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MEMORANDUM

DATE: October 20, 2000

TO: Jim Thomson, HNTB

FROM: Michael A.P. Kenrick, P.E., and Michael J. Bailey, P.E., Hart Crowser

RE: **Sea-Tac Third Runway – Borrow Area 3**
Preservation of Wetlands
J-4978-06

As requested by the Port of Seattle, this memo and the attached figures provide conceptual design and supporting information for the proposed drainage swale to protect wetlands in Borrow Area 3. We also provide a brief explanation of the hydrology that supports the wetlands, including why excavation of Borrow Area 3 will not drain these wetlands. Figure 1 shows the location of Borrow Area 3 to the south of Sea-Tac Airport.

REVIEW OF BORROW AREA 3 WETLAND HYDROLOGY

The first section of this memo provides a review and explanation of the hydrology that currently supports and sustains wetlands in Borrow Area 3. Understanding these hydrologic factors is important in ensuring the long-term preservation of the wetlands during and after excavation of the fill materials contained in Borrow Area 3.

Factors Promoting Preservation of the Wetlands

Existing wetlands and current topography in Borrow Area 3 are shown on Figure 2; the proposed area of mining and resulting contours for final excavation are shown on Figure 3.

The series of wetlands mapped in Borrow Area 3 follow a line of shallow depressions in the southcentral part of the site, extending to the southeast from Wetland 29 through Wetlands B9, 30, B7, B6, and B5. These wetlands exist in an area of relatively permeable subsoils where the main groundwater table is at a depth of 10 to 15 feet below the wetlands. Depth of the water table indicates the wetlands are supported by other sources of water. The sources of water appear to include surficial runoff and shallow interflow, as well as

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groundwater seepage occurring from a perched zone above the main water table that discharges in the area of Wetland 29. Observation wells in the area indicate the perched zone does not contribute flow directly to the other wetlands but, by extension, flow from Wetland 29 appears to pass along the line of wetlands, to each wetland in turn.

The key factors for sustaining wetland hydrology in Borrow Area 3 are (1) ensuring the continued supply of water and (2) preventing the undue loss of water from the wetlands. Wetland hydrology is typically sustained by a combination of hydrologic processes, as shown schematically on Figure 4. The processes supporting wetland hydrology include precipitation (P), groundwater flow (GW) and spring seepage (Sp), runoff (RO), and interflow (IF). Other processes such as evapotranspiration (Et) and deep percolation (DP) lead to the potential loss of water from wetlands. Where wetlands exist, it can be assumed that the sources of water exceed the losses, for at least a large part of the year. Maintenance of the water sources, without increasing the losses, should ensure preservation of the wetlands in perpetuity.

One of the main constraints on wetland development in the area is the relatively high permeability of the surficial soils. In agricultural terms, the surficial soils are identified to be part of the Indianola series (USDA, 1973) and are characterized as being "excessively drained" with "rapid permeability." This is consistent with the predominant soil material in Borrow Area 3 being stratified glacial drift, which is primarily sand and gravel outwash with varying amounts of silt in a predominantly granular matrix.

The overall approach for maintaining wetlands in Borrow Area 3 focuses on preserving or enhancing the existing sources of water, and ensuring that no additional loss pathways are created.

Wetland 29

Wetland 29 is unique in that it occurs on a hillside (see Figure 3). Its existence is attributable primarily to a continuous supply of groundwater that seeps from the hillside at this point. Investigation of subsurface conditions at Borrow Area 3 links this area of seepage with a laterally continuous zone of perched groundwater that extends to the north and west, behind Wetland 29 (Hart Crowser, 1999, see reference list following the text of this memo). In hydrologic terms, the wetland occupies part of a surface seepage discharge area for groundwater flowing through the perched zone, as illustrated in the cross section on Figure 4. Part of the seepage from the perched zone flows into Wetland 29, the rest of the seepage from the perched layer does not appear elsewhere on the surface, so is assumed to percolate down into the shallow regional aquifer in the eastern part of the site where the perching layer has been removed by erosion.

The proposed borrow area excavation to the east of Wetland 29 (Figures 3 and 4) will not interfere with the perching layer behind or beneath the wetland and will, therefore, have no direct effect on the continued discharge of groundwater from the west. An analysis of groundwater flow potentially diverted from Wetland 29 (Hart Crowser, 2000) indicates that excavation could change the seepage gradient and result in a decrease in flow to Wetland 29. Mitigation to address this potential change is discussed below.

Although the base of the Borrow Area 3 excavation will be lower in elevation than most of Wetland 29, excavation will occur in predominantly permeable soils that are above the water table. These existing permeable soils already provide a drainage pathway for seepage losses from the wetlands. The persistence of the wetlands despite the presence of permeable soils and a relatively deep water table demonstrates that wetlands will not be drained by the adjacent excavations.

Other Wetlands

Water in Wetland 29 is primarily lost by percolation to the underlying aquifer and evapotranspiration. A portion of the water flowing through Wetland 29 is inferred to move downslope as interflow or shallow subsurface flow to feed successive wetlands that trend southeastward from Wetland 29, occupying a series of shallow depressions (see Figure 3 - note that this flow is out of the plane of the cross section on Figure 4). This inference is based on the topographic position of the adjacent wetlands and the absence of other sources of water. Flow appears to move from one wetland to the next, and some water is likely lost as deep percolation into the permeable subsurface soils that underlie most of the site, including the wetlands. Some additional water probably comes as surface runoff or interflow from the surface catchments feeding each wetland.

According to the Wetland Delineation Report (Parametrix, 1999) and supporting Field Data Sheets, the wetlands in Borrow Area 3 typically feature 10 to 12 inches of "black muck" - a fine-grained richly organic soil that appears to help the ponding of water in the wetland, and likely retains saturation of the root zone rather than allowing much of the water to percolate downward. The concept is illustrated on Figure 5, which is a cross section through Wetland 30.

Note that Wetlands 30, B7, B6, and B5 appear to exist beyond the main perching layer. It is possible that these wetlands formed on locally silty (less permeable) zones in the predominantly granular soil, promoting shallow perched conditions that sustain the wetland hydrology. As evidence of this, Wetland B7 is reported to have a seasonally high water table that would be 10 to 15 feet above the main groundwater table in the underlying relatively permeable shallow regional aquifer. As a result, excavation of the perching layer northeast of Wetland 29 would not have any direct impact on the other wetlands in Borrow Area 3 provided flow into Wetland 29 is maintained as described below.

Proximity of Excavations

The Port proposes that excavations of Borrow Area 3 (see Figure 3) will leave at least a 50-foot buffer around the wetlands. Excavation to the east of the wetlands will proceed to approximate elevation 233 to 235 feet, whereas the wetlands themselves are at approximate elevations 236 feet (Wetland 30) and 235 to 238 feet (Wetlands B6 and B7), see Figures 5 and 6. The hydrology of these wetlands will not be adversely impacted by the excavations because:

- The wetlands already exist over permeable subsoils;
- The buffer will be retained, preventing any lateral "short circuit" flowpath that could divert water from the wetlands and into the borrow site excavation; and
- Base elevations of the proposed excavations are at most only a foot or two lower than the lowest point in these adjacent wetlands.

