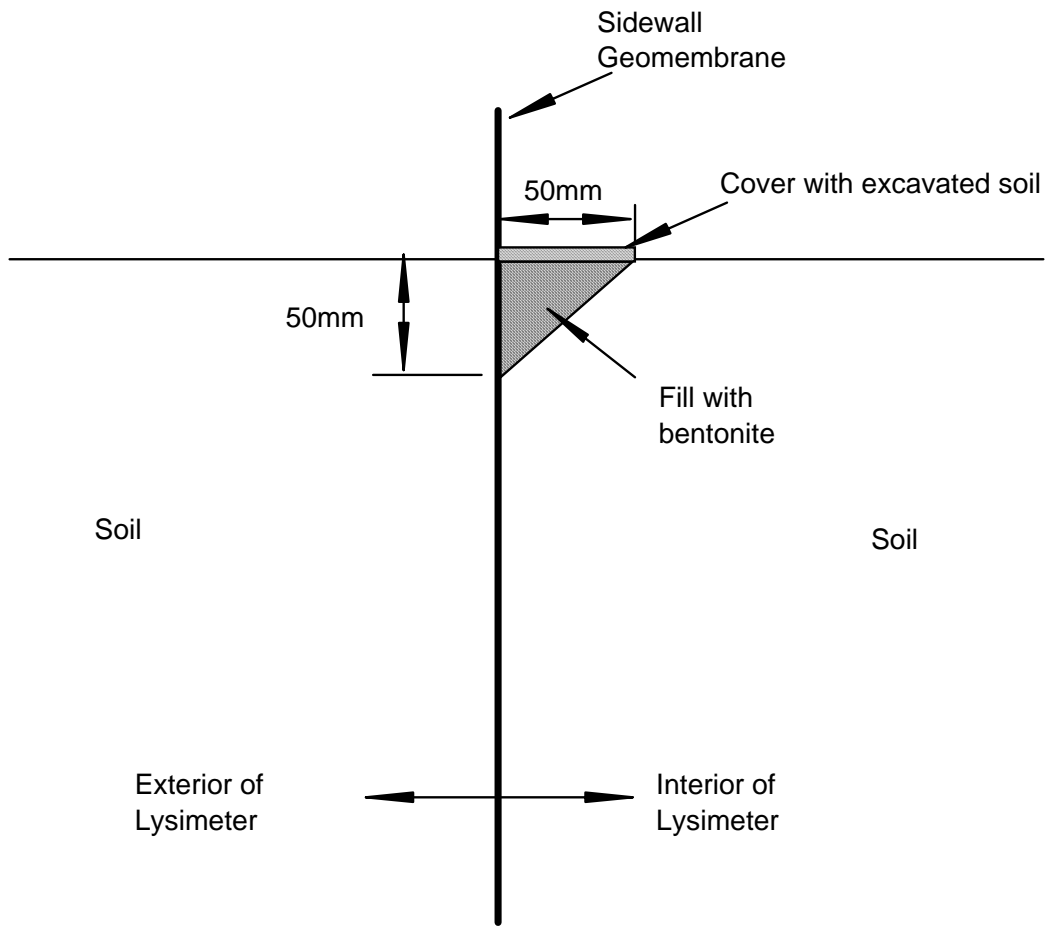


Fig. 8. Anti-seep detail along sidewall geomembrane.

