Channel-Pool-Mound (C-P-M) Design Detail

The previously described **tidal wetland** design is intended to duplicate the natural **c-p-m** complex as exists in salt marshes in the area. Channels will be cut into the tidally influenced area beginning from two separate infalls at the Ship Channel, and terminating within the center of the work area. They will weave similar to natural channels at a depth varying from 1 to 2 feet. Small "sedimentation" pools of at least 6' in depth will also be dug contiguous to the channels imitating natural eddies.

First, any of the "O" horizon (organic layer) of the soil to be removed that is vegetated will be saved as seedbank/topsoil material. Then, a large trackhoe will cut the channels and pools.

Current elevations will remain in the mound areas where the extant contours are very near those of the final grade desired. The objective is to increase aquatic habitat complexity (which also aids in stability) of the new wetland system resulting in a unique and valuable habitat.

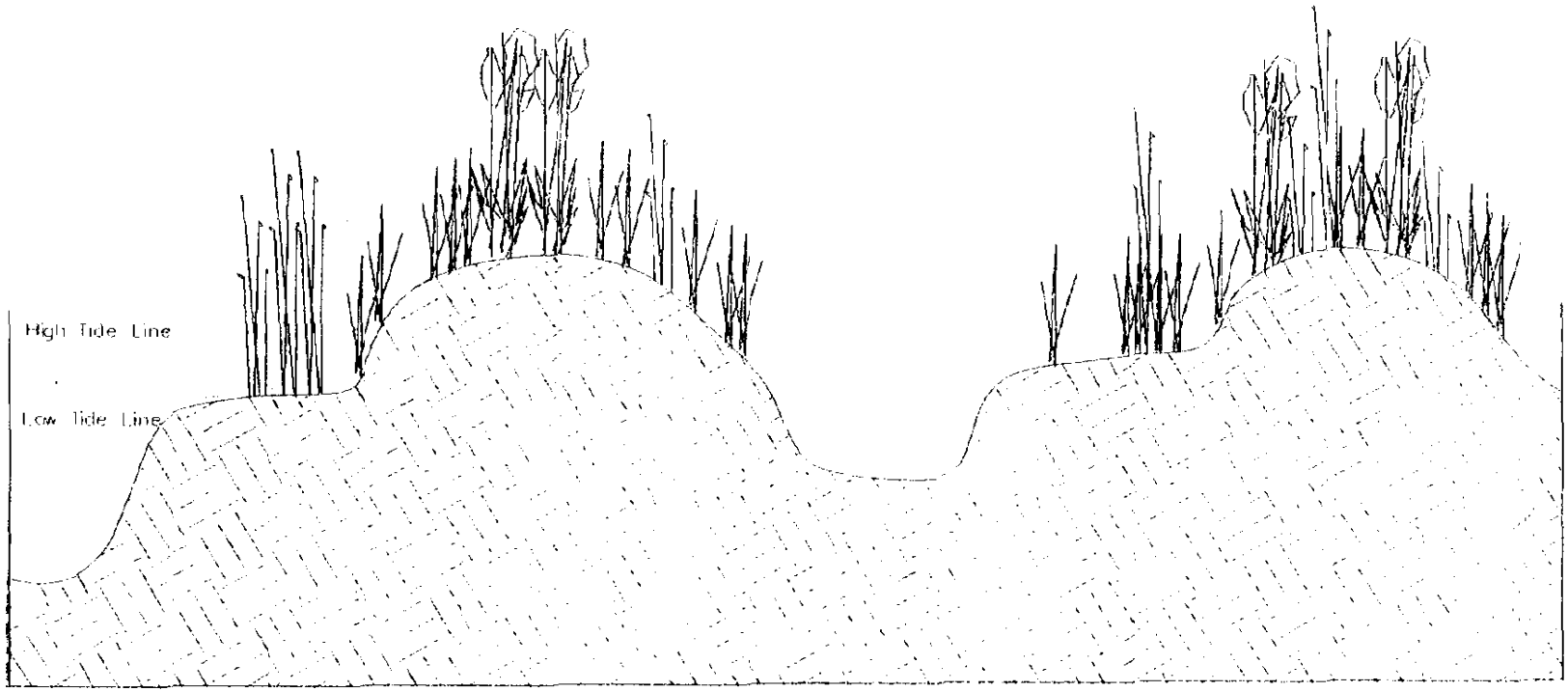
As the **C-P-M Cross Section** drawing (directly following on page 27) indicates, each side of the channel will have a final elevation approximating the low tide line. This will result in less volume of open water and a greater amount of planted wetland shelf.

The previously removed "O" horizon will be placed upon the mounds and shelves and then replanted by hand with *Spartina alterniflora* and various mature plants from within the tract boundaries. These higher mounded areas may provide bird nesting habitat through protection from predation.

Summary: The **c-p-m** criteria specifies future sedimentation capacity, correct elevation of planting shelves, and central cores of "avoided" parent soil material where possible in order to prevent erosion.

Quality of Tidal Waters: Additional Restoration credit of 1 acre is calculated due to the specification included for blocking the current tidal inflow of low quality brackish water from the adjacent shipyard. The new inflow point directly from the Ship Channel will be duplicated at the opposite end of the enlarged tidal zone, in order to provide circulation for enhancement of dissolved oxygen.

Constructed Channel Cross Section



NOTES:

1. TWO CHANNELS TO BE CUT FROM THE EXISTING SHIP CHANNEL IN THE NORTHWEST CORNER EASTWARD TO AS NEAR THE PIPELINES AS PRACTIBLE.
2. CHANNEL WILL VARY IN DEPTH FROM 1' TO 2', AND IN WIDTH FROM 5' TO 20' WITH SMALL POOLS TO BE EXCAVATED ADJACENT TO THEM.
3. MOUNDS AND SHELVES WILL BE REPLANTED BY HAND WITH MATURE PLANTS AFTER RECEIVING DEPOSITED SEED BANK.

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Tidally Influenced Project
Channel-Pool-Mound
Cross Section Detail

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11-14-94	MM-3

Pipeline Work Plan Details

During design consideration of the 33 acre wetland construction site, two adverse conditions existed; namely the presence of some metal scrap, and of pipelines crossing the 17 acre tidally influenced project site.

A suitable **Work Plan Methodology** to incorporate surface removal where planned, and avoidance and/or crossing of the pipelines; is as follows:

Description of Work Plan Details--

Stored Metal Material: Most of the primary 17 acre site contains little or no stored metal material; however the upland area adjacent to the current outfall ditch, and some of the Freshwater project site contains metal piping, vessels, and other buried metal materials.

Construction Work Methodology: Large metal items on the surfaces to be excavated (work area) will be removed and hauled away from the constructed wetland sites prior to beginning excavation to design elevations.

Pipeline Locations: The primary (**17 acre Tidal Project**) work area is crossed in two directions by chemical product pipelines; one set of pipelines is administered by **Chevron Pipeline Company,** and the other by **Amerada Hess Corporation** as shown on the attached map (page 34).

The Chevron set extends from the south boundary directly across the planned work area adjacent to the existing tidal pool. The Amerada set follows the south boundary to the existing inlet channel, crosses under the channel, then continues on the same line to the existing upland area, and then dog-legs northward to the Houston Ship Channel.