Wetland B5 is at about elevation 230 feet, well below the proposed excavation. Wetlands B9 and 29 are upslope of the proposed excavation and would be protected against any potential loss of water by the proposed mitigation discussed herein. Wetland B10 is upslope of the perched zone and, therefore, would not be impacted by changes in perched zone flow.

Potential Loss of Surface Flows

In some areas of the buffer zone between the wetlands and the proposed excavation, there may be localized low spots that provide a potential pathway for overland flow to occur from the wetland into the excavation at periods of exceptionally high water levels. If erosion occurs during periods of high water in the wetlands, formation of gullies could divert increased surface flows from the wetlands into the excavations. Erosion will be prevented by preserving existing vegetation in the wetland buffer areas and revegetating the excavated area in accordance with Washington Department of Natural Resources reclamation criteria. However, if erosion threatens the wetland floor, mitigation could easily be accomplished. The Port has proposed a period of wetland monitoring following excavation of the borrow site. If necessary during or after excavations, berms or other erosion protection will be constructed outside the wetland buffer and on the edge of the excavations to prevent overland flow occurring from the wetland depressions into the adjacent excavation. This element of the mine plan will depend on field surveying for elevation control of the land-surface profile along the buffer zone, reclamation of the site to a stable condition, and monitoring after reclamation, which the Port has already committed to.

DRAINAGE SWALE DESIGN

The remainder of this memo addresses the design of a drainage swale that will provide additional water to Wetland 29 to replace the potential loss of seepage from the perched zone.

As described in Hart Crowser (2000), groundwater modeling suggests the possibility that mining will produce a small change in the groundwater flow regime within the perched zone that feeds Wetland 29. Modeling suggests increased drawdown in the perched zone due to excavation in the Borrow Area 3 (see Figure 3) could cause a shift in the seepage gradient. This change in gradient could reduce groundwater flow by a maximum of about 20 percent of the current flow to Wetland 29, or about 400 ft^3/day (roughly 2 gallons per minute). The Port proposes to mitigate this potential indirect impact by collecting groundwater seepage in a swale along the western slope face of the excavation (see Figure 3) and diverting this to Wetland 29.

Overall Concept for Drainage Swale

The proposed drainage swale is designed to collect groundwater seepage from the excavated slope face on the north and west sides of Borrow Area 3, as depicted on Figure 3. The groundwater seepage represents natural flow from the perched zone that is forced to discharge at the cut slope face, as described in detail in Hart Crowser (2000). The flow will be collected and conducted southward in a swale that drains into Wetland 29. Grades along the swale are expected to be between about 1 and 2 percent. A schematic profile along the drainage swale is shown on Figure 7. Modeling shows there is about 2,400 ft^3/day of groundwater flow available compared to projected maximum loss to Wetland 29 of 400 ft^3/day (Hart Crowser, 2000). There is more than enough seepage flow available to make up any loss in the natural perched zone groundwater flow to Wetland 29.

Adaptive Design Approach

The detailed design and construction of the drainage swale will be modified as needed to take account of field conditions revealed during the excavation of Borrow Area 3. For example, the swale could be lined with HDPE (see Figure 6) if needed to prevent loss of flow in the event soils encountered during construction are more permeable than indicated by the borings. Design, construction, operation, and maintenance issues are described under the following headings.

Typical Cross Section

The typical cross section for the proposed drainage swale is shown on Figure 6(a). This cross section presupposes that a sufficient thickness of natural low-permeability soils (the lateral extension of the perching layer) will be present in the upper part of the bench holding the swale.

Prevention of Leakage

To allow for potential variability in the surface elevation or thickness of the perching zone, the design assumes the invert of the swale may extend below the base of the perching horizon in places, in order to maintain the design slope of 1 to 2 percent. If the perching horizon is thin or even be eroded away in places, this will be revealed as excavation of Borrow Area 3 occurs and the intersection of the perching layer with the final cut slope becomes visible. In the event that field mapping during excavation shows insufficient low-permeability soil is present to form the required subgrade for the unlined drainage swale, the swale grade or alignment could be modified, and/or an impermeable lining (protected by gravel) would be used in the base of the swale to prevent seepage loss, as shown on Figure 6(b).

Control of Excess Flows

The position of the drainage swale at mid-slope around the northern and western sides of Borrow Area 3 will cause the swale to collect surface water runoff during high precipitation. Some precipitation upslope of the swale is likely to infiltrate but may appear as shallow interflow or perched water and contribute to seepage in the swale. Also, if constructed to its full length as shown on Figure 3, the swale is expected to collect more than enough groundwater seepage to make up for the projected maximum loss in flow from Wetland 29.

Two measures are available to deal with these anticipated excess flows:

1) A flow-control structure will be constructed in the course of the swale before it enters Wetland 29 (see Figure 9); and
2) The length of the swale can also be modified (at time of construction, or after some period of post-construction monitoring) to control the amount of seepage (and runoff) that is collected and diverted to Wetland 29.

The proposed flow control weir or diversion structure will be designed to provide a consistent low flow of seepage into Wetland 29 and enable diversion of excess flow in the drainage swale away from Wetland 29. The excess flow will be diverted along a channel and into the base of Borrow Area 3, where it will infiltrate and/or be handled by the stormwater facilities for managing runoff from the remainder of the borrow area.

The flow control structure will be constructed of reinforced concrete. As illustrated on Figure 9, it will include a narrow flow slot at the lower elevation to enable a continuous low flow from the drainage swale into Wetland 29. The second part of the flow control structure will include a broad overflow weir that will allow water to spill over into a diversion channel during periods of higher flow in the swale. Flow through both the narrow slot and the broad weir will be controlled with adjustable boards as shown on Figure 9. Flow to Wetland 29 will be fine-tuned during the initial maintenance period (following construction) by adjusting the height of the boards placed in each part of the structure. Final flow levels may then be fixed by replacing the boards with masonry at the end of the monitoring period.

Construction

Construction of the drainage swale will be integrated with the mining and reclamation plan for the excavation of Borrow Area 3. This will prevent over-mining of the perching layer in close proximity to the final slope contours for the excavation. Mining will progress from the highest area of the site in the northwest part of Borrow Area 3, working down the slope and reclaiming the upper part of the final cut slope as excavation proceeds. The perched zone will be encountered as wet areas at the base of the working slope. Mining will then step in approximately 20 feet to allow the bench for the drainage swale to be formed in the perching layer beneath the perched zone.

