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Design and Construction of Demonstration/Research Wetlands for Treatment of Dairy Farm Wastewater

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16. ABSTRACT

There are no constructed wetlands currently used in Oregon for treating agricultural wastes. This report discusses the construction of nine wetland cells at the Oregon State University dairy farm. These wetlands will be used in a long-term project which will attempt to: 1) Develop optimal loading rates for milking parlor wastewater and diluted dairy cow manure, not only for maximum treatment efficiency, but also for adequate treatment of wastewater to allow direct discharge into surface waters. 2) Measure seasonal variation in treatment effectiveness. 3) Develop design criteria for farms with limited wastewater generations. 4) Measure variation in treatment efficiencies between several wetland plant species and develop propagation techniques for wetland plants. Over the next five years, observations and data from these wetlands should help develop better design criteria and economics for form-scale wetlands.

Results of the long-term project will be published in Extension Service publications and technical papers for use by farmers, other researchers, technical advisors, and regulatory agencies.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Introduction and overall project objectives

Constructed wetlands have been used for the treatment of municipal and industrial wastes. There are three basic characteristics of wetlands that make them attractive in treating agricultural wastes:

* They can physically trap pollutants by sorption on surface soils and organic litter.
* Microorganisms in the system use and transform compounds.
* Low energy and maintenance is required to attain consistent treatment levels.

There are no constructed wetlands currently used in Oregon for treating agricultural wastes. This report discusses the construction of nine wetland cells at the Oregon State University dairy farm. These wetlands will be used in a long-term project which will attempt to:

1. Develop optimal loading rates for milking parlor wastewater and diluted dairy cow manure, not only for maximum treatment efficiency, but also for adequate treatment of wastewater to allow direct discharge into surface waters.
2. Measure seasonal variation in treatment effectiveness.
3. Develop design criteria for farms with limited wastewater generation, such as those with intermittent lot runoff.
4. Measure variation in treatment efficiencies between several wetland plant species and develop propagation techniques for wetland plants.

Over the next five years, observations and data from these wetlands should help develop better design criteria and economics for farm-scale wetlands.

Results of the long-term project will be published in Extension Service publications and technical papers for use by farmers, other researchers, technical advisors, and regulatory agencies.

Design specifications

Six wetland cells, each measuring 4.6 x 29.0 meters (203 m^2) [*23'x 95' (1/20 acre)*] at the inside top of the side berms, and three cells, 4.6 x 6.1 meters (28 m^2) [*15'x 20'*] each, have been constructed south of the dairy buildings, as shown in Figures 1 through 5. Inside and outside slopes of dikes are 2.5 to 1. Cell size was limited by location and budgetary constraints. The cell dimensions follow the 4:1 length:width ratio recommended[1,2]. Total cell volumes will allow 2 to 10 day retention times with diluted and undiluted wastewaters (*see "Loading rates"*). The smaller cells are for the treatment of the more dilute milking center wastewater; the larger cells will treat diluted stored animal wastewater. Cells will be a "single pass" system. Wastewater will be treated in a single cell, collected, and returned to the main dairy storage system. The southern-most cell, Cell 10, is about 1 meter [*3.1 feet*] deep (see Figure 1). It will receive effluent from each wetland for storage prior to field application or pumping back to the main dairy storage tank.

Total depth of cells is 60 cm [*24"*] with liquid depth to be maintained at 30 to 45 cm [*12 to 18 inches*]. Total volume of larger cells is approximately 45,560 liters [*12,150 gallons*] at a 30 cm [*12 inch*] depth. Two cells were designed with a deep center section to provide an anaerobic area (without plants) between aerobic sections at either end to allow comparison of treatment efficiencies (see Figure 4). Original designs with cuts and fills are shown in Figures 1 and 2. Cell bottoms slope slightly east to west to allow draining, if necessary. Finish slopes of cell bottoms are approximately .05 percent.

Site location and topography

The wetland system was built on the Oregon State University dairy unit, approximately 4490 Harrison Street, Corvallis, Oregon. A field was chosen on the southwest side adjacent to the main dairy housing building. The field is about 350 x 150 meters [*1,150' x 530'*]. Oak Creek is south of the field, about 100 meters [*330'*] from the lowest cell.