Construction Methodology for the Chevron Pipeline Set: The multiple lines enter the ground at the eastern edge of the tidal pool, and travel northward directly from the pool edge under the existing outfall channel to the Ship Channel beach. This area falls within the section designed to be left at the current elevation as an island. As Chevron previously excavated to a depth that located the lines under the current tidal pool level, no special methods are required to avoid them after they are marked by Chevron personnel (provided that the buried depth of the lines does not rise within the work area).

Construction Methodology for the Amerada Pipeline Set: Where the Amerada lines follow the south boundary and cross under the existing saltwater inlet; no special work methods are needed other than to avoid the lines as located by Amerada personnel.

However, where the lines dog-leg northward crosses a major excavation area of the designed project. As indicated on the following attached map, the area of concern rises in elevation to the extent that soil removal to design elevations will either expose the lines or bring the surface level very close to them.

These impacts were discussed by telephone several times with Mr. Vance Rannells of Amerada, including providing him with a copy of the color map showing the intended work area. He subsequently referred to Mr. Andrew Zizinia who provided the details necessary to determine the final work methods. According to Mr. Zizinia, Amerada personnel will locate the exact pipeline placement by inserting rods into the ground until they strike the pipes to find the exact depth. They will then stake the locations, and mark the depths on the stakes.

The heavy construction equipment used for excavation will be directed to work at the sides of the pipeline set, without traveling on or excavating across them. The linear area covering the Amerada lines is planned to be left at current elevation by careful excavation along its' edges (operators are to be supervised by Amerada). The lines are buried at a depth such that the remaining higher ground may become the future access roadway. The weight limit of the roadway will be restricted to pick-up sized trucks and small maintenance equipment.

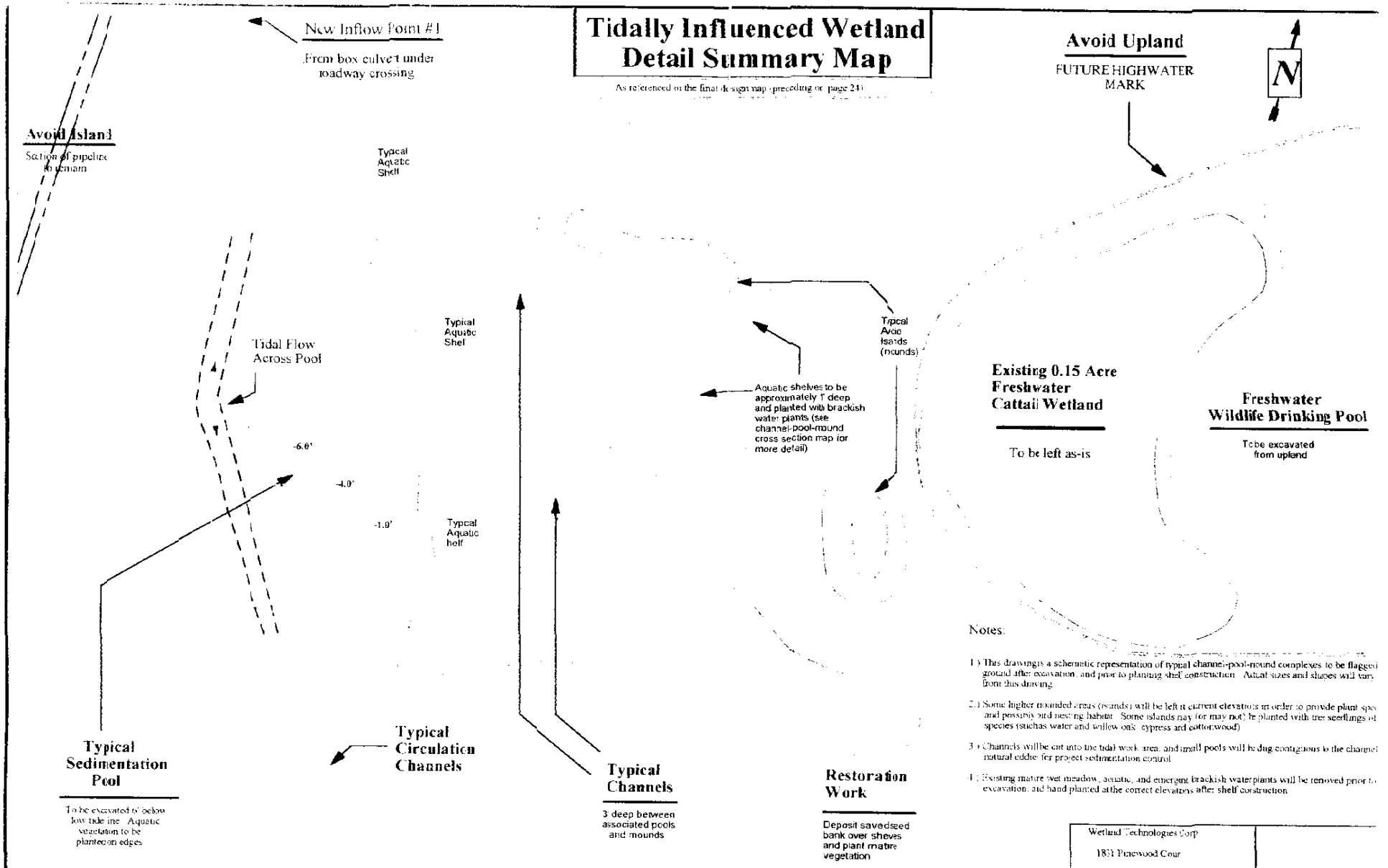
Only under extreme circumstances would it be necessary for small equipment such as a backhoe to cut a crossing either under or over the lines (whichever is the safest method). If so, a culvert will be laid over the lines if they are several feet under the final surface elevation; and a "u" culvert will be installed under them if they are at the surface (under direct Amerada supervision).

This easement is well marked on the ground by Amerada signage, which was walked in its entirety to assess the probable impact on the project as designed. Photographs of the subject areas are included.

Summary: After staking, the Chevron lines may be avoided entirely without impacting the planned design. The Amerada lines may be carefully excavated up to their edges, and culverts placed across or under them according to supervision to be provided by Amerada.

Tidally Influenced Wetland Detail Summary Map

As referenced on the final design map preceding or page 24)



Notes:

1.) This drawingis a schematic representation of typical channel-pool-mound complexes to be flagged ground after excavation, and prior to planting shelf construction. Actual sizes and shapes will vary from this drawing.

2.) Some higher mounded areas (islands) will be left at current elevations in order to provide plant spec and possibly bird nesting habitat. Some islands may (or may not) be planted with tree seedlings of species (suchas water and willow oak, cypress and cottonwood)

3.) Channels willbe cut into the tidal work area, and small pools will be dug contiguous to the channel natural eddies for project sedimentation control.

4.) Existing mature wet meadow, aquatic, and emergent brackish waterplants will be removed prior to excavation, and hand planted at the correct elevations after shelf construction.