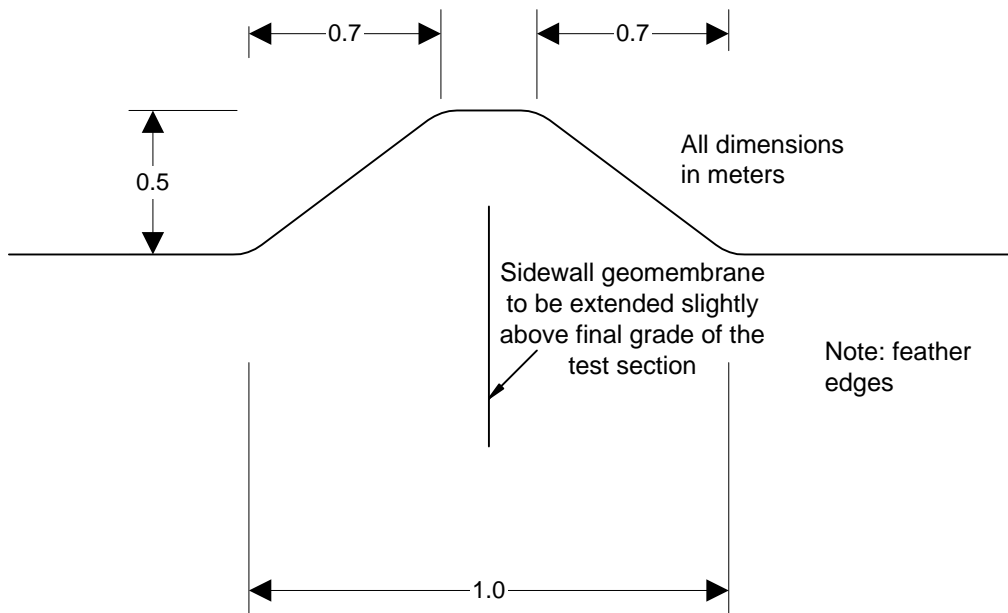


Fig. 9. Diversion berm for surface runoff.

4.2 Surface Run-Off (SRO) Collection Point

Install a collection pipe in a trench at the centerline of the lower berm as shown in Fig. 10. Ensure the invert of the collection pipe is at the lowest point in the bottom berm. Install the anti-seep collar around the pipe and tighten the clamps. Extrusion weld the collar to the sidewall geomembrane. Backfill the trench with soil and compact to the similar density as the surrounding soil and to the satisfaction of the Resident Engineer. Feather the soil in the interior berm to ensure water drains to the invert of the pipe. Cover the upstream end of the pipe with a section of GSE Fabrinet (or equivalent) and spike the Fabrinet to the berm or attach a wire mesh (or equivalent) to the open end of the pipe using a hose clamp.

