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-Final Document-

Proposed Use of Trees to Uptake Affected Ground Water Gordon's Creek Fill Area Containment Cell

Former Gulf States Creosoting Site Hattiesburg, Mississippi

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Hattiesburg, Mississippi

Executive Summary

This document presents a plan for planting trees within the Gordon's Creek Fill Area containment cell at the former Gulf States Creosoting site in Hattiesburg, Mississippi. The objectives of this measure are to uptake ground water contaminants and to reduce the potential for ground water mounding within the containment cell. Hybrid poplars and black willows have been selected for use because they are native to Mississippi, take up large quantities of ground water, and have been demonstrated to remove hydrocarbon compounds in ground water. The program presented in this plan will not be implemented until written approval is received from the Mississippi Department of Environmental Quality (MDEQ).

Trees will be planted throughout the containment area and in an upgradient control area. Within both the containment area and the control area, trees will be planted in staggered rows. The two tree species will be planted in an alternating pattern within each row. The initial activities will include planting, site grading, seeding, irrigation for the first growing season (to stimulate root growth), technical assistance from an agricultural specialist (as needed), and engineering supervision and documentation of the planting activities. Cultivation and maintenance activities will include watering and/or irrigation system maintenance, mowing, weed removal, removal of dead trees (it is anticipated that not all trees will take root), and monitoring of ground water levels.

Site monitoring and record keeping will include documentation of climate, rainfall, applied water, tree growth, tree mortality, and ground water levels. Growth and maturity of trees will be recorded and evaluated on a grid basis. The control group will be monitored to establish baseline comparisons on growth and mortality.

1.0 Introduction

1.1 Site Description

The Gulf States Creosoting site is the location of a former wood treating facility in Hattiesburg, Mississippi. The Gordon's Creek Fill Area (the Fill Area) is a portion of site where contaminated fill materials were apparently placed during commercial redevelopment of the site in the early 1960s. The placement of these materials has resulted in impacts to shallow soils and ground water beneath an approximately two-acre area along the eastern bank of Gordon's Creek. Additionally, intermittent seeps of dense non-aqueous phase liquids (DNAPLs) into the creek have been documented in the past.

1.2 Fill Area Remedy

Kerr-McGee Chemical, LLC (KMC) has been conducting remedial construction at the Fill Area since April 2003, in accordance with a *Final Remedial Action Work Plan* (Michael Pisani & Associates, Inc., August 21, 2002). Because much of the contamination within the Fill Area is beneath the top of ground water, making removal technically impracticable, MDEQ agreed to a containment remedy with institutional controls. To date, remedial construction activities at the Fill Area include:

1. Installed culvert in the ditch bisecting the Fill Area between West Pine Street and Gordon's Creek.
2. Installed a sealable-joint sheet piling barrier to cut off intermittent seeps of DNAPLs to Gordon's Creek and to eliminate the potential for lateral migration of DNAPLs.
3. Delineated the extent of visible DNAPLs in the Gordon's Creek streambed, then removed DNAPLs and heavily-impacted sediments from the streambed.
4. Installed a geosynthetic clay liner (GCL) atop affected Fill Area materials to inhibit the infiltration of precipitation through affected soils and reduce the potential for ground water mounding. The GCL was then covered with approximately one foot of topsoil and the containment area was seeded.
5. Installed a recovery system behind the sheet piling barrier to collect, contain, and dispose of recoverable DNAPLs.

The final step in the Fill Area remedy is to implement a phytoremediation program to reduce the potential for ground water mounding, promote the capture of affected ground water, and accelerate further degradation of site constituents in shallow soils.

1.3 Problem Definition

Due to historical filling with contaminated materials, shallow soils and ground water within the Fill Area are impacted with polycyclic aromatic hydrocarbons (PAHs). Shallow ground water is present at depths generally ranging from 5 to 10 feet below grade beneath the Fill Area. In addition, pockets of perched DNAPL are present beneath the top of ground water on top of low-permeability clay lenses throughout the Fill Area.