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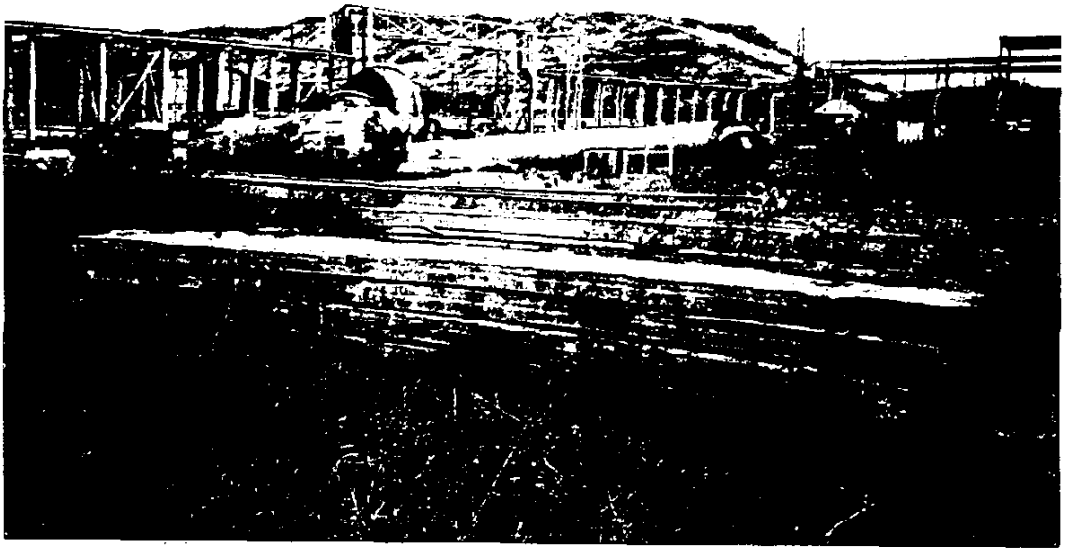
Date	Drawn By
1-13-95	Alex J.

Representative Area: This photo represents the natural channel-pool-mound complex as exists in salt marshes indicative of the Galveston Bay area; **however, brackish water species are to be planted primarily, as well as the *Spartina alterniflora* shown in this photograph.**

Close-up of intended channel-pool-mound complex: Channels will be cut into the tidally influenced area at a depth from 1 to 2 feet. Small pools for sedimentation capacity will be dug to a depth of 6'. Higher mounded areas will be left at current elevations to provide potential bird nesting habitat.

Amerada Pipeline Exit Point: The beach in the center foreground is the area where the Amerada Hess Pipeline set exits northward from the site into the Ship Channel.

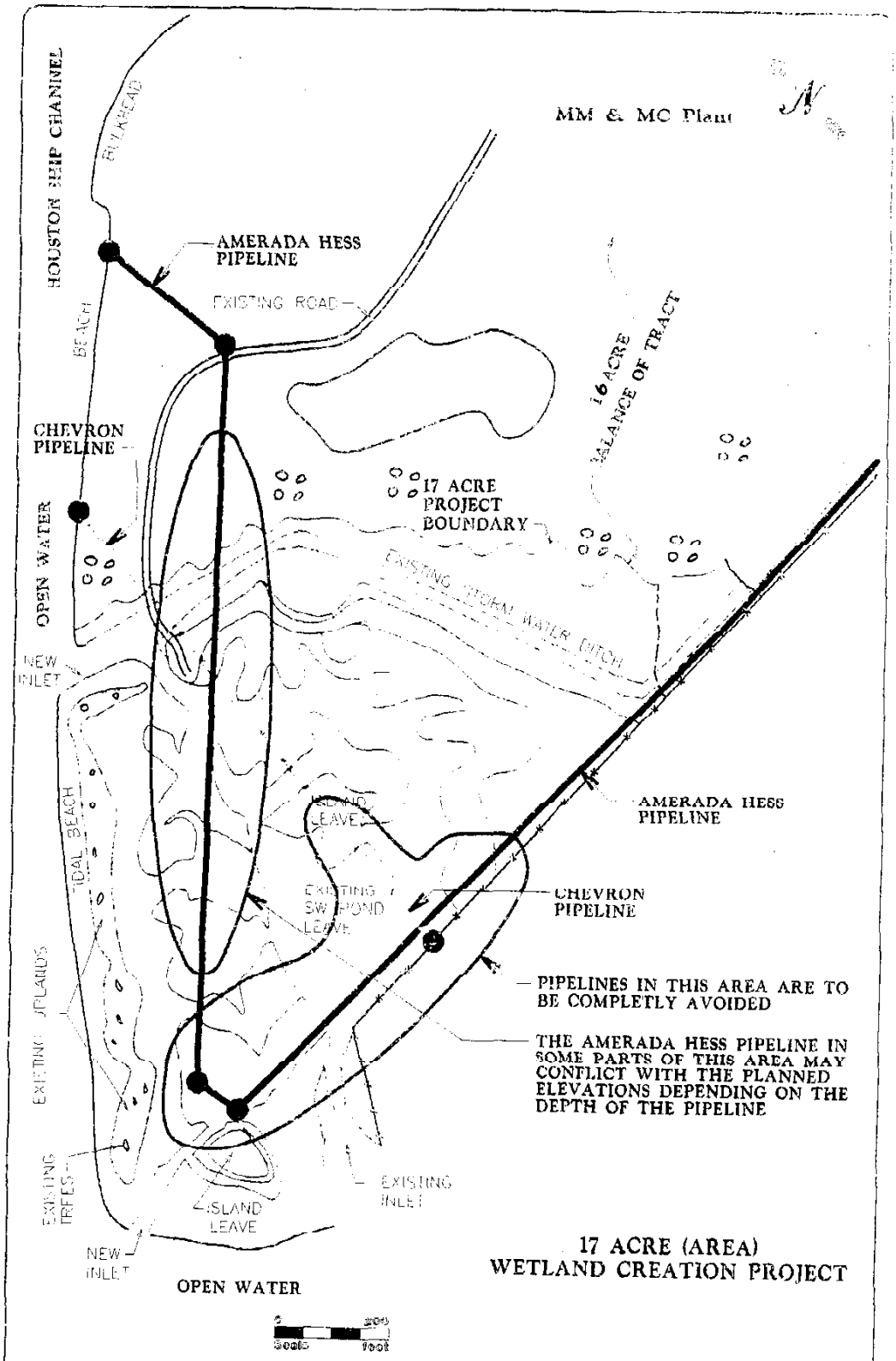
The lines extend from top center down the slope into this area.



Metal Storage Location: A close-up of the proposed work area in Section Two containing a large amount of metal to be hauled away. Note the open ended piping and vessels which appear to have contributed **no chemical residues** to the project area.

Pipelines Crossing the Planned Work Site: View of the proposed tidal project work area. The Amerada pipeline set extends downslope across the planned work area to the turn point shown below. Shallow wetlands are to be excavated carefully along it's edge. Heavy equipment will avoid the set of lines and their remaining surface will be used for future light vehicle access.

Pipeline Turn Point: A close-up of the area where the Amerada lines approach along the south boundary, cross under the existing pond edge, and turn northward in the immediate left foreground.