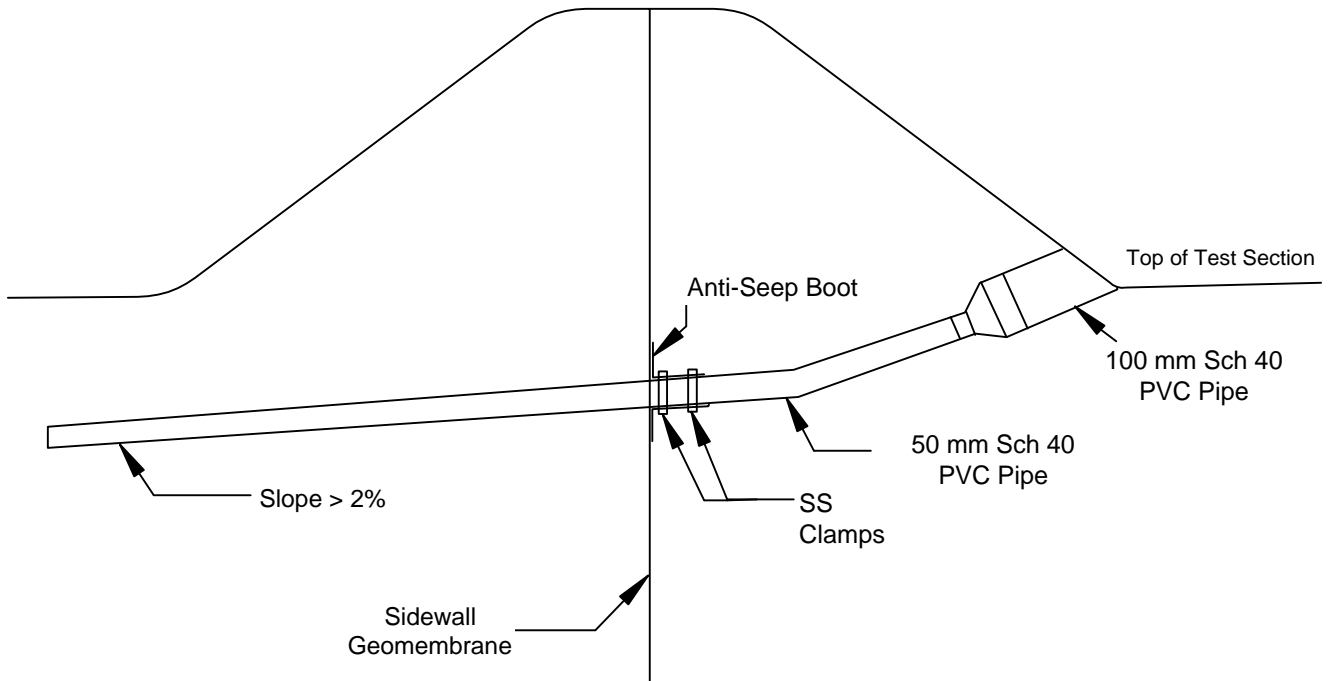
5. COLLECTION SYSTEM

5.1 Sedimentation Tanks

Install the sedimentation tank (Diverse Plastics A3042, or equivalent) between the surface runoff collection point and the collection basin. Install the tank approximately 1 m away from the surface runoff collection basin as shown in Fig. 11. Locate the tank so that the final water elevation is below frost depth. Install one hole on the upstream side of the sediment collection tank and another on the down stream side (Fig. 11) using a hole saw. Locate the holes so that the pipe coming from the test section maintains its slope to the collection basin. Use bulkhead fittings to attach the pipe to the sedimentation tank as shown on Fig. 11. Fill the sedimentation tank with water to the outflow elevation after installation.

5.2 Dosing Siphon

Install the basins with the dosing siphons (Orenco Model 214 Modified) at a location that will permit a pipe slope of at least $\pm 2\%$ from the test section to the basin and to ensure that the top elevation of the inflow pipe is below frost depth. If necessary, excavate overburden to form a pocket for the basin (Fig. 12). Leak test the basin before any backfilling. Compact the base of this pocket until it is firm. Place a pressure-treated wooden platform in the base of the pocket on a layer of sand and ensure that the platform is level.



Notes:

1. Slope swale in lower berm to collection pipe.
2. Cover opening of collection pipe with 10 mm x 10 mm galvanized wire mesh or geonet.
3. Ensure invert of 100 mm pipe is at lowest point in swale.
4. Weld Anti-seep boot. Seal boot-pipe connection with silicon caulk before clamping.

Fig. 10. Detail of SRO collection point.