The Fill Area remedy was developed to achieve the following remedial goals:

1. Eliminate the potential for seeps of DNAPLs into Gordon's Creek, by installation of a sealable-joint sheet piling barrier.
2. Eliminate or greatly reduce the potential for direct contact with affected materials, by placement of a geosynthetic clay liner (GCL) and implementation of institutional controls (i.e., restrictions on future land use and construction activities)
3. Eliminate or greatly reduce the potential for infiltration of precipitation through affected soils, by installation of the GCL (Note: When the GCL is punctured to plant trees, precipitation will be directed to the root zones of trees to stimulate growth).
4. Reduce the potential for ground water mounding, promote the capture of affected ground water, and accelerate further degradation of site constituents in shallow soils by implementation of a phytoremediation program.

2.0 Applicability of Phytoremediation

Phytoremediation is the direct use of plants to contain, immobilize, degrade, or remove contaminants from affected water and soils. The following are the primary mechanisms by which organic contaminants are phytoremediated: evaporative transpiration, rhizodegradation, phytotransformation, and phytovolatilization.

Evaporative Transpiration is the use of trees as hydraulic controls, whereby their root masses reach down to the water table and take up large quantities of water. This ground water uptake can serve to control the migration of a ground water contaminant plume by eliminating or reducing the forward flow of ground water, or to prevent ground water mounding within a containment cell. Poplar trees, for example, have been reported to transpire up to 50 gallons per day per tree.

Rhizodegradation is the breakdown of contaminants in the soil and ground water through microbial activity that is enhanced by the presence of the root zone (or *rhizosphere*). Substances produced by the plant roots, also known as plant *exudates*, can stimulate the degradation of organic contaminants in the soil and ground water and also reduce the mobility of certain contaminants (e.g., metals) in ground water by making them less soluble.

Phytotransformation is the breakdown of contaminants taken up by plants through metabolic processes within the plant or through the breakdown of contaminants outside the plant (i.e., in the soil/root contact zone) by enzymes or other compounds produced by the plants.

Phytovolatilization is the uptake and transpiration of volatile contaminants by plants, with the release of either the contaminant compound or daughter compounds to the atmosphere from the plants. As plants take up ground water and contaminants, some of the contaminants pass through the plants to the leaves, where the compounds evaporate, or *volatilize*, into the atmosphere.

The phytoremediation portion of the remedy for the Fill Area has been designed to optimize the evaporative transpiration of ground water to reduce or prevent the mounding or accumulation of ground water upgradient of the sheet piling barrier at the site. Additional removal of organic contaminants in ground water may be accomplished by DNAPL recovery, as described in the MDEQ-approved *Final Remedial Action Work Plan*.

3.0 Proposed Phytoremediation Plan

3.1 Tree Species

The tree species selected for this measure are hybrid poplars (populus X) and black willows (salix nigra). The two species are native to Mississippi and uptake large quantities of water. Poplars are a species that has shown significant potential in a number of studies supervised by U.S. EPA. The addition of another species (the black willow) minimizes the risk of losing all the trees to drought, a hard freeze, or other rapid change in environmental conditions at the site.

Poplars exhibit rapid growth rates (approximately 10 feet in height per year) and high evaporative transpiration rates (as high as 50 or more gallons per tree per day), and therefore make ideal candidates for phytoremediation applications. These trees grow easily from cuttings, and can be harvested and regrown from cut stumps.

Both the hybrid poplars and black willows will be planted as rootless cuttings. Therefore, the trees need to be planted at the end of the winter dormant season (i.e., in late February or March), in order to allow time for establishing root systems prior to the summer, when the water needs of each plant are maximized.

