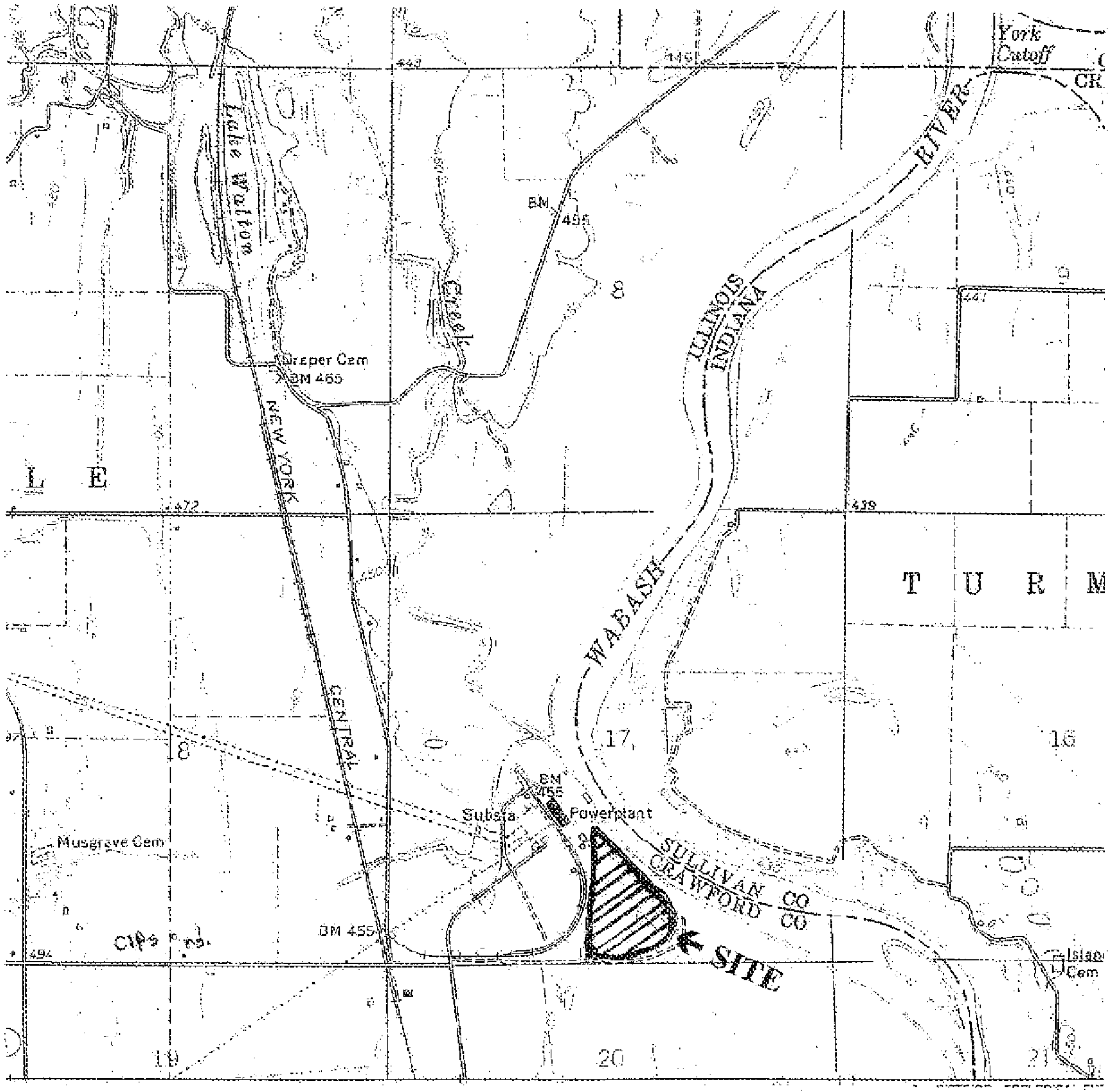
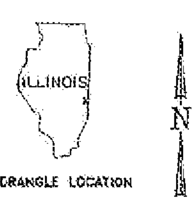


SOURCE: USGS 15 MINUTE QUADRANGLE, WEST UNION, DATED 1966.