The next stage will be to excavate within the bench width to cut the swale into the perched zone and underlying perching layer. The bench will be cleaned off and graded to form the swale, which will be constructed per the typical cross section. This will provide the opportunity to determine from field surveying the elevation, profile, and thickness of the perching layer in the area of the final slope. The final design of the swale invert elevations and cross sections will then be adjusted as required to best match subsurface conditions and topography, facilitating final construction the swale at the required elevation on the bench. Mining will then proceed into the lower part of the slope below the drainage swale.

Surface Protection and Reclamation

Reclamation of the borrow area will be accomplished in accordance with Washington Department of Natural Resources criteria and the Port of Seattle landscape plans. Once final grades have been established, the drainage swale and adjacent slopes will be protected from erosion using the same techniques demonstrated to be effective by the embankment construction to date. The excavation slopes will be dressed and hydroseeded with a bonded fiber matrix. The swale will be protected with erosion control matting until grass is established as part of the post-excavation site reclamation.

Operation and Maintenance

Operation of the swale, and particularly the flow control structure, will require monitoring and recordkeeping for an initial period of about two to five years. During this period, the amount of seepage and operation of the flow control weir will be monitored. The weir height may be adjusted to ensure stable and appropriate flows to Wetland 29, which are consistent with plant and ecological requirements of the wetlands.

Long-term operation and maintenance of the swale will be restricted to periodic (annual) inspections of the facility to check the basic integrity of the swale and look for signs of erosion or blockage that could require remedial work by Port grounds maintenance staff.

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Attachments:
References
Figure 1 - Site Location Map
Figure 2 - Pre-Excavation Topography and Wetlands – Borrow Area 3 Perched Zone
Figure 3 - Post-Excavation Topography and Drainage Facilities - Borrow Area 3 Drainage Swale
Figure 4 - Cross Section A - A' through Wetland 29
Figure 5 - Cross Section B - B' through Wetland 30
Figure 6 - Cross Section C - C' through Wetland B6
Figure 7 - Drainage Swale – Profile D-D'
Figure 8 - Typical Cross Sections E-E' - Borrow Area 3 Drainage Swale
Figure 9 - Flow Control Structure Schematic - Borrow Area 3 Drainage Swale

REFERENCES

Hart Crowser, Inc., 1999. Subsurface Conditions Data Report, Borrow Areas 1, 3, and 4, Sea-Tac Airport Third Runway. Prepared for HNTB and the Port of Seattle, September 24, 1999 (J-4978-02).

Hart Crowser, Inc., 2000. Evaluation of Perched Zone Interception and Possible Impacts to Wetland Hydrology, Borrow Areas 3, Sea-Tac Airport Third Runway. Prepared for HNTB and the Port of Seattle, September 12, 2000 (J-4978-13).

Parametrix, Inc., 1999. Wetland Delineation Report, Seattle-Tacoma International Airport, Master Plan Update Improvements. Prepared for Port of Seattle, August 1999.

USDA, 1973. Soil Survey, King County Area, Washington. United States Department of Agriculture, Soil Conservation Service, 100 pp. November 1973.

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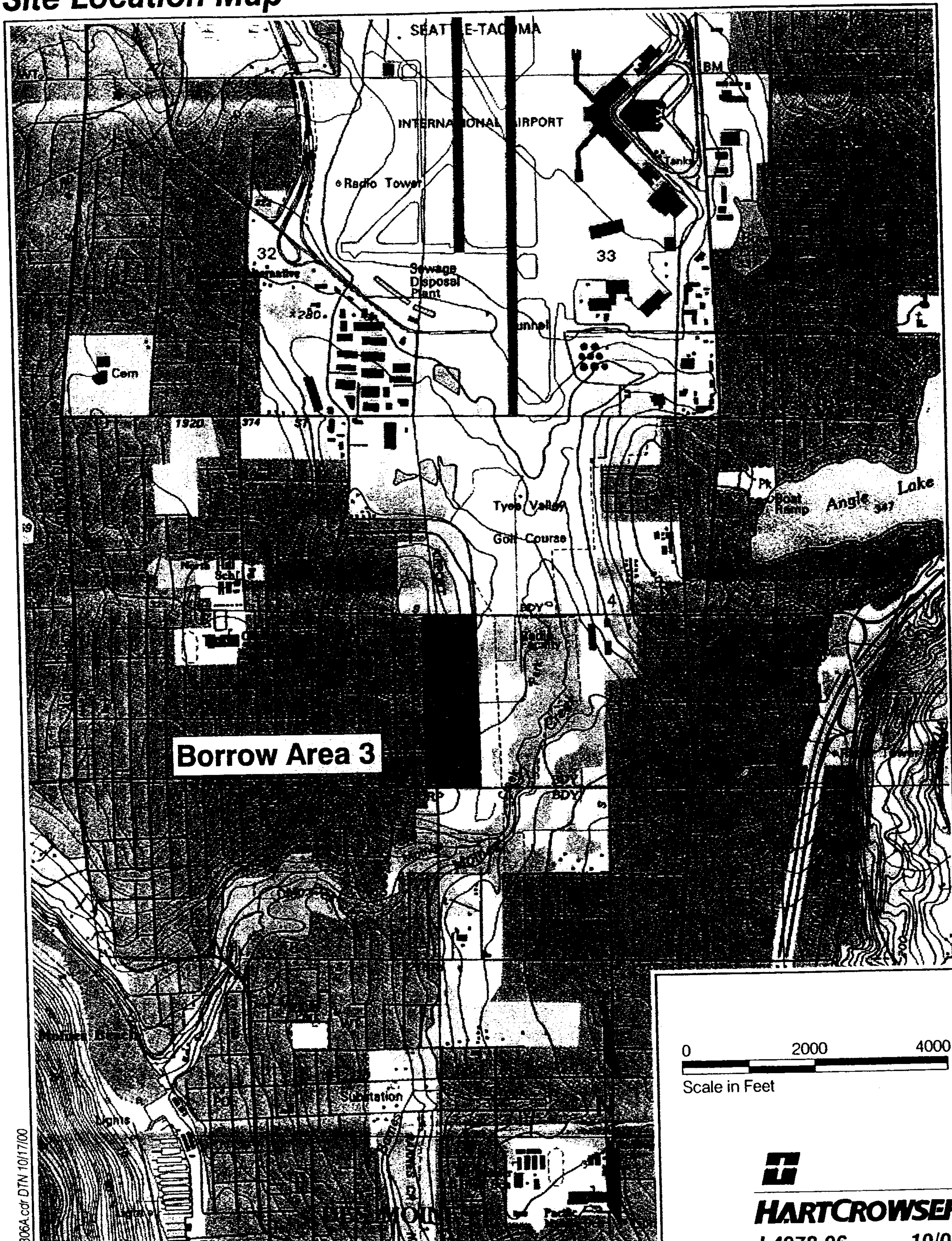
Site Location Map



Note: Base map prepared from USGS 7.5 minute quadrangle maps of Seattle South, Washington, revised 1995.