The site slopes gently (about 1%) north to south. Cell location was moved south to the center portion of the field to avoid a more severe slope about 60 meters [*200 feet*] north. While wetlands could be constructed on nearly any slope, a flatter site reduces the costs of excavation. Water levels in the northern-most top cells are slightly higher than in the lower cells, but the overall appearance of the wetlands is nearly flat when viewing the top of the dividing berms.

Soil properties at site

The wetland cells were laid out in Amity silty clay and Bashaw clay loam soils. Soil depth averages 60 cm [*24 inches*] throughout the site. Soil profiles show a poorly drained, mottled clay layer at sixty centimeters [*24"*]. Most cell bottoms were just above the surface of this clay layer, except for the center sections of cells 4 and 9 where the deeper center section entered about 60 cm [*24"*] of the clay layer. Top soil was not used in the bottom of cells as the Amity and Bashaw soils were adequate for wetland plant establishment.

Bottoms of cells are compacted Bashaw clay with an estimated hydraulic conductivity of less than $1x10^{-7}$m/sec. The above ground and above water level berms are compacted Amity soil supplied to the cells in 5 cm [*2"*] PVC. Diluted animal wastewater will come to cells in 10 cm [*4"*] PVC. There is approximately 5 m [*15 feet*] of elevation from the milking parlor and waste mixing area to the wetland cells. This will allow loading by gravity or mechanically as conditions warrant. If plugging of pipes or orifices under gravity flow is a problem, waste can be pumped to increase flow. Wastewater flow will be distributed into cells through a 10 cm [*4"*] diameter gated, submerged pipe about 3.67 m [*12 '*] long into Cells 4 through 9, but will enter one open 10 cm [*4"*] pipe at the outflow. This will prevent plugging in a smaller collection pipe. Ten centimeter [*4"*] PVC valves will be used to control flow into cells. Treated water leaving all cells will drain to the Cell 10 reception cell in 10 cm [*4"*] PVC pipe sloped about 0.1%. A five horsepower, 795 l/minute [*210 gal/minute*], high pressure, high volume pump will be installed in Cell 10 to either pump treated wastewater back to manure storage or to distribute it on nearby fields. The general hydraulic system layout is shown in Figure 5.

Loading rate specifications

Loading rates will vary based on the dilution and subsequent strength of wastewater, but in general, milking center waste will be held in cells for 2 to 5 days and diluted wastewater will be held 2 to 8 days. The strategy for loading wetlands has not been determined by the technical advisory group yet. The project will evaluate treatment efficiencies and determine a flow rate where treatment is adequate for discharge into surface waters. This dictates a wide range of loading rates and retention times. We will likely include batch and continuous flow comparisons during the project. At the stated retention times, flow rates would be 1,325 to 3,000 l/day [*350-800 gal/day*] in the small, milking parlor waste cells and 2,300 to 9,000 l/day [*600-2,250 gal/day*] in the larger cells, assuming a 45 cm [*18"*] depth.

Influent strength will not exceed 100 mg NH_3/liter, since this is usually rate-limiting. Higher concentrations can damage wetland plants and reduce treatment efficiencies[1]. Total solids and biochemical oxygen demand will usually not exceed 1,500 mg/l and 74 kg/ha-day, respectively. Stronger wastewater will be diluted before introducing into cells.

Wetland species culture

Two large wastewater cells were planted with cattail (*Typha latifolia*) and four with Hardstem bulrush (*Scirpus acutus*). The three small milking parlor water cells were planted with bulrush. Nursery plant stock was purchased in Spring, 1992, and planted in a 1 m x 0.6 m [*3'x 2'*] pattern in larger cells. Soil was kept wet, but not submerged. When more water was added, nutria (*Myocastor coypus*) destroyed most of the aquatic plants. The cells were planted again in the summer and a fence constructed to limit nutria access. The fence was built using wooden and steel line posts on 3.2 m [*14'*] centers. Welded wire with 5 x 7.5 cm [*2 x 3"*] holes was attached to the fence so that 5 cm [2"] extended into a shallow trench dug before setting the line posts. The trench was filled with soil and packed. However, the nutria dug under the fence in one place and damaged all the stands again. The fence must be lowered in the area where they have dug under it and extended on the east side away from Oak Creek so that the entire area is enclosed. Replacement planting will be done in Spring, 1993, just before starting trials. Plants are expected to fill cells when nutria can be excluded.