17 ACRE (AREA)
WETLAND CREATION PROJECT

Wetland Technologies Corp. 1831 Pinewood Court (713) 242-8734 Sugarland, Texas 77478	**MOBIL MINING & MINERALS CO.** PIPELINE LOCATION MAP Pasadena, Texas	Drawn By: SG	Sheet: 34 OF 48
		Date: 2-10-93	Project #: MM01

Section II: Freshwater Wetland Creation

Planned Construction Methodology

Plant Species: Large reed species prefer nutrients to a greater extent than lower growing wetland vegetation. *Typha angustifolia* (narrow-leaved cattails) dominate in stormwater ditches directly adjacent to the tailings piles; and a large reed grass dominates the existing outfall ditch from the **MM & MC** treatment plant. Use of these and other site-adapted species in the constructed wetlands are specified.

Microbial Remediation: Large reed species will uptake a small amount of nutrients; however their main purpose is to survive in the rich waters and provide within their root zone a suitable habitat for those microbes known to modify effluent nutrients.(2)

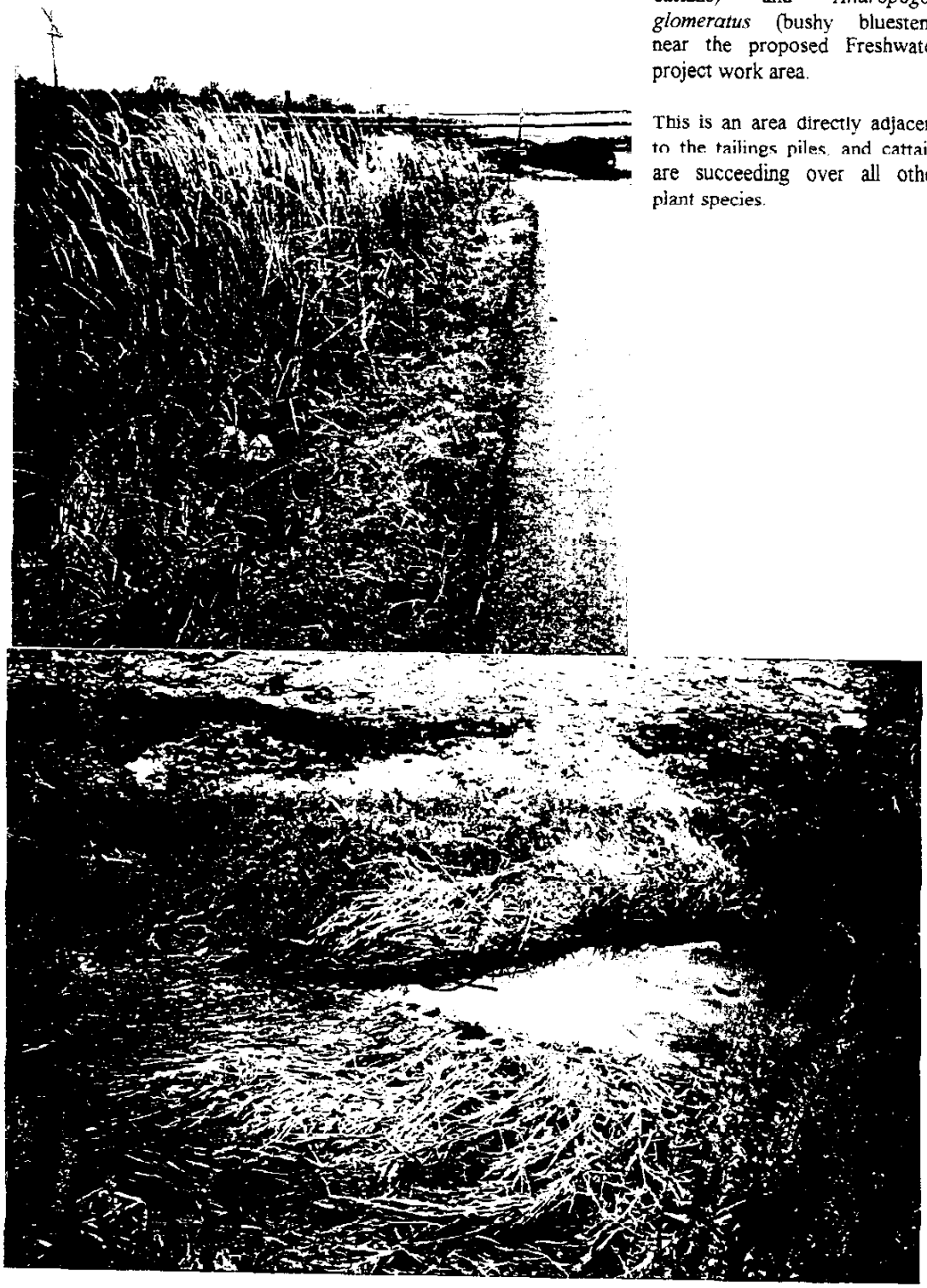
Contact Time: Contact time is controlled by the serpentine waterflow path through the project site planted with large reed species. Specifically, nutrient containing water will flow into a surge pond containing previously cleansed water, and then fall into meander ditches and associated shallow wetlands pushing clean water downstream into the balance of the system.

Small areas directly adjacent of the **Project** will have water collection ditches installed around them to flow into the next section of the treatment system. Consequently, small inflows of stormwater will be introduced into the main channel (central drain) for dilution and treatment at all stages prior to final outfall.

Therefore, nutrient containing waters flow from the treatment plant outfall through a ditch system planted with large reed species, into one large shallow wetland; the entire system being capable of detaining the **MM & MC** treatment plant discharge for a period of approximately 48 hours, and no less than 24 hours (except when receiving stormwater).

Cattails/Bushy Bluestem: A "donor site" of *Typha angustifolia* (narrow-leaved cattails) and *Andropogon glomeratus* (bushy bluestem) near the proposed Freshwater project work area.

This is an area directly adjacent to the tailings piles, and cattails are succeeding over all other plant species.



Reed Grass: A close-up of the large reed grass (species not identifiable on inspection date) dominating the existing oufall ditch edge. The seedbank from these sites is to be planted in association with cattails where specified.

SOUTHERN HALF OF FRESHWATER PROJECT
ADJACENT TO TREATMENT PLANT OUTFALL

The treatment plant west outfall point will be re-located to it's north side where it will connect with the constructed wetland system. The existing drainage ditch will be re-graded northward into the new system collector on two triangular tracts, and a rectangular tract currently fenced for material storage as is shown on the attached Freshwater Wetland Final Design Map on page 44.

Inflow Surge Pond: The first wetland system component is a small triangular tract directly north of the treatment plant. It will be excavated to a flood pool depth varying from 4' to 8' as the initial surge pond. It's edges will be planted with the reed grass, however it will serve mainly to attenuate inflow velocity.(3) A considerable amount of standing water will be maintained in order to dilute new inflow prior to entry into the meander system.

Serpentine Meander Ditch: The next component will be located on a much larger triangular site. Water will flow from the surge pond into the serpentine meander ditch system. The meander ditches and shallow wetlands will be planted with a mixture of cattail and reed grass. Reed grass may dominate the first part of the system while cattails may begin to succeed at the point where nutrient levels are somewhat lowered downstream.