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Figure 1

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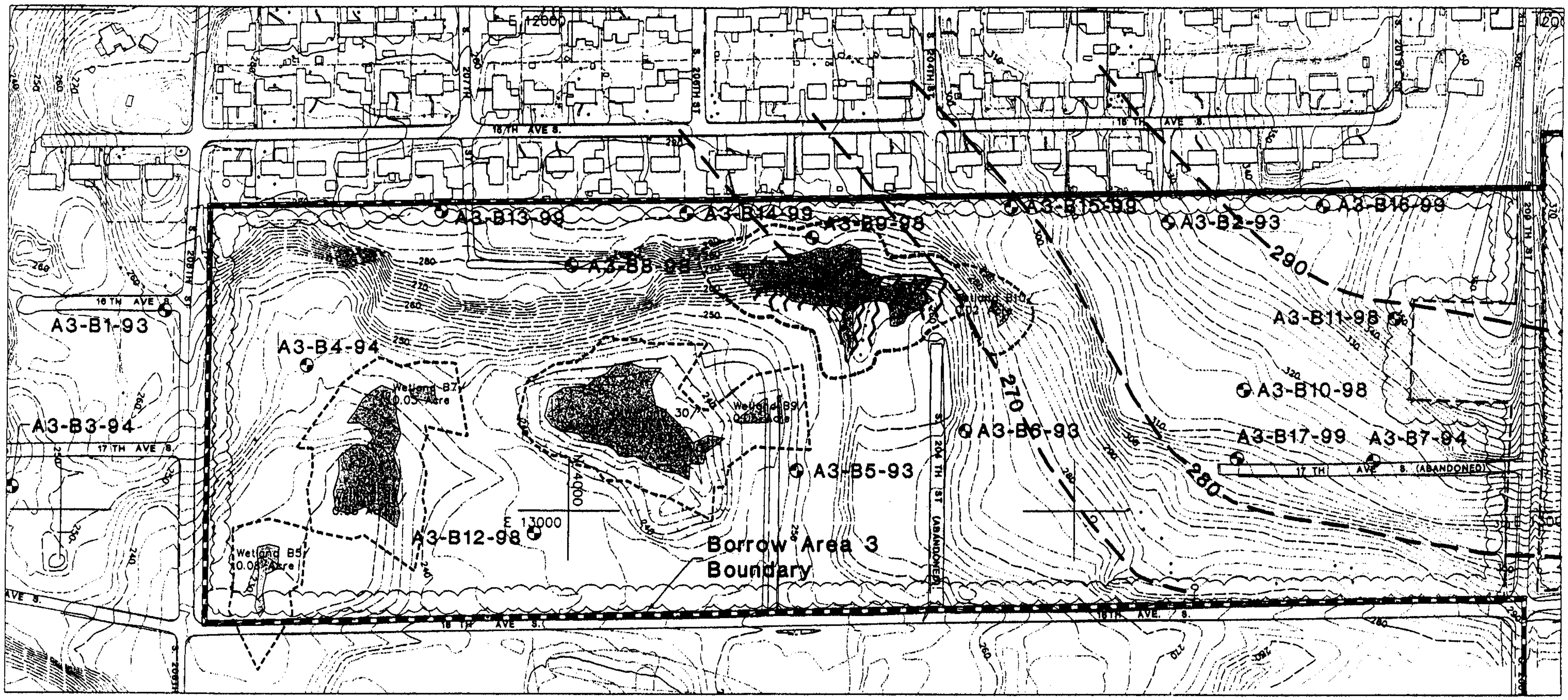
Pre-Excavation Topography and Wetlands

Borrow Area 3 Perched Zone



A3-B4-94 Exploration Boring with Monitoring Well

280 Perched Zone Groundwater Elevation Contour in Feet

Wetland Location, Designation, Acreage, and 50-foot Wetland Buffer (Based on Parametrix, 1999)

Inferred Seepage Face

0 200 400
Scale in Feet

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Figure 2

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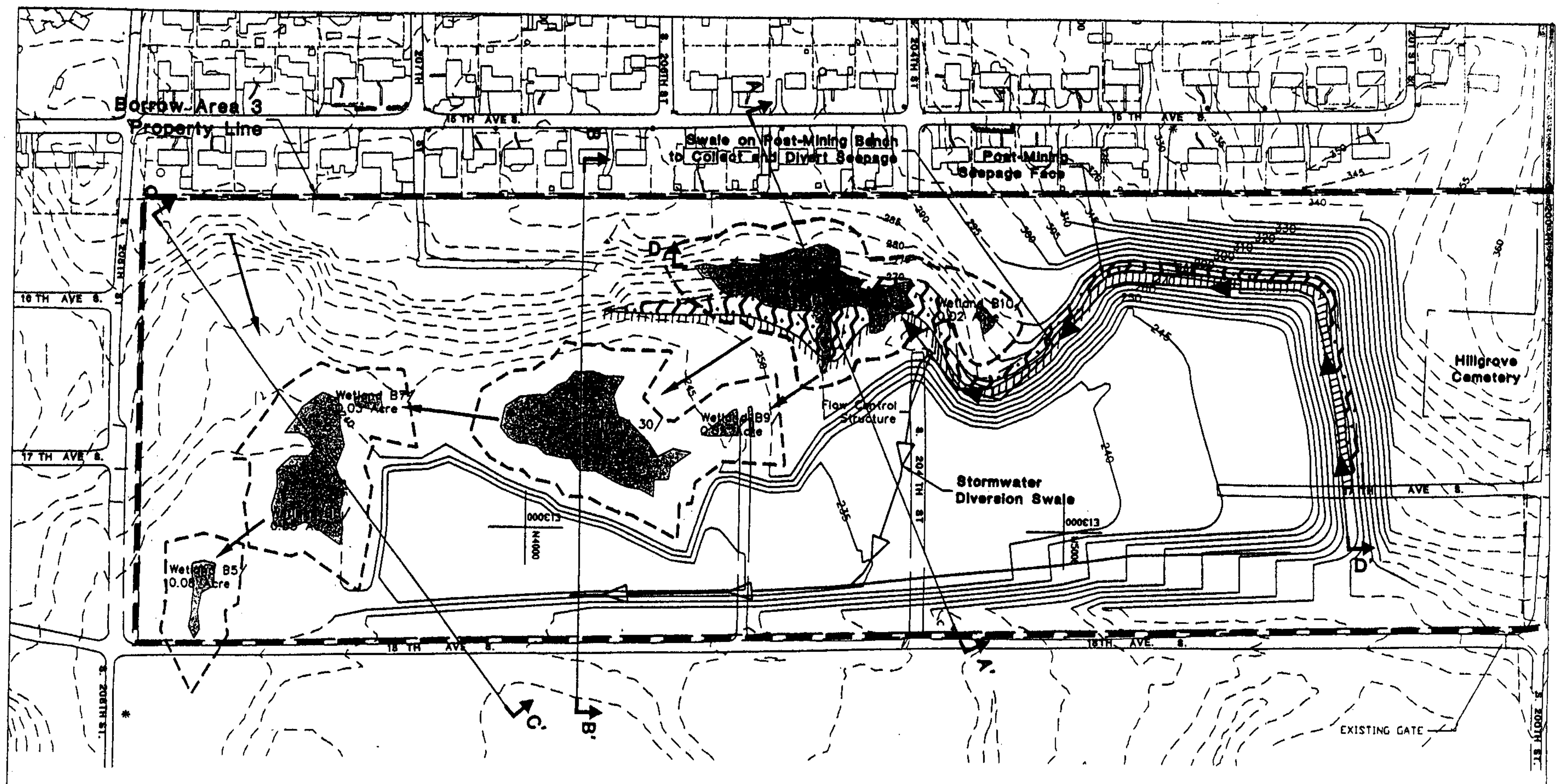
Post-E ᴚvation Topography and Drainage Facilities
Borrow Area 3 Drainage Swale