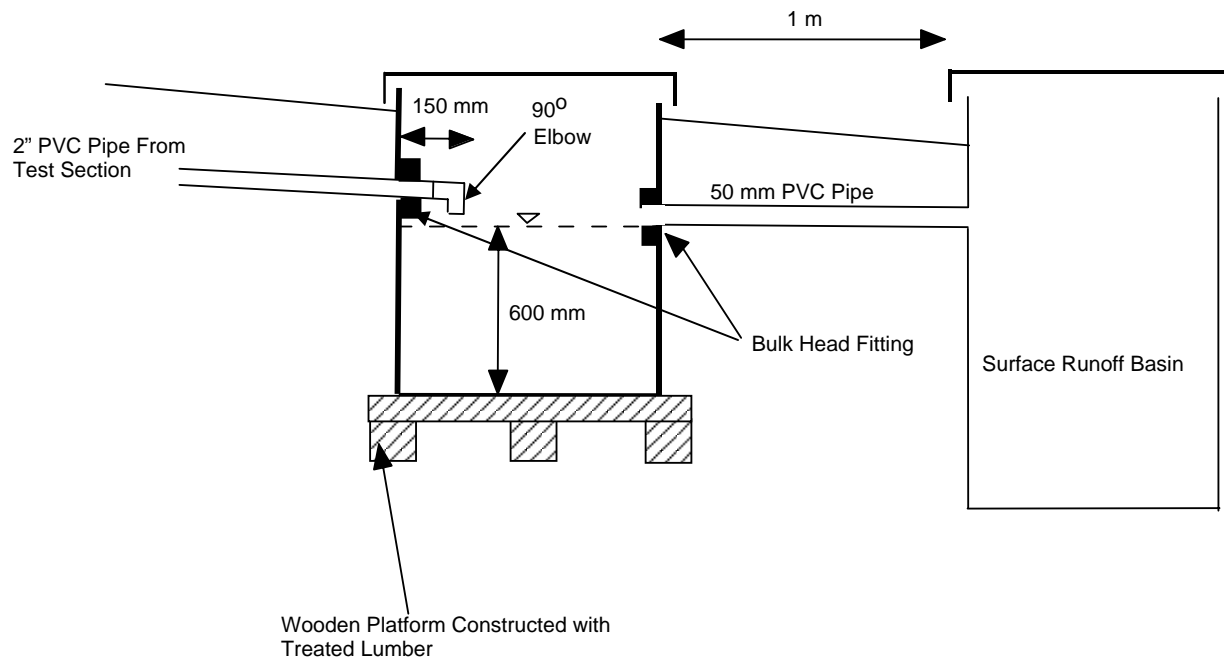


Fig. 11. Schematic of sedimentation tank.

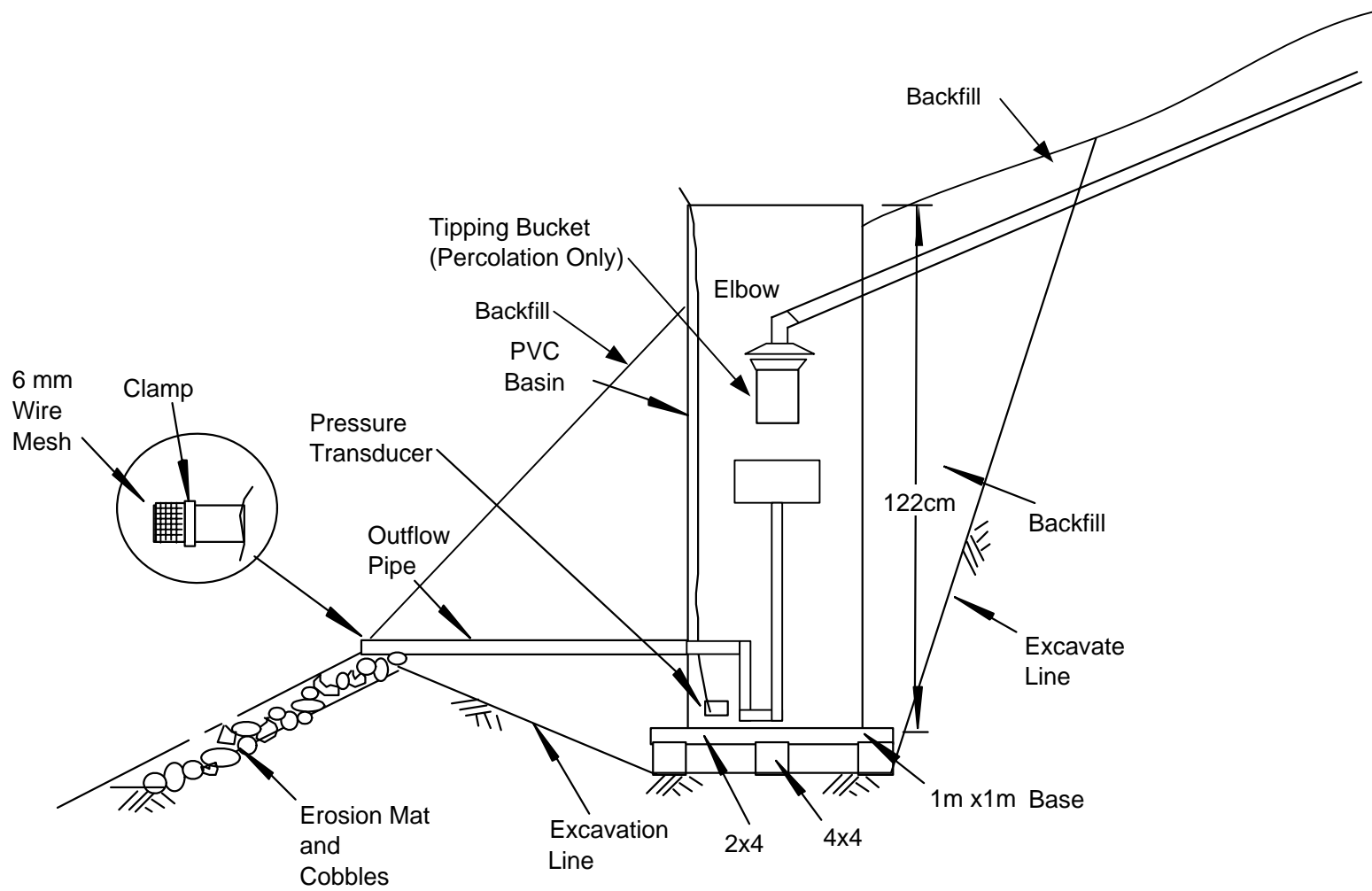


Fig. 12. Installation of dosing siphon.

