CHAPTER 3. THE SUBSURFACE BARRIER TEST FACILITY

In this chapter, the Subsurface Barrier Test Facility (SBTF) at Virginia Tech is described. Three pilot-scale soil-bentonite cutoff walls were constructed and tested at this facility in order to evaluate various methods of measuring hydraulic conductivity. The facility was constructed in the fall and winter of 1998.

This chapter is divided into the following three sections:

3.1 Concept of the facility.
3.2 Description of the facility.
3.3 Outline of pilot-scale cutoff wall construction at the facility.

3.1 Concept of the Facility

How do we go about evaluating the properties and behavior of a vertical subsurface barrier or investigating the effectiveness of a new barrier technology? One option is to construct a full-scale model in the field. The advantages of this are that we use real construction equipment and techniques and the dimensions and stresses are representative. Some disadvantages are that we cannot fully control the testing environment, such as the formation soil stratigraphy and the flow regime. In addition, how do we know what the final product actually looks like, since it is underground? Another option is to use laboratory-scale experiments. In this case we are not using real construction practices or working at full scale, but we do have excellent control over the testing environment and can generally see what we are doing. The goal of the SBTF is to operate at an intermediate scale, thereby balancing the advantages offered by the full-scale and laboratory-scale extremes, to study the properties and behavior of barriers and the effectiveness of new barrier technologies. The facility was designed to be applicable to the soil-bentonite cutoff wall research described in this dissertation, yet flexible enough to accommodate future research on other varieties of subsurface barriers.

3.2 Description of the Facility

Figures 3-1, 3-2, and 3-3 show plan and cross-section views of the facility. The main components of the facility are:

- **Barrier pit.** The barrier pit is a below-ground concrete pit in which vertical barriers can be constructed and tested. The 1.8-m-wide barrier pit is 2.8 m deep for the 3.2-m-long section in the middle, sloping at 3H:1V to the ground surface on each end. An end slope is required for 1) initial placement of backfill when constructing slurry-excavated cutoff walls and 2) access into the pit with equipment such as a Bobcat
Figure 3.1. Plan view of SBTF

See Figure 3-2 for section A-A and Figure 3-3 for section B-B.
Figure 3.2. Section A-A view of SBTF
loader and soil compactors. The scale of the pit allows small, but real, construction equipment to build the vertical barriers. Four 15-cm-diameter PVC monitoring wells were installed in the monitoring well chases shown in Figure 3-1. The wells extend from the bottom to the top of the barrier pit. Holes were drilled along the length of the wells to allow the head in the wells to equal the head in the barrier pit, and a geosynthetic filter was wrapped around the wells to keep out soil particles. The well diameter was large enough so that small submersible pumps could be placed in the wells to control the water levels in the barrier pit during testing. The inside of the barrier pit was painted with a penetrating sealer to reduce water leakage. In addition, water-stops were installed in all the construction joints during construction of the pit. The sealed concrete barrier pit provides a level of control in the pilot-scale cutoff wall tests that is unattainable in full-scale field tests.

- **Mixing/storage pit.** The mixing/storage pit is a below-ground concrete pit for mixing and storing materials. The unsealed, rectangular pit is 6.1 m long, 2.2 m wide, and 1.2 m deep. The primary purpose of the pit is for mixing and storing soil-bentonite backfill material.

- **Slurry mixing tanks.** The facility contains two above-ground polyethylene tanks for mixing and storing slurries. The capacities of the tanks are 7,570 liters (2,000 gallons) and 15,140 liters (4,000 gallons).

- **Concrete apron.** There is a large concrete apron for mixing and stockpiling materials. The apron, whose extent is shown in Figure 3-1, also allows for easy, clean access to the other components of the facility, such as the barrier pit, mixing/storage pit, and slurry mixing tanks. To help keep water out of the barrier pit, the apron slopes away from the barrier pit on all sides at approximately 1.5%.

- **Evaporation pond.** A small, unlined evaporation pond was constructed for disposal of used slurries.