——240—— Proposed Elevation Contour in Feet

– – – – 50-Foot Wetland Buffer

Wetland B5 0.08 Acre — Wetland Location, Designation, and Acreage

⟵ Direction of Surface/Shallow Subsurface Drainage

Inferred Seepage Face above Outcrop of Perching Layer

AA' Cross Section/Profile Location and Designation

N

0 200 400
Scale in Feet

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Figure 3

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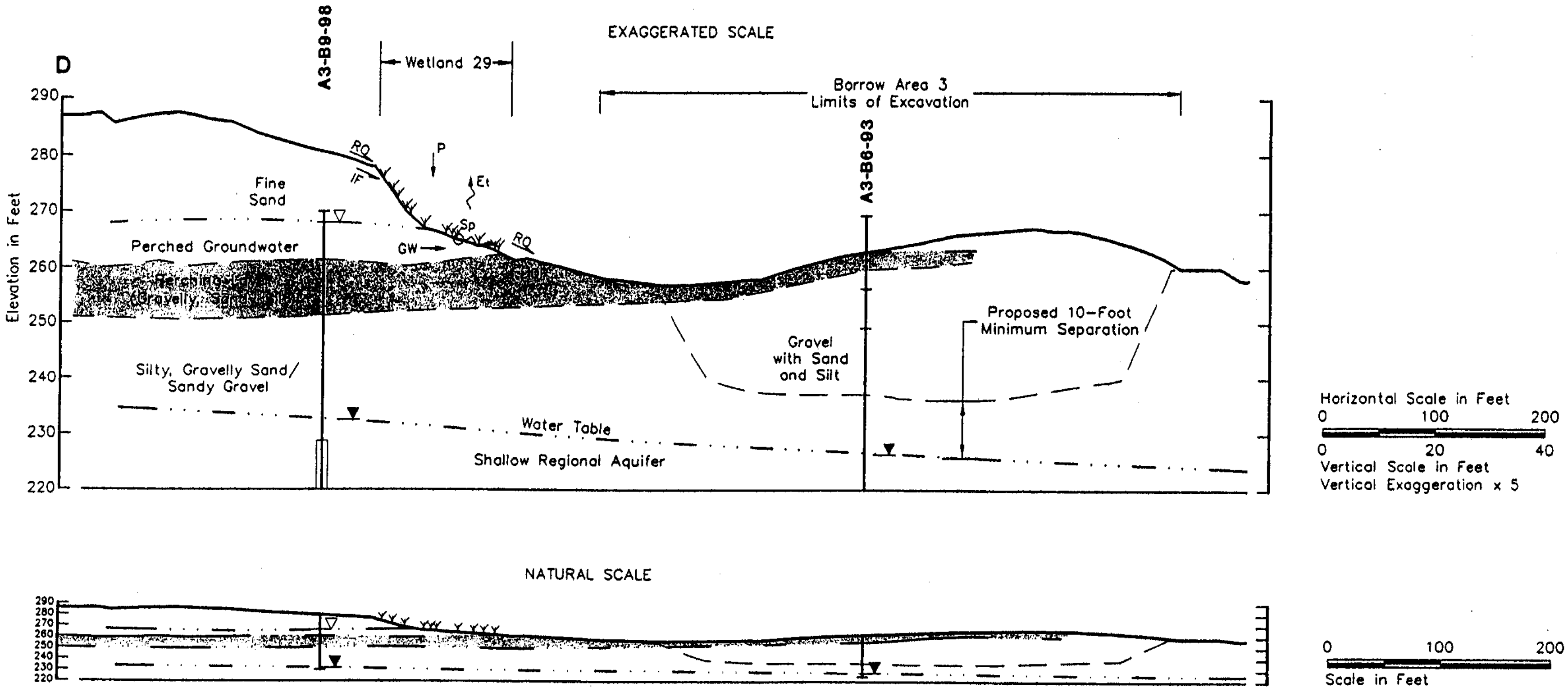
Cross Section A-A' through Wetland 29

Looking North



Note: Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.

<u>Wetland Hydrology</u>

Inflows:
- P Precipitation
- RO Runoff
- IF Interflow
- Sp Springs or Seeps
- GW Groundwater

Outflows:
- Et Evapotranspiration
- DP Deep Percolation

A3-B8-98 Exploration Number

Exploration Location.