Place the basin on the platform and carefully backfill the pocket up to the outflow port. Install a 100-mm-diameter outflow pipe (Fig. 12) following the manufacturer's recommendations. Use clamped rubber coupling to connect the outflow pipe to the basin. Backfill carefully around the pipe using sand and then backfill the remainder of the pocket using the excavated soil. Install erosion mat and place cobbles (or other erosion control device) to minimize erosion at the outflow. Install a screen on the outflow end of the pipe to prevent animal intrusion. Fill the basin with water to just below the discharge elevation. Measure the depth of water in the dosing siphon from the upper surface of the outer chamber at 5-min intervals for 30 minutes. If the water level drops more than 3 mm during this period, find and repair the leak. Then re-test the dosing siphon.

Calibrate the dosing siphon by placing a known volume of water into the basin until discharge begins. Mark the elevation at which discharge begins. Repeat this procedure two more times to check the calibration. If the calibration or flush elevation deviates significantly, find the source of the problem, correct it, and re-calibrate the dosing siphon.

Install a tipping bucket in the basin used to collect percolation from the test section as shown in Fig. 12. Attach the tipping bucket to the air pipe of the siphon with hose clamps as shown in Fig. 13. Ensure the tipping bucket is level after installation. Adjust if necessary. Drill one hole into the side of each basin for the pipe from the test section. For the percolation pipe, drill a 45-mm-diameter hole (1.75 in). A 65-mm-diameter (2.5 in) hole should be drilled into the side of the basin receiving surface run off. Collect the drill cuttings and dispose of them.

Install PVC pipes from the lysimeter (percolation or surface runoff) to the basins. Grade soil beneath the pipe as necessary to ensure the pipe has bedding with monotonic grade. Install a 90° elbow on the end of the pipe inside the basin to ensure water flows downward. For the basin collecting percolation, align the center of the outflow end of the elbow with the center of the tipping bucket.

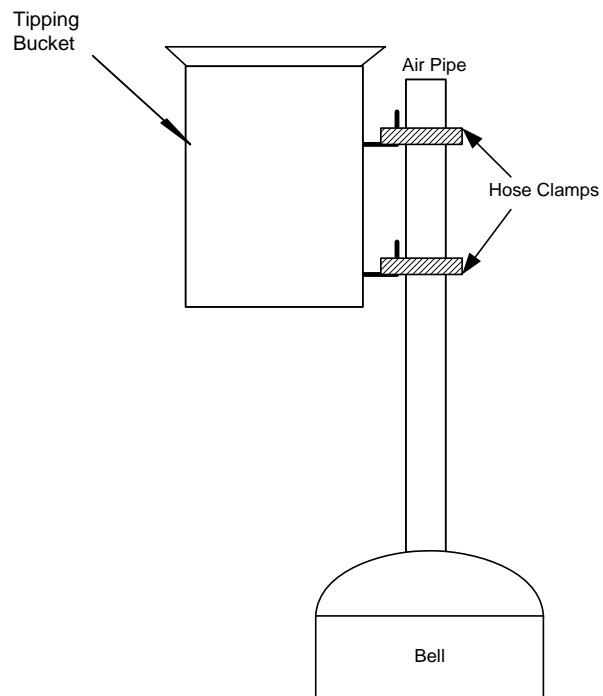


Fig. 13. Installation of tipping bucket in dosing siphon.