The serpentine meanders will continue on to a larger fenced rectangular tract slightly below the outfall of the second tract. It will also receive stormwater from new collection ditches installed around adjacent higher ground. These multiple inflows will collect within these meanders (including a certain amount of storm surge capacity); and it's edges will be planted with site-adapted reed species.

This rectangular site will contain an extensive meander ditch system with some shallow wetlands covering some 75% of the rectangular area. The meander channel will widen a few times into shallow constructed wetlands (that mimic natural wetland systems) as it courses across the tract.

The edges of meanders and shallow wetlands will be planted with site adapted *Carex spp.* (sedges) and *Andropogon glomeratus* (bushy bluestem) transitioning into *Cyperus spp.* (umbrella sedges) and *Eleocharis spp.* (spikerushes) which may survive if the water's nutrient level is appropriate. The ditch system will continue to flow through a larger adjacent rectangular tract and meander north towards the **MM & MC** plant site.

Serpentine Meander: The large triangular tract where the first "serpentine meander" is planned. A *meandering shallow channel planted with cattail and reed grass will receive effluent from the surge pond* (area shown below). **Most nutrient modification will occur here; and in the large shallow wetland to be constructed on the fenced rectangular site to the extreme upper right corner.**

Primary Surge Pond: A small triangular site adjacent to the treatment plant to be excavated for the first inflow surge pond. The planned new plant outfall location is in the upper left corner.

NORTHERN QUARTER OF FRESHWATER PROJECT ADJACENT TO MM&MC PLANT SITE

The first section falls downstream into this quarter of the project which consists primarily of meandering ditches flowing northward (along the edge of the **MM & MC** plant site towards the existing large storm surge pond). These meanders also receive stormwater from collector ditches installed into the interior of the higher land adjacent to the west as shown on the attached Freshwater Wetland Final Design Map on page 39.

Work Area Conditions: Piping, vessels, and other large metal items currently lay on the project work area. All large metal items will be removed and hauled away from the constructed wetland sites.

Serpentine Meanders: A meander system similar to those contained in the previous (southern) half of the tract will slow streamflow velocity. The meanders will flow northwest and connect to the aeration chute located in the northwest quarter of the project.

Water Quality Enhancement: Although consumption of dissolved oxygen by algae blooms may be performed upstream due to nutrient removal by system processes; a need to inject oxygen still remains. The considerable elevation fall from the adjacent northern quarter of the project to the northwestern quarter is to be utilized to aerate water by outfalling over a chute of broken concrete.

Beneficial Effects of Higher Diversity of Modifying Bacteria: The variety of bacteria species identified by the literature in the type of wetland system specified is typically five times the number of species found in a wastewater plant. In turn, the greater microbial diversity defines a larger variety of nutrients that can be subjected to **beneficial water and soil chemical processes in a combined aerobic/anaerobic environment.**(2)

Secondary Infall Point: The ditch to center left is the Planned outfall from the southern half into the northern quarter. The ditch from top center will be extended outward into the adjacent higher land; in order to collect it's runoff for insertion into the new water treatment system.

Secondary System Location: A close-up of the Planned work area in Section Two containing a large amount of metal to be hauled away. Note the heavy algae bloom on free-standing water from nutrients left in materials stored in the site underlying the Planned project area.

NORTHWEST QUARTER LOCATED
ADJACENT TO THE HOUSTON SHIP CHANNEL

The final quarter serves a **"polishing"** function as well as treatment of stormwater runoff from adjacent areas. However, it's main purpose is to receive all streamflow of the sites' various collector ditch and wetland systems as shown on the attached Freshwater Wetland Final Design Map.

Erosion Control: Close inspection of the area adjacent the northside beach revealed it to be directly in the path of high streamflows during major storm events. This exposure would eventually promote break-through of any tidal barrier constructed to protect the system outfall; thereby exposing the final collection pool to degrading waters of the Ship Channel. Consequently, the final system pool is to be dug into the area directly behind (south of) the surviving bulkhead section in order to protect it's improved water quality.

Flood Pool Design: The final pool will be constructed with very broad shelves varying between 10" to 24" below normal pool level. This particular design focuses on habitat for aquatic vegetation known to generate large quantities of dissolved oxygen that chemically bonds with water. This "natural" incorporation process is of such efficiency that it does not suffer the degredation effects of mechanical aeration.

Water Quality Improvement: The application of successful planting methodologies (which are imperative to establishing vegetation growth) plays an important role in improving water quality; such as:

1.) obstructing the flow of fast moving water; thus reducing it's velocity, which in turn enhances the **Project's** sedimentation rates, and

2.) extremely efficient conversion of nitrogen and phosphorus as nutrient removal for biomass production, and

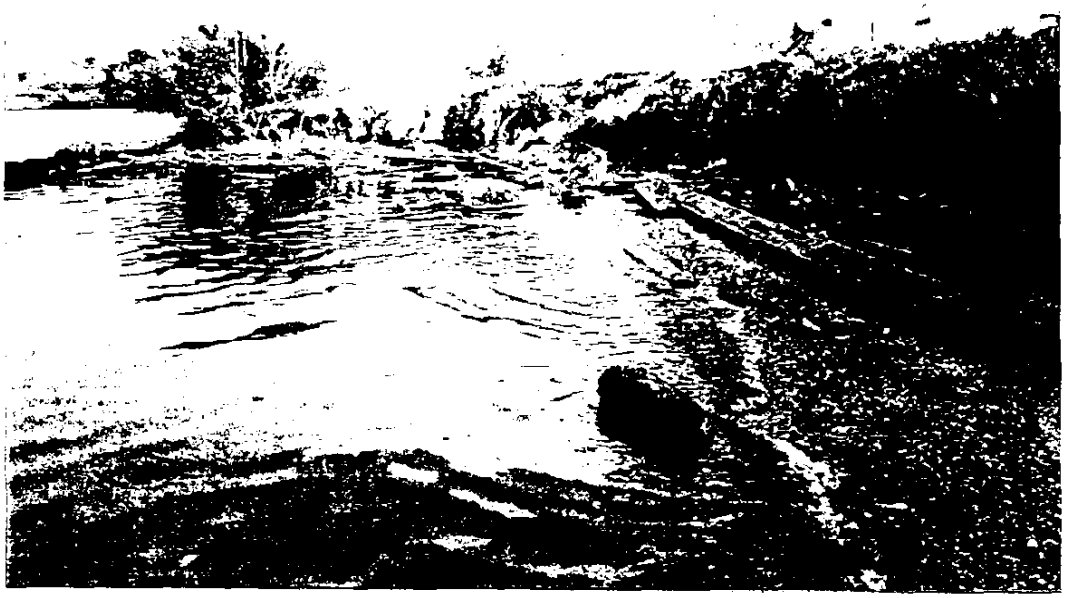
3.) increasing the surface area within the water column for the attachment of microbes, thereby multiplying the number of different microbial species, and their overall populations, and

4.) providing an aerobic environment around their roots for those microbes which require the presence of oxygen to conduct modifications of effluent nutrients and other compounds.(3)

Consequently, focusing on the establishment of a broader diversity of wetland plants translates into a higher diversity of microbial species (treatment bacteria) populations.

Final System Outfall Point: The old bulkhead is permanently in place at this point, and will support the final outfall pipe in the area shown.