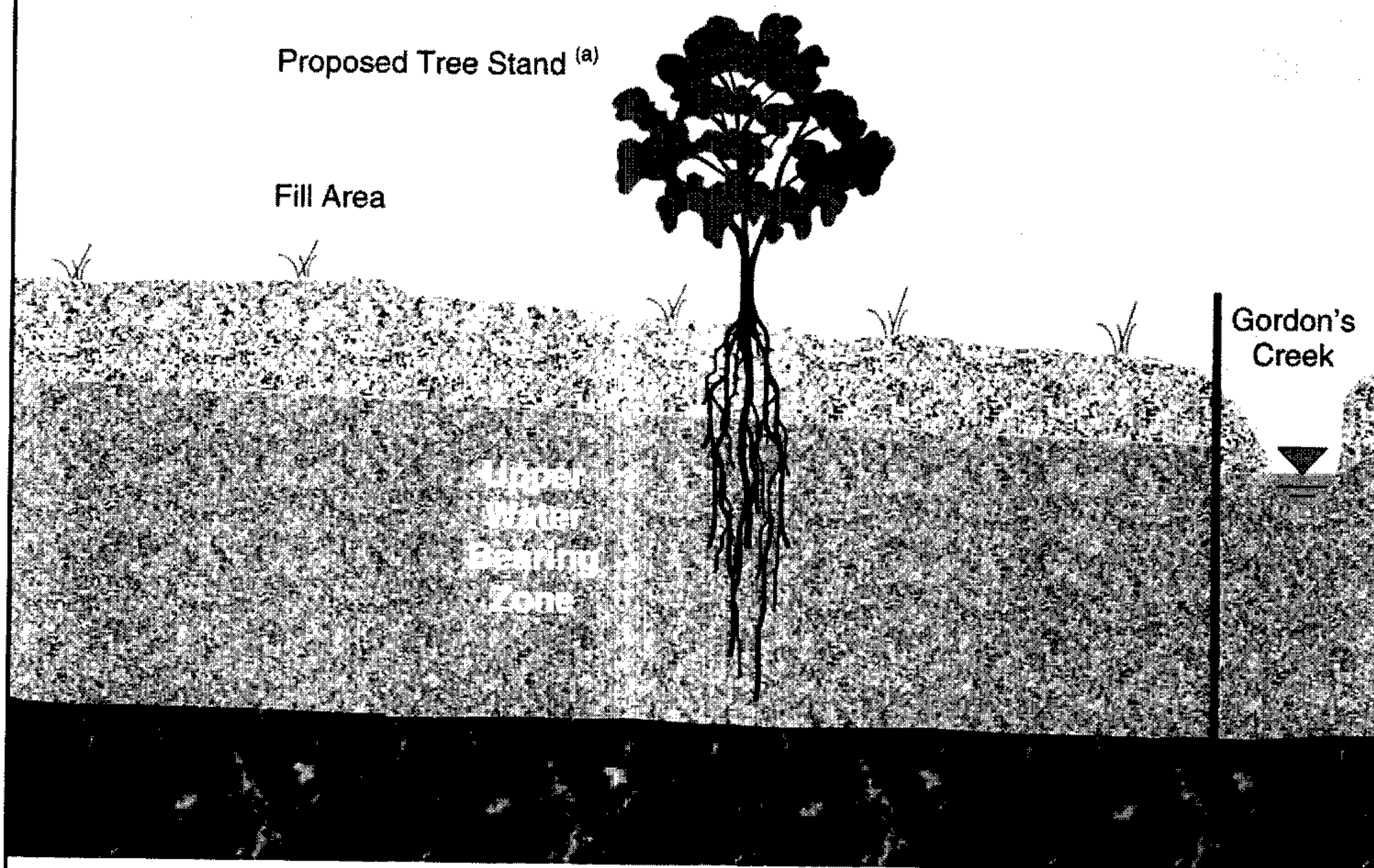
3.2 Tree Planting Configuration

The phytoremediation plan presented in this section consists of planting trees in rows through out the Fill Area containment cell. A schematic cross-sectional drawing of the proposed tree planting design is provided as Figure 3-1. The approximate extent of the proposed tree planting areas is shown on the plot plan presented as Figure 3-2.