Costs

Excavation	$3,800
PVC pipe and connections	800
Fencing (including modifications)	1,000
Equipment rental	1,000
Misc. supplies and equipment	700
Wetland plants	400
Total	$7,700

Labor

20 hrs. site survey and grade determination during excavation
30 hrs. fencing, including modifications planned
60 hrs. pipe and power installation
30 hrs. planting wetlands
20 hrs. tillage, seeding berms, mowing
10 hrs. observation well construct.
170 hrs. total labor in construction

Problems encountered in construction

No serious problems were encountered in construction. The serious problem with the water rodent, nutria, has caused delays in the use of the constructed wetlands. There were significant numbers of nutria in Oak Creek prior to construction. It is not uncommon to see 20 to 30 "grazing" in the pastures near the creek. They prefer slow moving or ponded water with a food source, hence they moved to the wetlands. While they are distributed throughout the Pacific Northwest, this site is especially suited to their needs.

Nutria are native to South America. They were brought to the Southeastern U.S. to help control noxious aquatic vegetation. Some were raised for their low value fur, but later released. The first report of nutria in Oregon is probably 1930 near the Nestucca River on the northern Oregon coast. They are prolific breeders and have no native disease or predator enemies. The damage they cause is similar to that reportedly caused by muskrats[4]. They will reportedly eat more than 40 species of native Oregon plants, but favor sweet or field corn when available. Nutria have complicated establishing wetland plants, but they also burrow into cell banks for shelter. At another research wetland, nutria burrowed through a 4 m [*13'*] berm causing cross flow from one cell to another. Further fencing at both sites will be necessary for successful establishment and maintenance of wetland plants.

Deviations between original design and "as-built" cells

Cells were built as designed. The final top view is shown in Figure 1 and their orientation to other dairy buildings is shown in Figure 5. Flow direction was changed to east to west easing collection and return of treated wastewater to storage or field application.

Recommendations for improvements

Clearly, constructed wetlands in some areas of the Pacific Northwest are going to need water rodent control. Nutria can remove several hundred square feet of plants every night and the burrowing behavior could release untreated wastewater to surrounding fields or surface waters. While some clear areas within a wetland might be advantageous, this is a serious problem in demonstration/research scale cells. We will likely investigate less desirable plant species, but as a side project. It is more important to exclude the nutria to maintain some degree of environmental control.

Berm slopes would likely be better at 3 to 1 inside and outside for ease of mowing and driving equipment near the berms. We will try grazing the berms with sheep this year to limit the mowing necessary.