This is an area some 100' from the beachfront erosion shown below.



Active Erosion: An example of beachfront erosion at the point where major stormflows strike the edge of the property. This area will have a minimum of 25' setback to the project final surge pond site to protect the integrity of it's banks and quality of outfall waters.

Freshwater Vegetation Planting Detail

Methodology: Soil manipulation techniques performed in the Freshwater project will be similar to those used in the tidal project. Seedbank from the area will be removed and saved until such a time as grading of the planting shelves is complete and the seedbank can be placed at the appropriate elevations. The seedbank will include those seeds site-adapted to this particular area such as cattails, sedges, reed grasses, and several species of aquatic plants.

Qualified personnel will indicate to the installation crew the different types of vegetation they are planting--upland plants as well as three types of wetland plants: **wet meadow, emergents, or aquatics.** The underlying "seedbank" (designated as the "O" horizon) includes most plant types that occur naturally in the area, and within about 6 weeks each individual area will revegetate itself with the correct plant type.(4) The appropriate "seedbank" material must be deposited in the correct (as specified) areas to ensure their survivability.(4)

Freshwater Plant Species List

Typha angustifolia (narrow-leaved cattail)

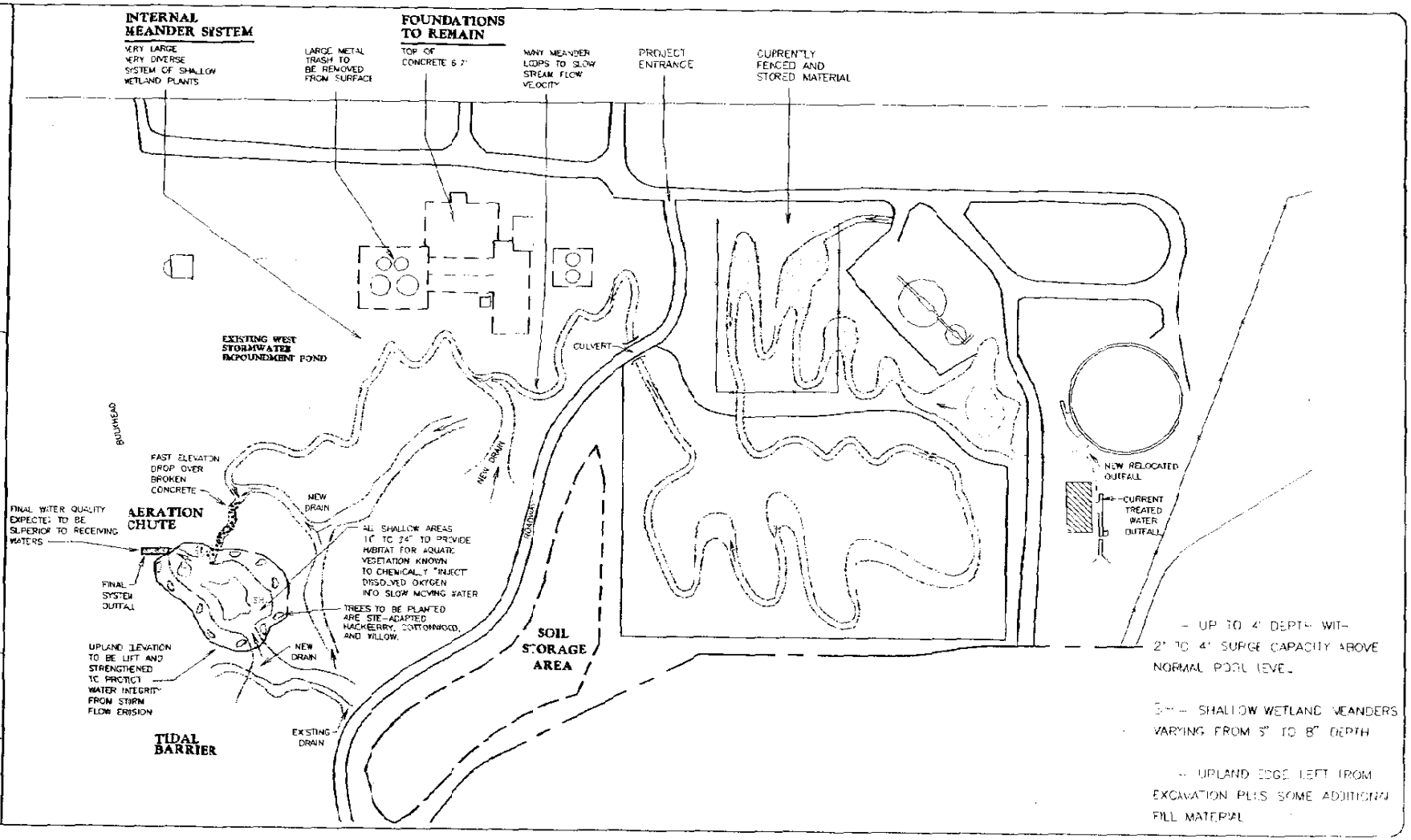
Rhynchospora spp. (beakrush)

Andropogon glomeratus (bushy bluestem)

Cyperus spp. (umbrella-sedge)

Ptilimnium capillaceum (mock bishop's weed)

Additional Plant Species: Ponded water species such as *Sagittaria spp.* (arrowhead) and *Pontederia cordata* (pickerelweed) will be imported from off-site. Site-adapted floodplain tree species located near the **Restoration Project** area will also be planted to uptake some persistent nutrients during their transpiration cycle. *Salix nigra* (black willow), *Celtis laevigata* (sugarberry) and *Populus deltoides* (cottonwood) seeds and/or seedlings will most likely be collected with the above plant's seedbank and establish themselves randomly throughout the project area.