Perched Water Level

Shallow Aquifer Water Level

Screened Interval

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Figure 4

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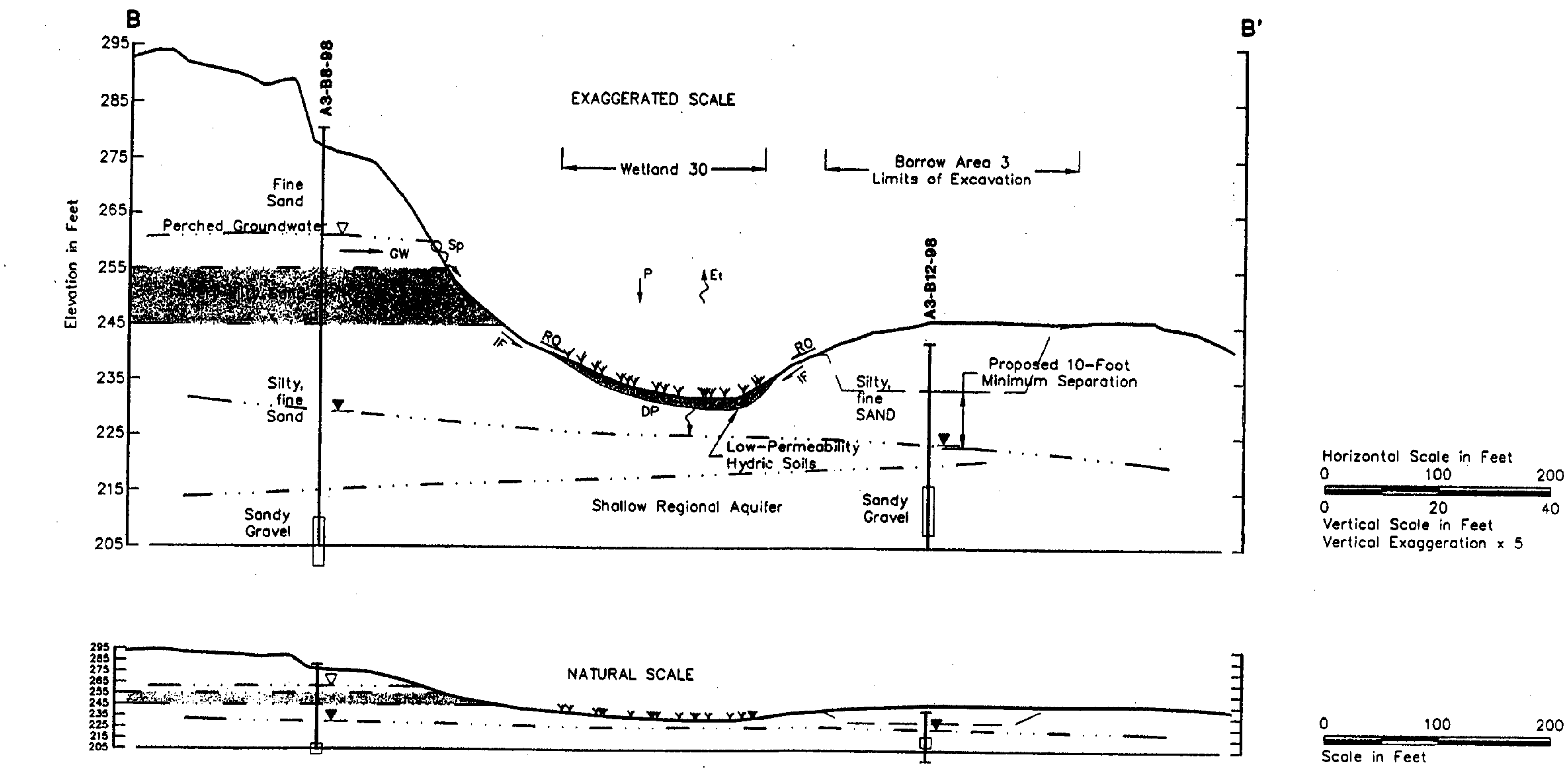
Cross   ction B-B' through Wetland 30

Looking North



Note: Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.

Wetland Hydrology

Inflows:
- P Precipitation
- RO Runoff
- IF Interflow
- Sp Springs or Seeps
- GW Groundwater

Outflows:
- Et Evapotranspiration
- DP Deep Percolation

A3-B8-98 Exploration Number

Exploration Location

Perched Water Level

Shallow Aquifer Water Level

Screened Interval

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Figure 5

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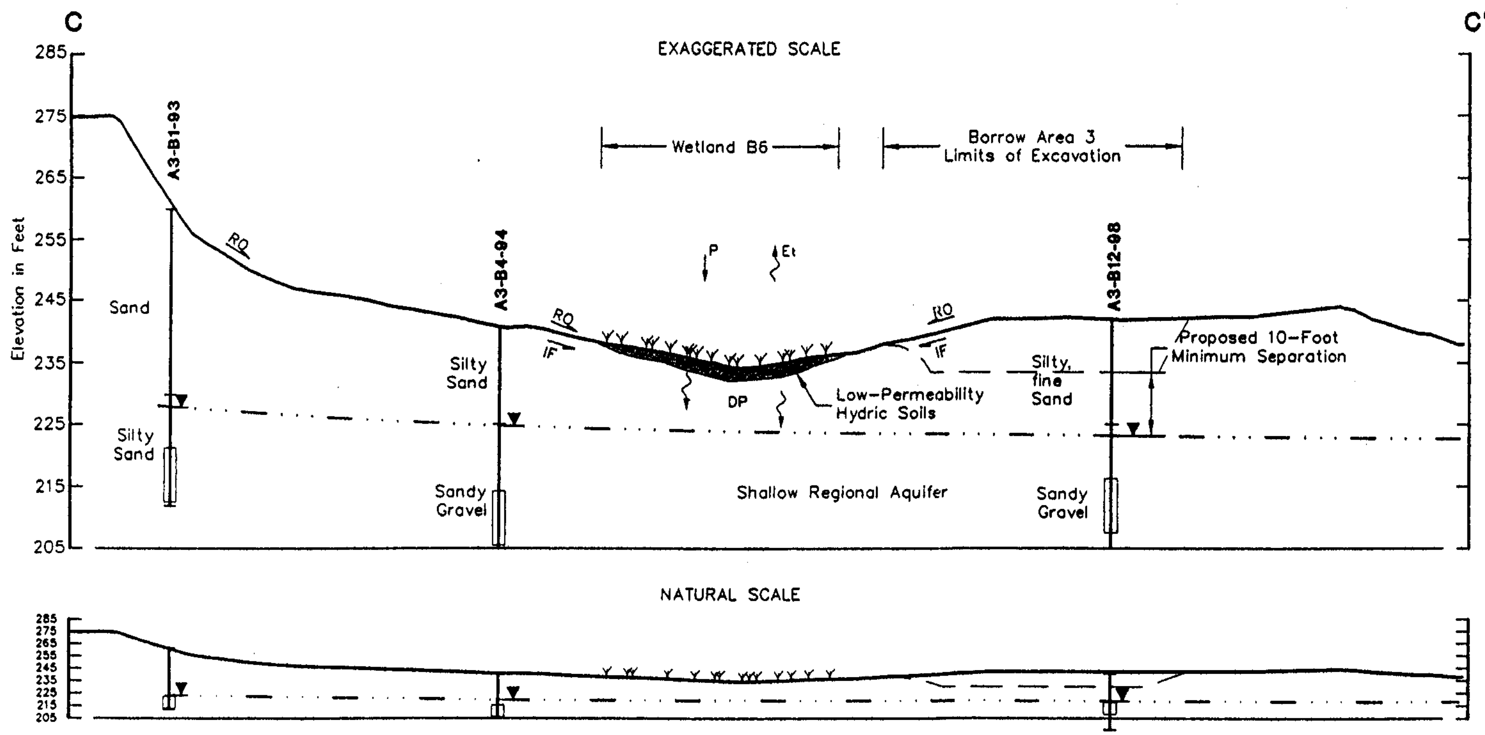
Cross Section C-C' through Wetland B6

Looking North



Horizontal Scale in Feet
0 100 200

0 20 40
Vertical Scale in Feet
Vertical Exaggeration x 5

0 100 200
Scale in Feet

Note: Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.