The trees will be planted in staggered rows on a linear spacing of one tree approximately every 10 feet. The rows of trees will also be approximately 10 feet apart. The planned placement frequency of trees is comparable to that recommended by the U.S. Department of Agriculture (USDA) for maximizing the growth of individual poplars over time.

Trees will be planted in a stand that encompasses the entire Fill Area containment cell. The lateral extent of the tree stand will be limited by the roads at the perimeter of the containment cell. An approximately 20-foot wide tree-free buffer zone between the planted trees and the perimeter sheet piling will be maintained to allow access to roads, fences, and ground water monitoring/recovery wells.

In addition to the trees planted to uptake affected ground water, a control group of approximately 80 trees will be planted outside of the containment cell, in an unaffected area. The control group will be planted in a rectangular stand in the open area located immediately upgradient of the perimeter sheet piling.



LEGEND

- Clay and Silty Clay
- Sand
- Sand and Mulch Backfill
- Surface of Ground Water
- Sheet Piling Barrier

NOTES

(a) Approximately 700 trees planted in two separate stands

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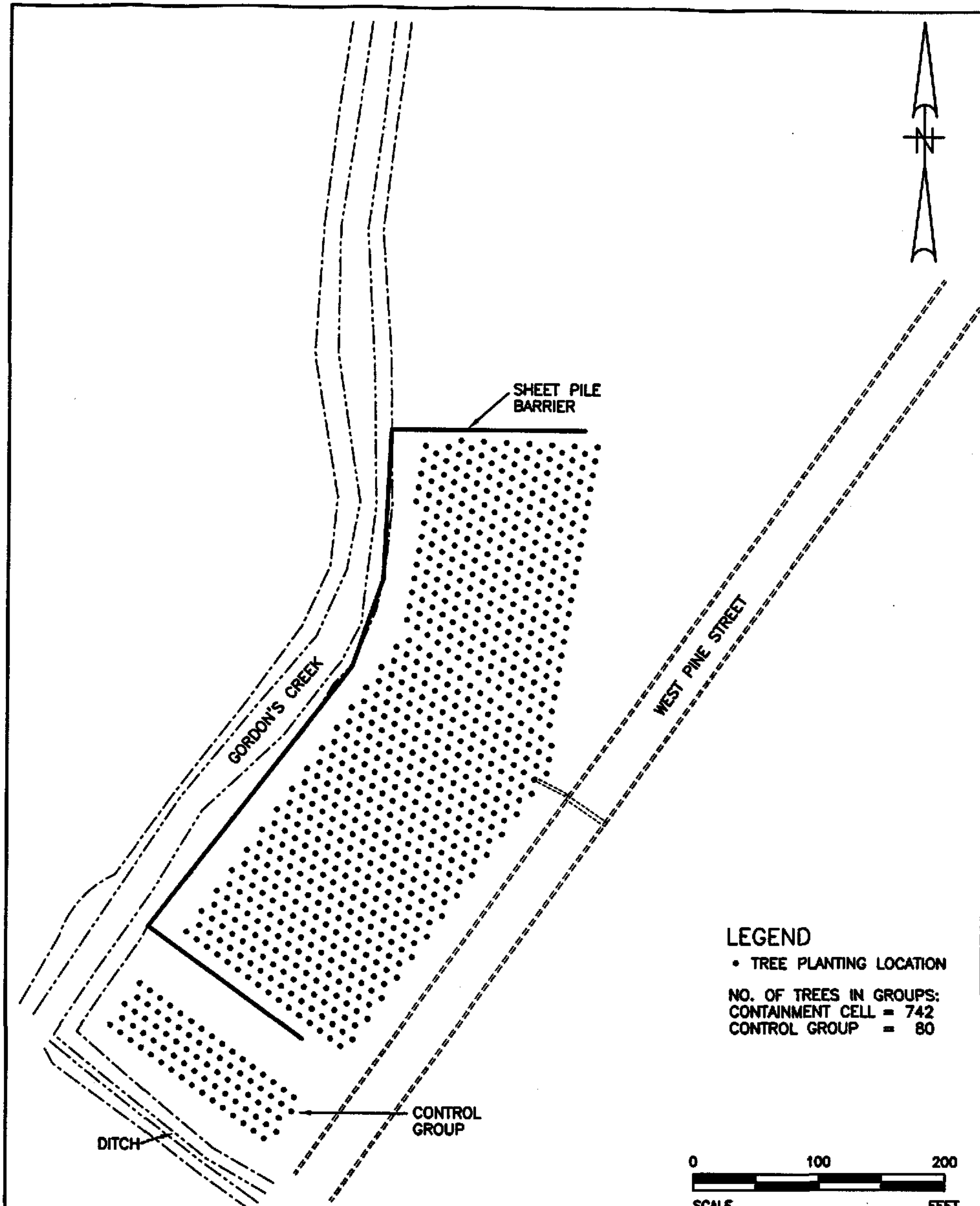
Figure 3-1