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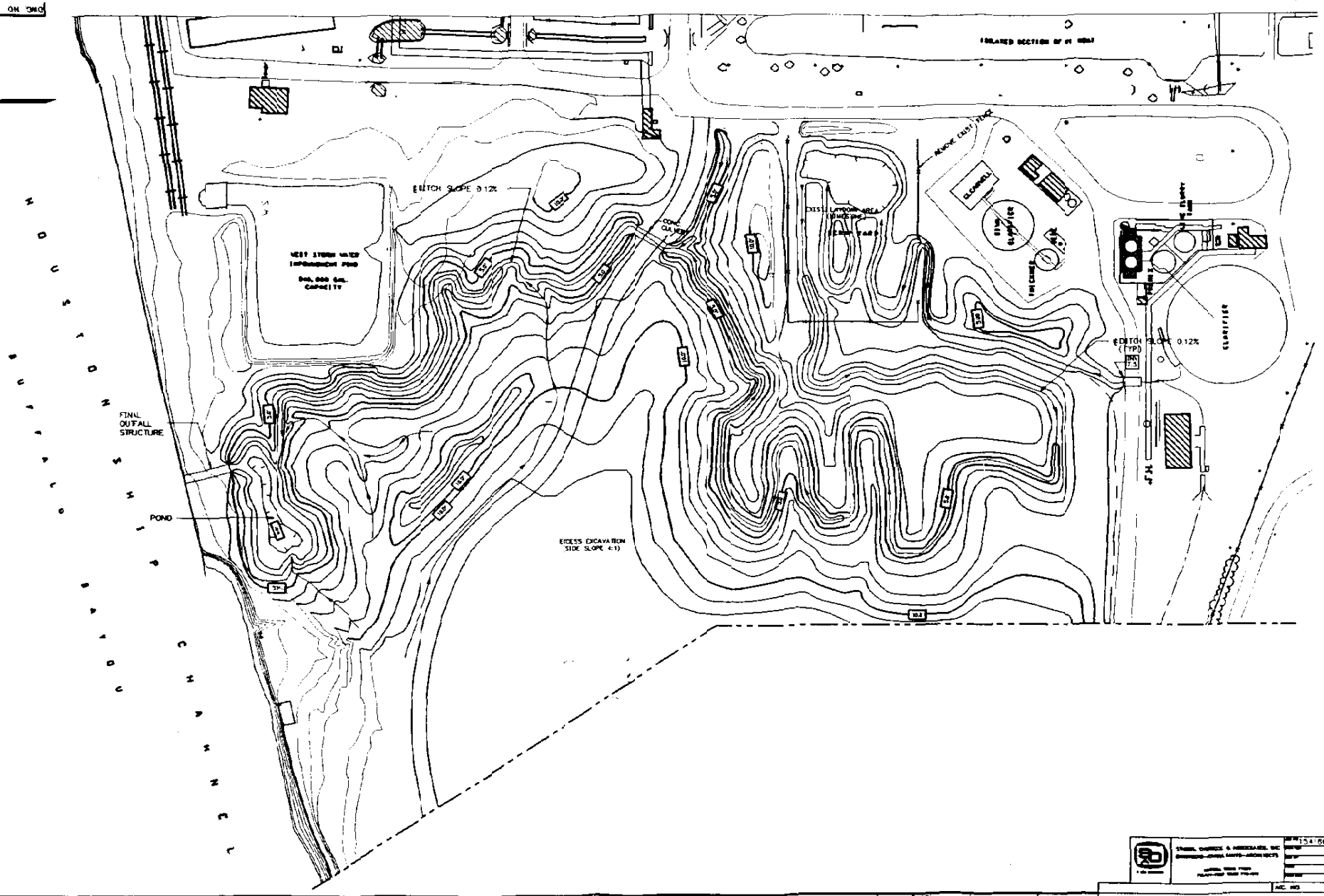
Mobil Mining & Minerals Co.
Freshwater Wetland Creation Project

FINAL DESIGN

Drawn By: SEA
Date: 1-4-85
Proj / File: MM/CONCEPT
Sheet: 44
Of: 55 Project #
MM03



Mobil Mining and Minerals Company

WETLANDS EXCAVATION MAP

Project Performance Criteria

Tidal Marsh Restoration:

Purpose: The primary criterion is specified to be a local increase in finfish nursery areas due to **the creation of new tidally influenced aquatic habitat** by:

1.) **excavating to the elevations shown on the Wetland Excavation Map, page 25,**

2.) **constructing planting shelves as described in the Construction Details section, page 21, and**

3.) **planting appropriate vegetation at the elevations shown in the Channel-Pool-Mound detail drawings, pages 26 to 28.**

A secondary purpose is to increase the water quality of inflow from the Ship Channel during it's "stand" in the **Tidal Marsh Project (Marsh Project)** area due to sedimentation, some addition of dissolved oxygen, and modification of pollutants by contact with the vegetation.

Marsh Project Performance Standards

The **Marsh Project "performance standards"** developed by the **Trustees** to ensure compliance with the above described **Criteria** are agreed to be as follows:

1.) Excavate to the elevations shown on the **Wetland Excavation Maps** to be attached to the detailed **Work Plan**, with certification of critical final elevations of the **Marsh Project** by a registered surveyor.

2.) After construction, work shall be performed as necessary in order to:

- **a.)** maintain a tidal connection at mean low tide to the Houston Ship Channel, and
- **b.)** maintain inlets and culverts to ensure proper flushing so that the **Marsh Project** area does not become isolated from adjacent water bodies, and
- **c.)** maintain channel depths so they remain flooded at mean low tide, and
- **d.)** maintain average water depths of the **Marsh Project** area at mean low tide so that they are reduced by no more than **30%** from final design specifications.

3.) At the end of the **Certification Period** (more fully defined in the following **Monitoring Plan** section), vegetative coverage of intertidal wetland areas shall exceed **60%** (measured as foliar coverage and expressed as percent of ground surface covered), and

- **a.)** vegetation in these areas must be characterized by a healthy and positive trend for desirable and target species, and
- **b.)** vegetative coverage of undesirable and invasive plant species must not exceed **10%** within the **Marsh Project** area (an invasive plant species list is to be attached to the detailed **Work Plan**).

Freshwater Wetland Creation:

Purpose: Water quality (particularly the ammonia nitrogen level) within the **Freshwater Project** is expected to improve by enhancing nitrification and/or denitrification processes due to extended contact with wetland vegetation, and detention time within the system by:

1.) **excavating to the elevations shown on the Freshwater Wetland Excavation Map, page 45,**

2.) **constructing planting shelves as described in the Construction Details section, page 21, and**

3.) **planting appropriate vegetation at the elevations shown in the Freshwater Wetland Design Map, page 44.**

Freshwater Project Performance Standards

The **Freshwater Project "performance standards"** are agreed to be as follows:

1.) Retention capacity of the constructed **freshwater wetland treatment system** shall not decrease by greater than **20%** of design specifications, and

2.) vegetative coverage of the **Freshwater Project** shall exceed **70%,** to be measured as foliar coverage and expressed as percent of ground surface covered at the end of the **Certification Period**, and

3.) vegetative coverage of undesirable and invasive plant species must not exceed **10%** within the **Freshwater Project** area (an invasive plant species list is to be attached to the detailed **Work Plan**).

Monitoring Plan

After Construction Monitoring Plan

The **Objectives of the Monitoring Plan** are to:

1.) evaluate and document the success, viability and sustainability of the **Restoration Project**, and

2.) provide a mechanism for determining when **Restoration Project Performance Criteria** are met, and

3.) provide timely identification of problems which may be rectified through corrective action during the **Certification Period** and/or through the use of the **Restoration/Maintenance Fund** after **Certification**.

The **Project Monitoring Plan** will be implemented during the initial **Certification Period** and for an additional three years after certification of completion of the **Project**. The **Natural Resource Trustees** will be responsible for oversight and management of the **Monitoring Plan**. The **Trustees** will limit personnel to the minimum required to adequately implement the Plan.

Certification Period

The Certification Period is defined to be complete when the **Marsh Project** achieves 60% vegetational coverage, the **Freshwater Project** achieves 70% vegetational coverage, both **Projects** meet the invasive plant species limitations and all other project criteria such as tidal connection, water depths, elevations and retention capacity are met. This **Period** is expected to occur about 2 years after completion of construction, but the **Project** may meet these requirements at an earlier (or later) date.

Tidal Marsh Component

Monitoring of the **Tidal Marsh** portion of the **Project** will focus on:

1.) percent coverage of vegetation, and

2.) species composition of vegetation, and

3.) water circulation/flushing of **Marsh Project** area.