Reference materials used

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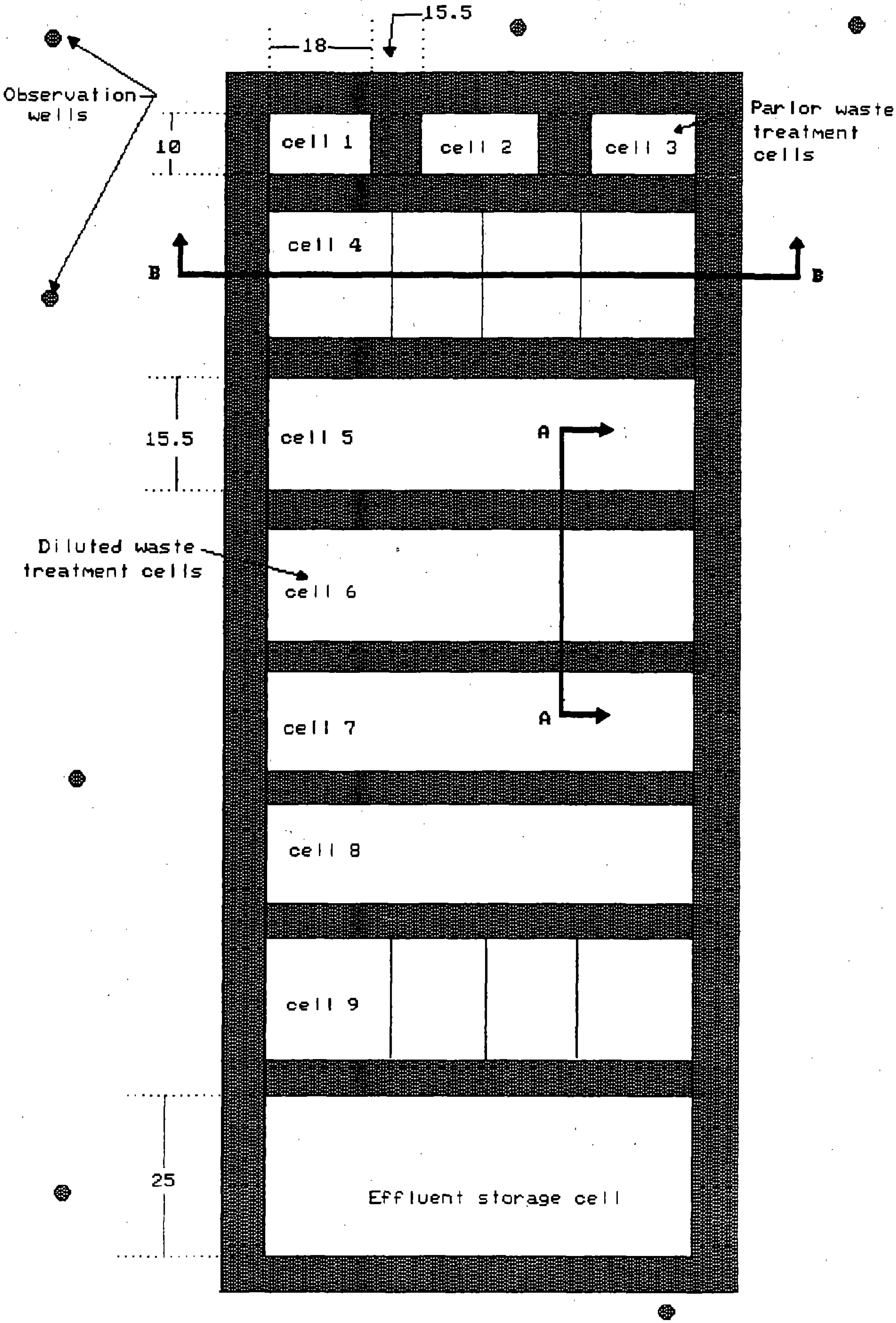