0 2000 4000

SCALE IN FEET

CONTOUR INTERVAL 10 FEET

SITE LOCATION MAP

HUTSONVILLE POWER STATION
AMEREN ENERGY GENERATING
HUTSONVILLE, ILLINOIS

NATURAL RESOURCE TECHNOLOGY

PROJECT NO. 1375

DRAWING NO. 1375-A04

FIGURE NO. 1-1

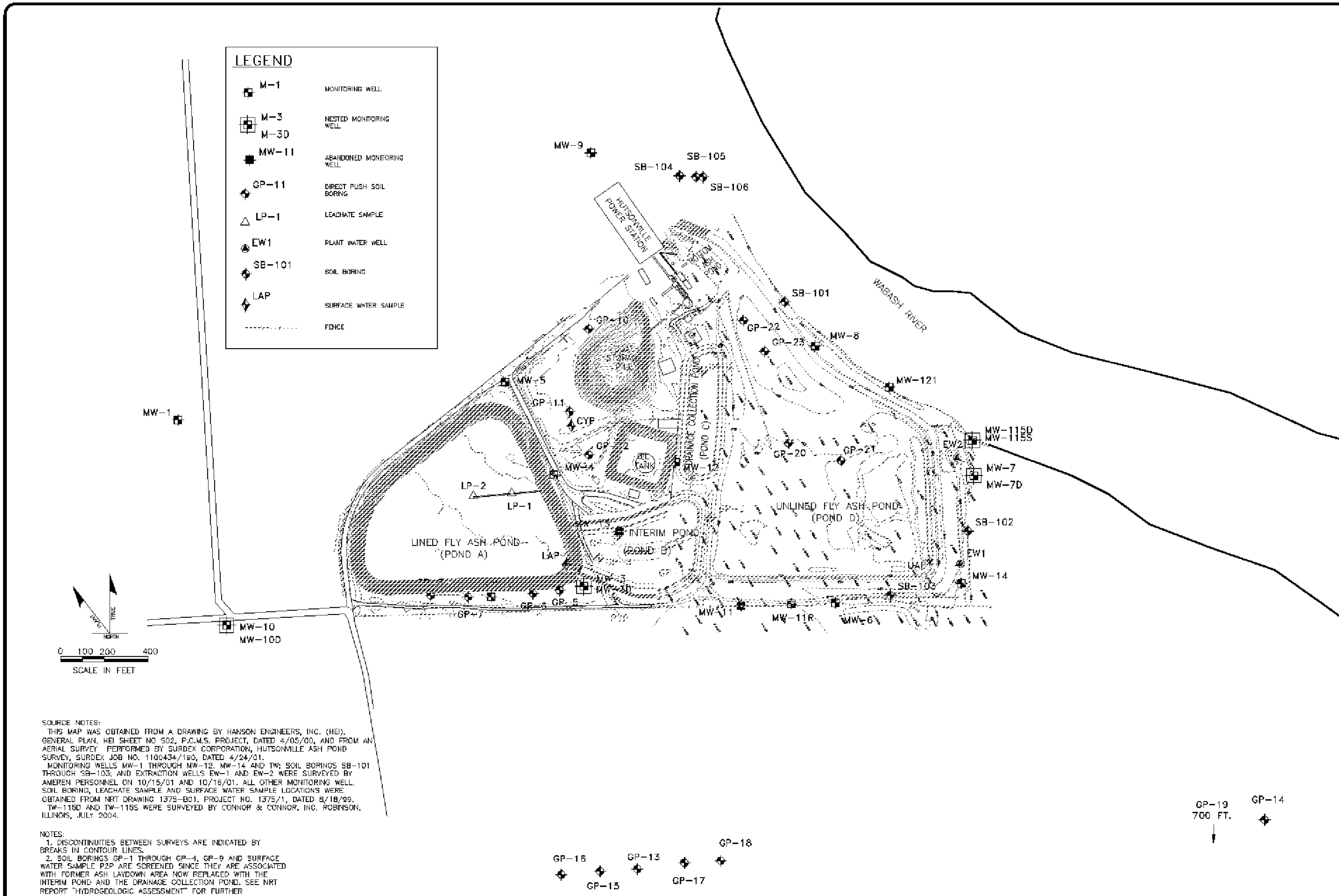
DRAWN BY: RLH 07/18/05 APP'D BY: BRH DATE: 07/18/05

SITE PLAN

LEACHATE MANAGEMENT AND FINAL COVER ALTERNATIVES REPORT
HUTSONVILLE POWER STATION–POND D CLOSURE
AMEREN ENERGY GENERATING, HUTSONVILLE, ILLINOIS

PROJECT NO.	1375/6.2
DRAWN BY:	BJK 03/05/08
CHECKED BY:	BGH 03/06/08
APPROVED BY:	BRH 03/05/08
DRAWING NO:	1375-62-B20
REFERENCE:	
FIGURE NO.	1