Wetland Hydrology

Inflows:
- P Precipitation
- RO Runoff
- IF Interflow
- Sp Springs or Seeps
- GW Groundwater

Outflows:
- Et Evapotranspiration
- DP Deep Percolation

A3-B8-98 Exploration Number

Exploration Location

Perched Water Level

Shallow Aquifer Water Level

Screened Interval

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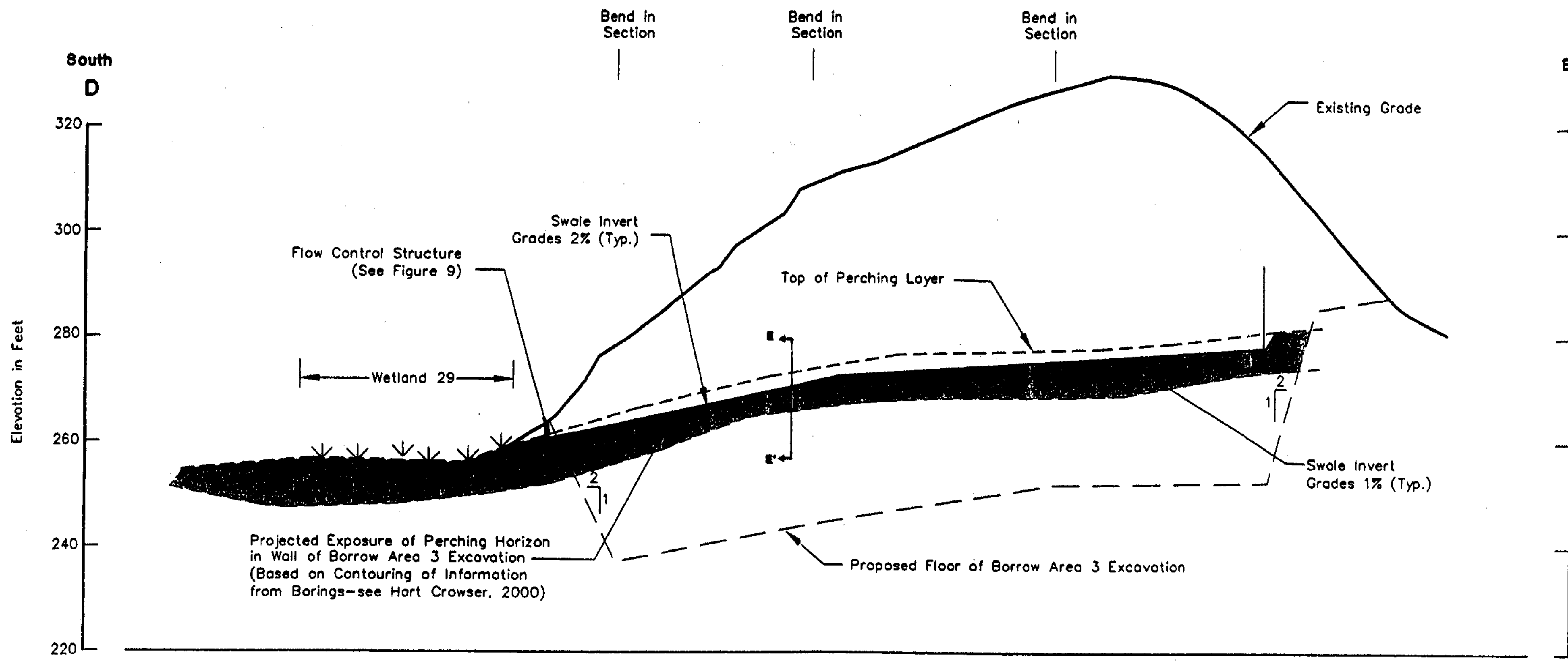
Figure 6

Drainag Swale - Profile D-D'

Borrow Area 3



Note: Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.

Horizontal Scale in Feet
0 200 400
0 20 40
Vertical Scale in Feet
Vertical Exaggeration x 10

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Figure 7

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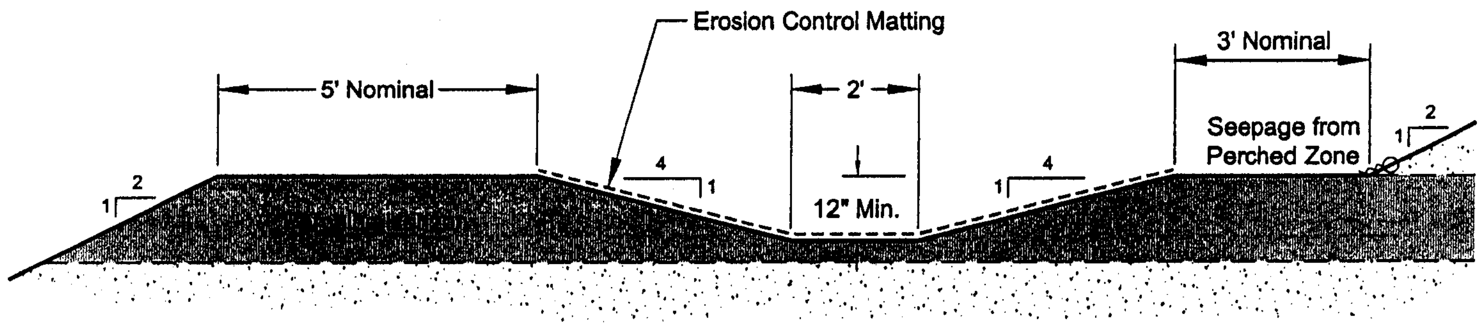
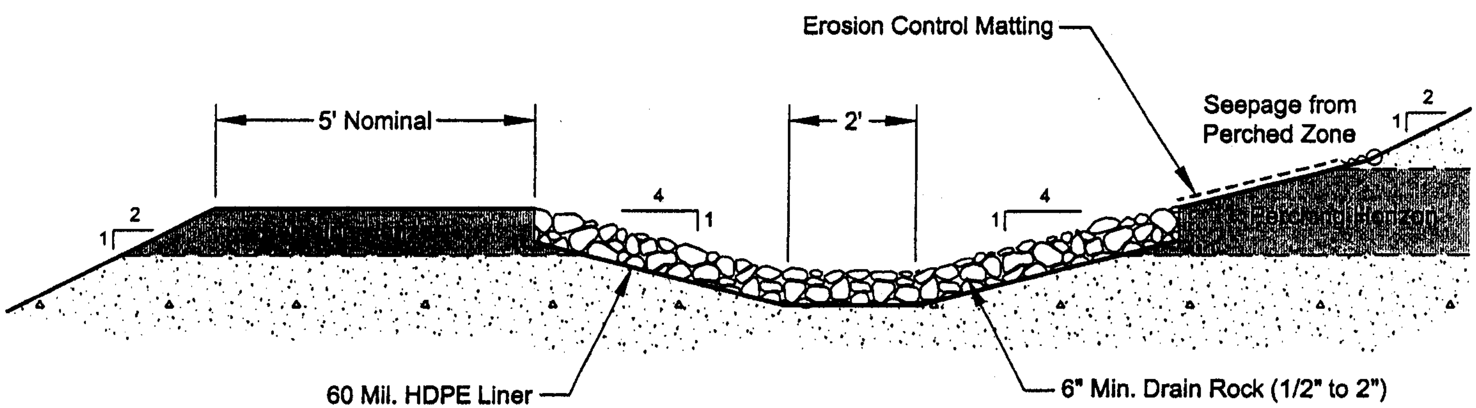
Typical Cross Sections E-E'