6. INSTRUMENTATION

6.1 Installation of Water Content Reflectometers, and Heat Dissipation Units.

Water content reflectometers and heat dissipation units shall be installed in three nests as shown in Fig. 14. If possible, the instruments should be placed after each lift has been installed by burying them by hand and routing the wires in conduit to a common point on the side of the test section. If the instruments cannot be installed after each lift, excavate a hole for each nest 450-mm across by 200-mm wide down to the root barrier. Cut a flap in the root barrier and continue to excavate 150 mm into the interim cover soil. Keep excavation spoils from the cover and interim cover layers separate. Install a water content reflectometer (WCR) at the base of the hole by hand as shown in Fig. 15. Press the WCR horizontally (or at the angle of the slope) into the interim cover soil, with the rods oriented upslope. The WCR can also be installed vertically, except in the topsoil layer, with approval of the Resident Engineer and/or the Field Manager. In this layer the WCR should be placed horizontally at mid-depth unless another orientation is approved by the Resident Engineer and/or the Field Manager. Install a heat dissipation unit (HDU) in a cylindrical horizontal hole oriented upslope (15 mm diameter, 30 mm long) adjacent to the water content reflectometer. HDUs shall be soaked in water prior to placement. Soil around HDUs shall be soaked with water to ensure good hydraulic contact between the sensor and the soil. Route the wires along the base of the hole to the opposite wall and then route them upward as shown in Fig. 15. Backfill the hole with interim cover soil and tamp to the same density at which it was originally placed.

Install another WCR and HDU at this depth using the procedure described previously. Route the wires to the back of the hole and bundle all wires together with a cable tie. Install a sheet of 0.1 mm (4 mil) polyethylene around the wires as an anti-seep collar. Locate the collar 100 mm above the location of the instruments. Place a small quantity of bentonite CETCO Super Gel-X (or equivalent) on top of and around the anti-seep collar (Fig. 15). Backfill the hole and tamp to the original density.