The facility is located adjacent to Virginia Tech's off-campus geotechnical engineering lab on Price's Fork Road, which provides electricity and access to a variety of useful equipment, such as a Bobcat loader and soil compactors. Water at the site comes from a groundwater well, and will henceforth be called Price's Fork water (PFW).

### 3.3 Outline of Pilot-Scale Cutoff Wall Construction

In this section, the general procedure for constructing a pilot-scale soil-bentonite cutoff wall at the facility is described. This is only a rough outline; Chapter 4 contains a detailed description of the construction of the three soil-bentonite cutoff walls in this dissertation, including construction techniques, equipment, and materials.
**Step 1:** Construct a compacted clay liner (CCL). To simulate a low-permeability layer in the subsurface, a compacted clay liner is installed in the bottom of the barrier pit (see Figures 3-2 and 3-3). The cutoff wall is keyed into this CCL.

**Step 2:** Construct an aquifer. To simulate a high-permeability aquifer in the subsurface, clean sand is compacted above the CCL all the way to the top of the barrier pit (see Figure 3-3). The sand is compacted for strength, so that there are no stability problems during cutoff wall excavation. The hydraulic conductivity of the sand is orders of magnitude higher than that of the soil-bentonite that forms the cutoff wall, so that head losses in the tests may be assumed to occur entirely in the soil-bentonite and not in the sand.

**Step 3:** Mix the soil-bentonite. A bentonite-water slurry is mixed in a slurry mixing tank. This slurry, along with dry bentonite if necessary, is added to a silty sand base soil and the parts are mixed together on the concrete apron with the Bobcat loader.

**Step 4:** Mix the excavation support slurry. Both bentonite-water slurry and a biodegradable slurry were used for excavation support. The slurries are mixed in the slurry mixing tanks. Before mixing the biodegradable slurry, the tanks and mixing equipment (pump, hoses, etc.) are sterilized.

**Step 5:** Excavate the trench. A track-mounted excavator is used to dig a trench along the length, and in the center, of the barrier pit (see Figures 3-2 and 3-3). The trench extends all the way through the CCL to the concrete bottom of the barrier pit. The water level in the compacted sand (from prior precipitation) is lowered prior to excavation to increase the stability of the excavation.

**Step 6:** Backfill the trench with soil-bentonite. The Bobcat loader is used to place the soil-bentonite into the trench, starting at one end of the barrier pit. As the soil-bentonite is placed, the support slurry is pumped from the trench into the evaporation pond. The pumping is controlled so that there is always a high slurry level in the trench for support. After all the support slurry has been displaced and the trench is full of soil-bentonite, additional soil-bentonite is mounded above the trench to compensate for future settlement of the soil-bentonite in the trench.

**Step 7:** Final treatment of the cutoff wall. A thin layer of moist sand is placed above the barrier pit to help prevent drying, and the barrier pit is covered with plastic sheeting. The water levels on each side of the cutoff wall are lowered to the bottom of the barrier pit, and the cutoff wall is allowed to consolidate under this condition.

**Step 8:** Hydraulic conductivity testing. This step is described in detail in Chapter 5. Tests include API tests on grab samples, measurement of the average hydraulic conductivity of the entire cutoff wall, single-well tests, and piezocone soundings. The average hydraulic conductivity of the wall is evaluated by setting a head difference across the wall (by controlling the water levels in the sand on each side of the wall, as shown in Figure 3-3) and measuring the corresponding flow rate through the wall. The average
hydraulic conductivity of the wall can be evaluated by finding the uniform hydraulic conductivity for a representative wall in a theoretical model that produces the same flow rate as that measured through the actual barrier.

**Step 9:** Destructive evaluation. The soil in the barrier pit is excavated with the Bobcat loader so that the cutoff wall can be inspected for content, size, uniformity, and continuity. Samples of the cutoff wall are taken, and among other things, hydraulic conductivity is measured.