NATURAL RESOURCE TECHNOLOGY



SOURCE NOTES:
THIS MAP WAS OBTAINED FROM A DRAWING BY HANSON ENGINEERS, INC. (HEI). GENERAL PLAN, HEI SHEET NO S02, P.C.M.S. PROJECT, DATED 4/05/00, AND FROM AN AERIAL SURVEY PERFORMED BY SURDEX CORPORATION, HUTSONVILLE ASH POND SURVEY, SURDEX JOB NO. 1100434/190, DATED 4/24/01.
MONITORING WELLS MW-1 THROUGH MW-12, MW-14 AND TW; SOIL BORINGS SB-101 THROUGH SB-103; AND EXTRACTION WELLS EW-1 AND EW-2 WERE SURVEYED BY AMEREN PERSONNEL ON 10/15/01 AND 10/16/01. ALL OTHER MONITORING WELL, SOIL BORING, LEACHATE SAMPLE AND SURFACE WATER SAMPLE LOCATIONS WERE OBTAINED FROM NRT DRAWING 1375-B01, PROJECT NO. 1375/1, DATED 8/18/99.
TW-115D AND TW-115S WERE SURVEYED BY CONNOR & CONNOR, INC. ROBINSON, ILLINOIS, JULY 2004.

NOTES:
1. DISCONTINUITIES BETWEEN SURVEYS ARE INDICATED BY BREAKS IN CONTOUR LINES.
2. SOIL BORINGS GP-1 THROUGH GP-4, GP-9 AND SURFACE WATER SAMPLE P2P ARE SCREENED SINCE THEY ARE ASSOCIATED WITH FORMER ASH LAYDOWN AREA NOW REPLACED WITH THE INTERIM POND AND THE DRAINAGE COLLECTION POND. SEE NRT REPORT "HYDROGEOLOGIC ASSESSMENT" FOR FURTHER INFORMATION.

AMEREN SERVICES

GROUNDWATER MODEL EVALUATION OF IMPOUNDMENT CLOSURE OPTIONS

AMERENCIPS HUTSONVILLE POWER STATION
CRAWFORD COUNTY, ILLINOIS

PROJECT NO: 1375

GROUNDWATER MODEL EVALUATION OF IMPOUNDMENT CLOSURE OPTIONS

AMERENCIPS

HUTSONVILLE POWER STATION

JANUARY 2000

INTRODUCTION

Background

AmerenCIPS operates the Hutsonville Power Station in Crawford County Illinois. The Power Station is located on the west bank of the Wabash River between the Towns of Hutsonville and York (SW ¼, Section 17, Township 8N, Range 11W). The coal-fired power plant has been in operation since the 1940's. There are currently two units operating at the plant, completed in 1953 (unit 3) and 1954 (unit 4), with a combined generating capacity of 164 MW. Fly ash from the operating units is collected by an electrostatic precipitator and sluiced to a lined ash impoundment. Bottom ash is sluiced to a separate pond and eventually recycled. Sluice water from both the bottom ash pond and lined fly ash impoundment is routed through an unlined ash impoundment, before discharge to the Wabash River via an NPDES permitted outfall. The lined ash impoundment was constructed in 1986, and has an area of about 12 acres. Most of this area is ponded. The unlined impoundment was constructed in 1968, and has an area of about 17 acres. Only the southern portion of the unlined impoundment is ponded, the northern portion is dry. In addition to the impoundments, there is an ash laydown area between the impoundments that covers an area of about 6 acres. The ash laydown area is dry.

Groundwater quality has been monitored at this facility since 1984. Concentrations of boron, sulfate, and several other parameters exceed Illinois Class I groundwater standards at some monitoring wells. Boron and sulfate are indicator parameters for coal ash leachate in groundwater. A hydrogeologic assessment report for this facility was prepared in August 1999 by Science & Technology Management and Natural Resource Technology (NRT, 1999). That report describes hydrogeologic conditions and sources for elevated concentrations of boron, sulfate, and other constituents in groundwater. Monitoring wells and boring locations used in the hydrogeologic assessment, as well as site layout, are shown in Figure 1.

The purpose of this work was to model groundwater flow and transport at the site to predict the effect of different closure scenarios for the unlined impoundment on groundwater quality. Four closure scenarios were modeled:

- Dewatering[1] with no cap
- Dewatering with a native soil cap
- Dewatering with a compacted clay cap constructed as specified in Illinois Title 35 Part 811.314
- Dewatering with a synthetic barrier cap

Summaries from the hydrogeologic assessment are presented below, and modeling procedures, assumptions, and results are described in the following sections.

Summary of Hydrogeologic Assessment

The upland portion of the site is underlain by a thin layer of sandy sediments, which are underlain by sandstone bedrock. The lowland portion of the site in the Wabash River valley is underlain by alluvium that coarsens downward. Regional groundwater flow through these materials is predominantly northeast toward the Wabash River, although localized irregularities occur due to the unlined impoundment and past pipe leaks between the impoundments.