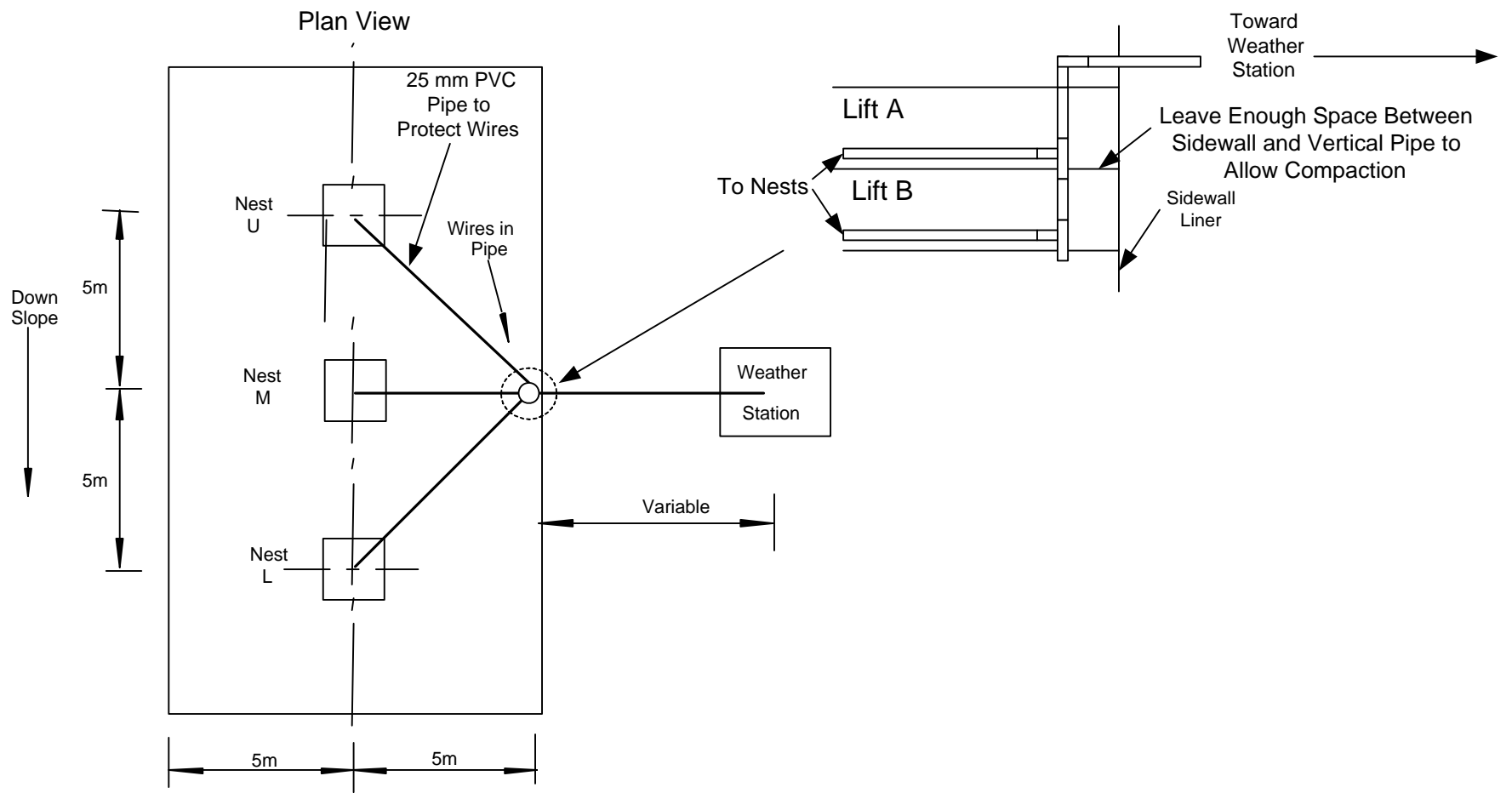


Fig. 14. Locations of instrumentation nests and weather station.