Schematic Diagram Of
Proposed Tree Stands

Gulf Coast Creosoting Fill Area

Hattiesburg, Mississippi

SCALE: DRAWING NOT TO SCALE	DWG. NO.:



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SCALE: 1"=100' | DWG. NO.: 21-04/297A

FIGURE 3-2
DIAGRAM OF TREE PLANTING AREAS
FILL AREA

FORMER GULF STATES CREOSOTING SITE
HATTIESBURG, MISSISSIPPI

The primary consideration in determining the tree-planting frequency was to establish a full canopy as rapidly as possible while maximizing long-term evaporative transpiration of ground water affected with site-related constituents. In addition, the selected tree placement pattern was designed to maximize ground water uptake within the affected ground water plume (i.e., within the containment cell).

3.3 Tree Planting Procedures

In order to facilitate tree planting, it will be necessary to cut a hole in the GCL and advance a borehole at each tree-planting location. The holes in the liner will allow precipitation to enter the subsurface only at tree-planting locations, thereby directing precipitation to the sites where water is needed.

The cuttings to be used in this project were planted over a year ago, and will have developed a minor root system prior to harvesting for shipment and planting. The 3- to 4-foot long cuttings will be planted to a depth of approximately three feet, with one foot of cutting protruding from the ground. Boreholes will be backfilled with organic-rich soil augmented with slow-release fertilizer to promote maximum growth during the first year after planting.

To maintain a dense root network within the Fill Area containment cell, the planted trees will be thinned out as little as possible. At the end of six months after planting, the tree stands will be evaluated by an agricultural specialist to determine how many trees (if any) should be thinned. Thereafter, the planted tree stands will be thinned annually on an as-needed basis.

For the first six months after planting, the trees will be irrigated at a rate comparable to one to two inches of rainfall per week. An irrigation system will be installed to provide water from the local municipal water supply to the trees during their first six months of growth. The irrigation system will be operated on either a batch or a timed-flow basis at a watering rate recommended by an independent forestry consultant or agricultural expert. Alternatively, if deemed to be more cost-effective, trees may be manually watered during the first growing season.

During planting, surface and shallow subsurface soil samples will be collected for agronomic analysis (e.g., pH, acidity, nutrients, organic content, etc.) to determine if additional steps are needed to assist the growth of the trees. At the end of the initial six-month irrigation period, growing conditions at the site will again be assessed by an agricultural expert to determine if continued artificial irrigation or other measures are needed to optimize tree growth.