Borrow Area 3 Drainage Swale



(a) DRAINAGE SWALE (TYPICAL)

Not to Scale



(b) LINED DRAINAGE SWALE (AS NEEDED)

Not to Scale

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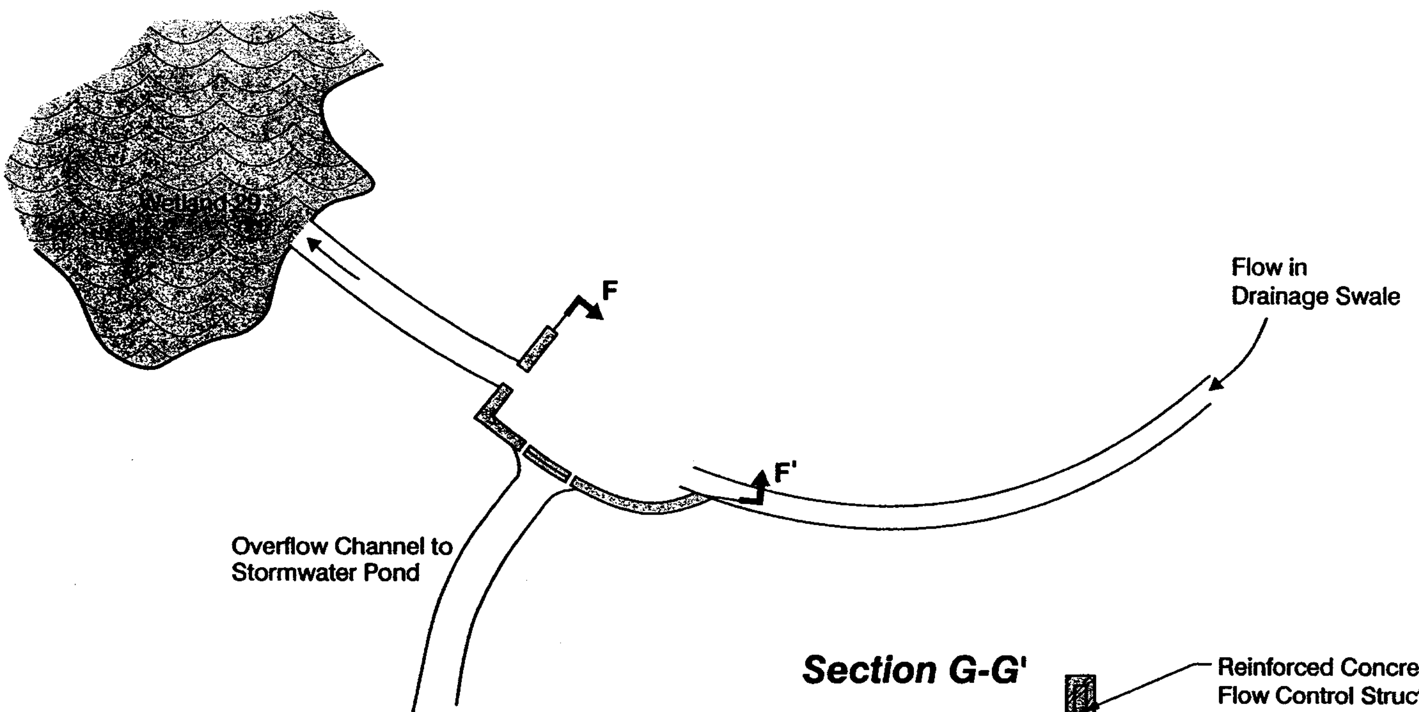
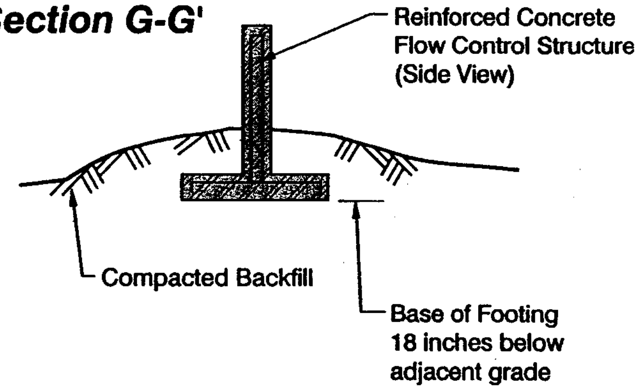
Figure 8

Flow Control Structure Schematic

Borrow Area 3 Drainage Swale



Section G-G'



Elevation F-F'

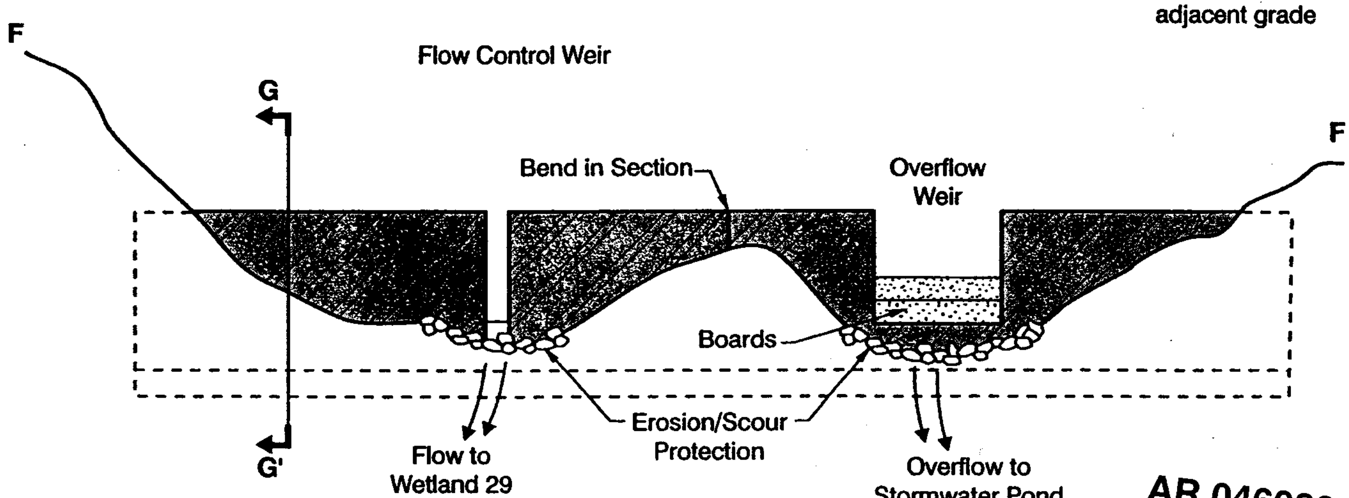


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Figure 9