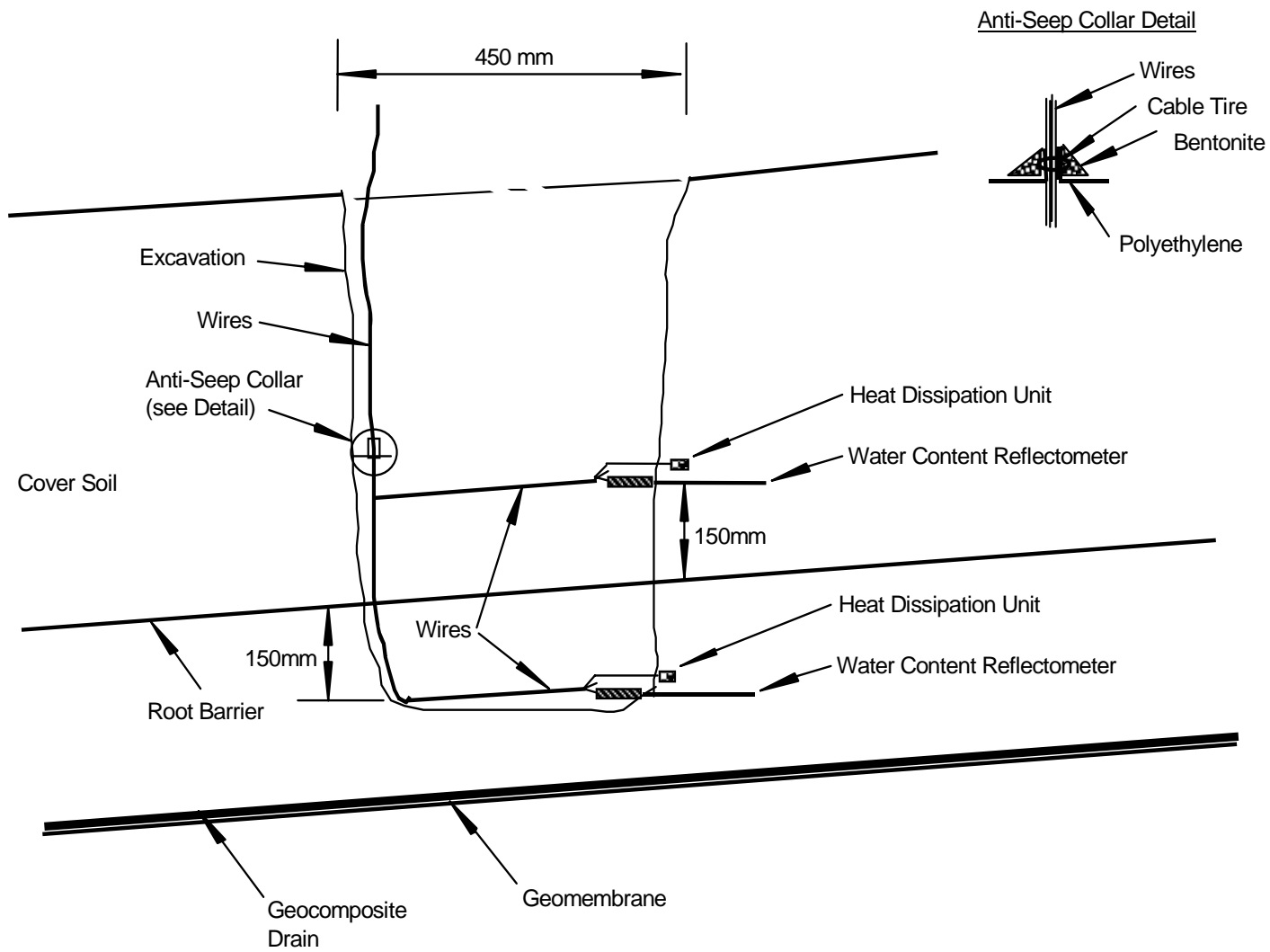


Fig. 15. Installation of instruments in an instrumentation nest.

Place the remaining four WCRs and HDUs at an equal spacing. Bundle the wires at each probe with cable ties, install an anti-seep collar, and backfill to the depth for the next set of instruments. The uppermost set of instruments shall be placed at mid-depth of the topsoil layer. Feather the surface of the backfill so that no water will collect at the surface of the excavation.

6.2 Routing of Wiring to Datalogger

Place the wires from each nest in PVC conduit and route the conduit in a small trench 150 mm deep excavated along the surface of the test section as shown in Fig. 14. Pass the wires through the surface runoff berm and the sidewall geomembrane. Route the wires to the surface at the weather station. Backfill the trench and compact to the original density of the soil. Feather the surface of the backfill so that the trench does not affect surface flow.

6.3 Weather Station

Install the tripod and grounding rod for the weather station adjacent to the test section following the manufacturer's recommendations. Anchor the ground concrete footings using the anchorage spikes. Bolt the data acquisition cabinets to the tripod. Install the pyranometer, temperature and humidity sensor, and wind sentry on the tripod following the manufacturer's recommendations. Wire all sensors, including those installed in the test section, following the Standard Operating Procedure for Datalogger Programming and Data Checking for ACAP Sites.

Embed a 32-mm-diameter and 2.5-m-long galvanized steel pipe into the existing soil for the rain gauge. Locate this pipe near and upwind from the weather station. Clamp the rain gauge to the pipe following the manufacturer's instructions. Ensure the top of the steel pipe is below the uppermost surface of the rain gauge. Fasten the wire from the rain gauge to the pipe with cable ties at 150-mm centers. Route this wire to the weather station in a small trench approximately 150 mm deep. Backfill this trench and tamp by hand to the surrounding density. Wire the rain gauge to the datalogger following the DRI wiring instructions.

6.4 Dosing Siphons

Install a PVC pipe in the basin of the dosing siphon to hold the pressure transducer. Attach the transducer to the pipe so the sensing element is 300 mm above the bottom of the basin. Route the wire from the transducer, the wire from the dose meter, and the wire from tipping bucket (percolation tank only) through a 12-mm-hole drilled in the side of the basin. Locate the hole approximately 150 mm from the top of the basin. Seal the hole with caulk (GE Silicon II or equivalent). Allow the caulk to cure for at least 120 min.

Excavate a narrow trench (50 mm wide, 150 mm deep) from the dosing siphons to the weather station. Place the wires in conduit, lay the conduit in the trench, and backfill. Compact the backfill using a hand tamper. Attach the wires to the datalogger following the Standard Operating Procedure for Datalogger Programming and Data Checking for ACAP Sites.

7. VEGETATION

Prepare the surface of the test section for seeding following the procedure described by the consulting engineer or in the site-specific design report. The vegetation plan will specify the plant species, placement density, and fertility requirements for the vegetative cover. Site operators may work with ACAP to develop the vegetation plan.

APPENDIX I: ASTM STANDARDS

APPENDIX II: MATERIAL SPECIFICATIONS

(Spec Sheets for Gel-X not included yet)

APPENDIX III: PHOTOGRAPHIC ILLUSTRATION OF INSTALLATION METHODS