Part I-Vegetation-

Percent Coverage and Species Composition of Vegetation: A quantitative vegetative inventory, and also a qualitative analysis will be performed in order to describe the composition and structure of vegetation present at the **Marsh Project** site. The extent of vegetative coverage will be assessed, and areas with different types of dominant vegetation will be identified, as follows:

1.) **Aerial Photography:** Color aerial photographs at a scale equal to 1"=200' will be taken biannually during spring (April/May) and fall (September/October) months during the initial **Project Certification Period** and annually thereafter.

Total dominance of plants will be evaluated in terms of foliar coverage and expressed as a percentage of ground surface covered.

2.) **Primary Inspection:** Aerial surveys will be ground-truthed by a concurrent **site inspection program** to monitor growth and development of dominant or important species. Photgraphic and visual estimate of percent of vegetated cover will be made within permanently marked 1 m^2 vegetated quadrats located on transects radiating from open water to upland areas. Secondly, plant species will be identified in the quadrats, and the relative density of each species will be tabulated for the transects.

These assessments will be supplemented by other general field observations to verify and document vegetational characteristics of the **Project** area as is more fully described below.

3.) **Secondary Inspection:** A **field study** may be performed quarterly during the initial **Certification Period**, and biannually after **Certification**, in order to determine the presence of conditions which may limit vegetative growth in the **Project** area; and to determine the presence of nuisance species, and identify other conditions responsible for unhealthy or unbalanced plant communities at the **Project** site.

When feasible, this activity will be performed concurrently with other aspects of the monitoring program.

Part II-Water Circulation-

Flushing of Marsh Project Area: Water circulation of the **Project** area will be assessed as follows:

1.) **Primary Inspection:** A bathymetric survey of the **Project** area (focusing on tidal inlets and major channels), will be performed biannually during the initial **Certification Period** and annually thereafter, to identify problems in circulation associated with siltation, scouring or other depth altering processes.

In order to compare such elevation changes, a permanent **staff gauge** shall be installed in a subtidal area to create a stable datum from which to compensate for variations in tidal height at the time of each survey.

When installing the **staff guage,** mean low tide **(MLT)** is to be marked as 0.0' elevation where indicated by existing **tidal vegetation,** irrespective of it's level as recorded on standard Surveyor's topological maps of the area.

2.) **Secondary Inspection:** Basic water quality parameters (temperature, dissolved oxygen, pH, salinity) will be measured as indicators of poor water circulation and/or altered hydrology of the **Marsh Project** area. Samples will be collected mid-depth between surface and bottom at three locations:

a.) in one of the primary inlets, and

b.) in the northern corner of the ponded tidal pool, and

c.) in a side channel in the northeast portion of the **Project** area.

A significant part of the **field survey** will also be devoted to inspection of tidal inlets and internal culverts for plugging, and to identify other conditions responsible for improper or irregular hydrology at the **Project** site.

The water quality measurements and general **field survey** may be performed on a quarterly basis during the initial **Certification Period**, and biannually after **Certification**. When feasible, these activities will be performed concurrently with other aspects of the monitoring program.

Freshwater Component

Monitoring of the freshwater, water-polishing portion of the **Project** will focus on:

1.) percent coverage of vegetation, and

2.) species composition of vegetation, and

3.) retention capacity of the system, and

4.) nutrient reduction and improvement of water quality.

Part I-Vegetation-

Percent Coverage of Vegetation and Species Composition: Vegetative coverage will be assessed by the same methods and to the extent possible on the same dates as are more fully specified in the **Marsh Component** of the **Project**. A quantitative vegetative inventory and analysis will also be performed by the same methods and to the extent possible, on the same dates as the **Marsh Component** of the **Project**.

Part II-System Capacity-

Retention Capacity of the System: The retention capacity of the system will be assessed as follows.

1.) **Primary Inspection:** A bathymetic survey of the **Project** area will be performed biannually during the initial **Certification Period** and annually thereafter, to identify problems in system retention capacity associated with siltation, or other depth altering processes.

In addition, a **dye study** may be implemented on an annual basis to evaluate changes in retention capacity and contact time of the Project. The appropriate amount of an approved, non-toxic dye would be released at the initial plant outfall point. The time elapsed between release of the dye and the time at which it appears at the final outfall would be used as an indication of changes in system retention time.

2.) **Secondary Inspection:** A **field study** may be performed quarterly during the initial **Certification Period** and biannually thereafter, to inspect for and identify conditions responsible for alterations of established retention capacity; and for any other improper or irregular hydrology at the **Project** site.

Part III-Water Quality-

Nutrient Reduction and Improvement of Water Quality: To monitor the nutrient stripping capacity of the **Project**, the following activities will be conducted as follows:

1.) Water samples will be collected and analyzed for total phosphorus, orthophosphate, total nitrogen, total ammonia nitrogen, total nitrate nitrogen, total nitrite nitrogen, total Kjeldahl nitrogen, total dissolved solids, and total suspended solids.

Samples will be collected at mid-depth between surface and bottom at three locations:

a.) at the initial treatment plant outfall,

b.) in the meander ditch midway between inflow surge pond and final collection pool, and

c.) at the final system outfall.

2.) **Samples** for the purpose of analyzing basic water quality parameters (temperature, dissolved oxygen, pH, and perhaps salinity) will be collected at the same three sites as indicators of the general **water quality** of the **Project**.

Water quality samples will be collected and analyzed on a quarterly basis during the initial **Certification Period**, and biannually after **Certification**.

Monitoring Plan Timeline

Dates of inspection to be performed after construction according to requirements of the Monitoring Plan

Item Description	Yearly-Prior to Certification apprx. 2 yrs.		Yearly-After Certification 3 yrs.	
Primary Study	**# times**	**season**	**# times**	**season**
❶ Color Aerial	2	spring/fall	1	spring
❷ Vegetation (s/w and f/w) a.) % Coverage b.) Species Composition	2	spring/fall	1	spring
❸ Bathymetric (s/w and f/w)	2	spring/fall	1	spring
❹ Dye Study (f/w) only	1	spring	1	spring
Supplementary Study				
❺ Vegetation (s/w and f/w) a.) Observe General Conditions	4	all	2	spring/fall
❻ Water Quality (s/w and f/w)	4	all	2	spring/fall
Report Preparation				
❼ Yearly Report	1	following spring	1	following spring

References

Wet Tech has referred extensively to material in the following publications:

1.) Kentula, M. E., R. P. Brooks, S. E. Gwin, C. C. Holland, A. D. Sherman, J. C. Sifneos. 1993. *An Approach to Improving Decision Making in Wetland Restoration and Creation.* Edited by A.J. Hairston. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

2.) Hammer, Donald A. 1989. *Constructed Wetlands for Wastewater Treatment.* Lewis Publishers, Inc. Chelsea, Michigan.

3.) Horan, N.J. 1990. *Biological Wastewater Treatment Systems.* John Wiley & Sons Ltd. West Sussex, England.

4.) Kusler, Jon A. and Mary E. Kentula. 1990. *Wetland Creation and Restoration.* Island Press. Washington, D.C.

5.) National Research Council. 1992. *Restoration of Aquatic Ecosystems.* National Academy Press. Washington, D.C.