Figure 1: Plan View of OSU Constructed Wetland Cells

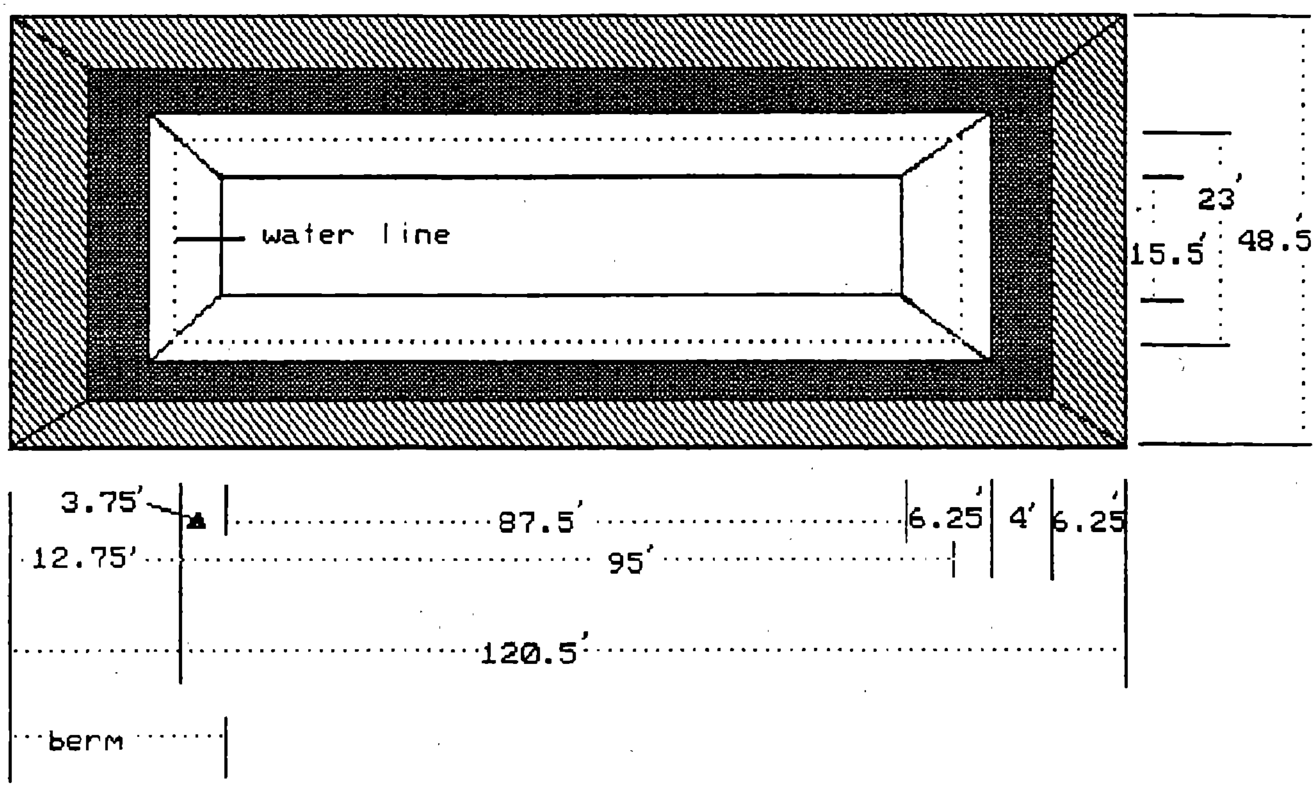

Figure 2: Dimensions of Constructed Cells

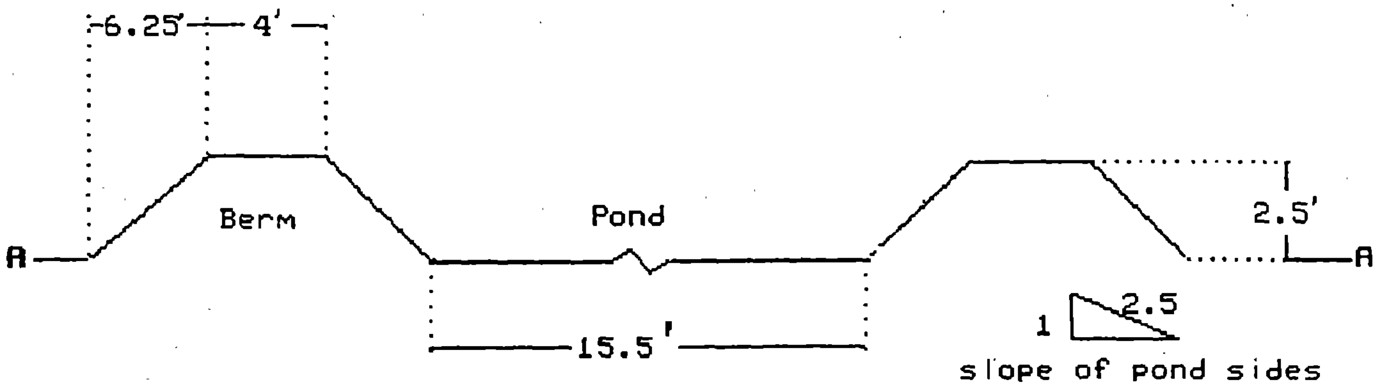