According to the Mississippi State Extension office, the poplar trees should grow to a height of about 10 feet in the first year, and approximately 10 feet per year thereafter until they reach maturity. The black willow trees are anticipated to grow at a similar or slightly slower rate. The resulting tree canopy height will provide a visually pleasing tree stand within a reasonably short time period.

3.4 Tree Mortality and Monitoring

It is anticipated that some planted cuttings may not take root. According to U.S. EPA National Risk Management Research Laboratory (Cincinnati, Ohio), a 10% to 20% initial mortality rate can be expected under ideal conditions, and initial mortality rates can range as high as 40% or 50%, depending upon the season during which the trees are planted.

In addition, some mortality may occur after the planted trees take root. Tree mortality after planting may be caused by environmental changes (e.g., weather, excessive storm water ponding, drought, disease, etc.) or by potentially toxic concentrations of site-related constituents in ground water taken up by the trees. The control group of trees planted outside of the perimeter sheet piling will provide baseline performance data against which tree growth within the containment cell will be compared.

Growth performance of the trees will be monitored by periodically measuring or estimating leaf area indices of the planted areas, average trunk girths, percent canopy closure, and other applicable forestry parameters. Monitoring will be performed annually between April and June, at which time trees generally exhibit full growing season foliage. The growth performance parameters of the planted areas will be evaluated by a forestry expert on a regular basis, and the tree maintenance program will be modified as needed to optimize tree growth.

A review of technical literature indicates that although hybrid poplars and black willow trees have shown great potential for phytoremediation applications, very little field data has been published regarding the toxicity of specific compounds to the trees. Therefore, the opportunity exists in the phytoremediation application described herein to collect site-specific field data correlating observed concentrations of site related constituents in ground water to tree growth, tree growth inhibition, or tree mortality.

In the event that any cuttings do not take root or if any die after they take root, the dead trees will be cut down to minimize adverse visual aesthetics. Inhibited growth or mortality of individual trees will be documented and compared to ground water quality data, weather conditions, growth of the remaining trees, or other site data to monitor performance of this project.

The planting pattern was designed to allow for some tree mortality. Trees were planted at 10-foot intervals, which is approximately twice the density of the planting interval prescribed by the U.S. Department of Agriculture (USDA). The average mortality rate for a newly planted stand of trees is 15 percent. So long as the tree mortality rate remains below 15 percent, no trees will be replaced. Should the mortality rate exceed 15 percent, tree replacement will be performed every other year for the first four years at the end of the dormant season. The type of trees used in replacement will be determined based on the health of the species originally planted. After the first four years, the tree canopy will be dense enough that tree replacement would provide little benefit.

3.5 Implementation Schedule

It is anticipated that hybrid poplar and black willow cuttings will be shipped to the site during the first two weeks of March 2004, and that all cuttings will be planted before the end of March 2004. After planting, the trees will be irrigated for a minimum of six months to promote growth. Local ground water elevations will be monitored by recording water levels in Fill Area monitoring and recovery wells. Based on published typical growth rates for poplars and black willows, the root structure will probably reach affected ground water within one to two years after planting.

4.0 Conclusions

Hybrid poplar and black willow trees have been used at a number of sites to phytoremediate ground water contaminated with hydrocarbons. These tree types transpire significant quantities of ground water through their roots and evaporate it into the atmosphere.

Though phytoremediation using poplar tree species have been applied to a number of sites with hydrocarbon contamination problems in the ground water, little to no case data is available regarding the long-term performance of this technology. However, sufficient studies have been performed to indicate that this technology is a feasible means of reducing hydrocarbon concentrations in ground water.

This proposed plan does not intend to utilize trees to clean up ground water to numerical standards. As stated previously, MDEQ has agreed to a containment remedy with institutional controls for the Fill Area. It is anticipated, however, that implementation of this phytoremediation plan will be effective in achieving its primary objectives, which are to uptake ground water contaminants and to reduce the potential for ground water mounding within the containment cell. In addition, it will provide a visually aesthetic stand of trees within the Fill Area.