Figure 3: Cross section "A" of wetland cells

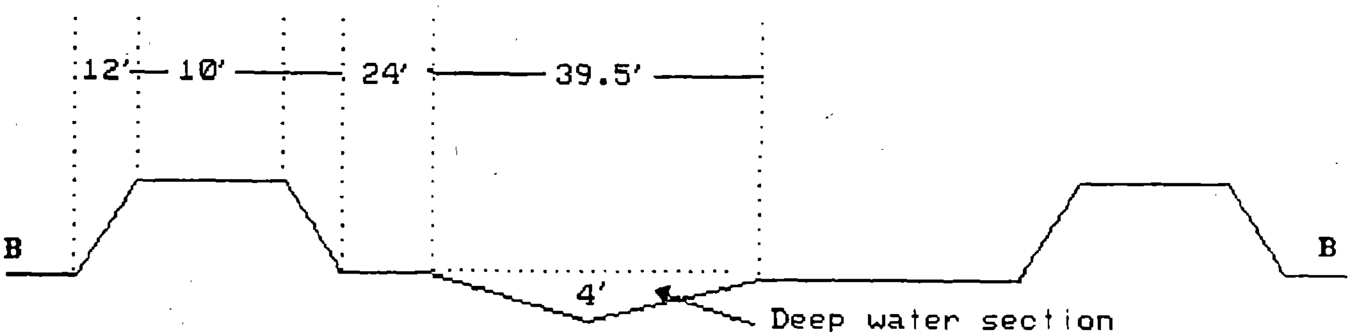

Figure 4: Cross section "B" of wetland cells

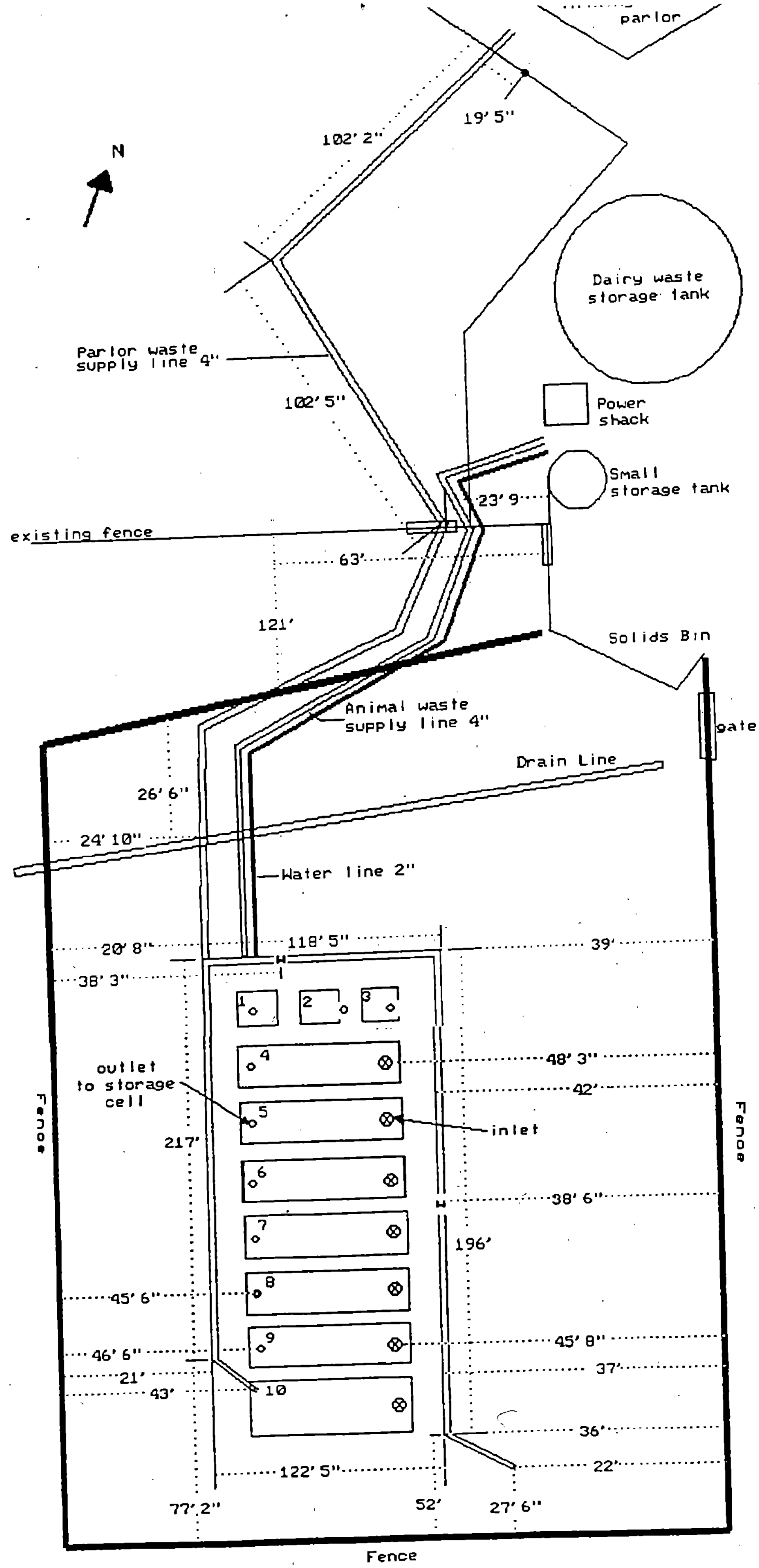

Figure 5: OSU Constructed Wetlands Piping Schematic