Groundwater samples from some sample locations had concentrations of boron, manganese, sulfate, TDS, iron, and nickel higher than Class I groundwater standards. High iron and nickel concentrations were found in locations where coal was present; however, there was no evidence that iron and nickel from the coal pile and coal spill areas is migrating beyond those areas. Manganese is ubiquitous in local groundwater, exceeding the Class I standard in background and downgradient groundwater. Boron and sulfate[2] are migrating east toward the Wabash River. The

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[1] Passive dewatering via gravity drainage is assumed for all scenarios.

[2] Because TDS is an indicator parameter rather than a specific constituent in groundwater, it does not migrate, but it

primary sources of boron were identified as the unlined impoundment and the ash laydown area between the impoundments, while the unlined impoundment, ash laydown area, and coal pile were all identified as sources of sulfate.

MODEL INVESTIGATION GENERAL APPROACH

Boron transport was modeled because it has high concentration in all source areas and is mobile in groundwater. The model was first calibrated to produce a head and concentration distribution representative of conditions while the unlined impoundment was in service. The calibrated model was then used as a starting point to predict changes in boron concentrations caused by removing the impoundment from service.

Three model codes were used to simulate groundwater flow and contaminant transport: 1) post-closure leachate percolation was modeled using the Hydrologic Evaluation of Landfill Performance (HELP) model; 2) groundwater flow was modeled in three dimensions using MODFLOW; and 3) contaminant transport was modeled in three dimensions using MT3DMS. The HELP model provided leachate percolation rates for input to MODFLOW, and MODFLOW calculated the flow field that MT3DMS used in the contaminant transport calculations.

Help Simulation of Closure Alternatives

Help Model Description

The Hydrologic Evaluation of Landfill Performance (HELP) code was developed by the U.S. Environmental Protection Agency and is used extensively in waste facility assessments. HELP predicts one-dimensional vertical percolation from a landfill or soil column based on precipitation, evapotranspiration, runoff, and the geometry and hydrogeologic properties of a layered soil and waste profile.

For this investigation, the most-recent version of HELP (Version 3.07; Schroeder et al., 1994) was selected to estimate percolation (i.e., water flux) from the impoundment for four closure

tends to be elevated where sulfate is elevated.

scenarios. The hydrologic data required by and entered into HELP are listed in Table 1 and described in the following paragraphs.

Help Model Set-up

Four closure scenarios were modeled:

- No Cap – assumes the impoundments were allowed to dewater and the ash uncapped with poor vegetative cover. This scenario assumes that measures are taken to facilitate surface water runoff.
- Native Soil Cap – a one-layer cap comprised of three feet of native soils with a fair grass cover.
- Compacted Clay Cap – a three-layer cap comprised (from top to bottom) of three feet of native soil with fair grass cover, three feet of low-permeability compacted clay, and a one foot gravel subbase.
- Synthetic Cap – a two-layer cap comprised (from top to bottom) of one foot of native soil with fair grass cover, and a 30-mil HDPE synthetic barrier material.

Each closure scenario was simulated for two impoundment cases. One impoundment case represented the southern portion of the unlined impoundment that is currently ponded, and the other represented the northern portion of the unlined impoundment that is dry. For all scenarios, the ash was assumed uncapped with no runoff during the first year (2001), while the impoundment dewatered and the closure alternative was enacted. Scenario-specific changes were simulated beginning the second year (2002) and through the end of the simulation (2010). A 10-year simulation (2001 through 2010) was sufficient for the system to reach equilibrium after enactment of the closure scenario.

Input Data

Climatic input variables were synthetically generated by the model using modified default values for Evansville, Indiana, and a latitude of 39.13° N for the Hutsonville Power Station. Rainfall frequency and temperature patterns for more than 100 cities are programmed into HELP. Evansville was selected as the closest city to Hutsonville. The model used Evansville's precipitation and temperature patterns with average monthly precipitation data recorded at the two closest monitoring stations with long-term records[3] to generate daily precipitation and temperature data.

Physical input data were based on the configuration of the impoundment, and a combination of measured and assumed soil properties. The ash was subdivided into three 60-inch thick sublayers. This subdivision resulted in more rapid percolation responses to surface changes, such as dewatering, than two 90-inch layers, yet provided the same results as six 30-inch thick layers. The 15-foot combined thickness of the ash layers represented the estimated thickness of ash above the water table after dewatering.

Hydrogeologic properties for the ash and cap soils were selected from the HELP database. For simulation of the ponded portion of the impoundment, initial moisture content of the uncapped ash was set equal to its porosity, as expected under saturated conditions. Dewatering of the saturated ash was then modeled for one year. Then the four closure scenarios were simulated with initial moisture content of the ash layers equal to the moisture content calculated by HELP at the end of the first (dewatering) year. Initial moisture content of the cap materials used in the closure scenarios was set equal to their field capacity. Initial moisture conditions for the dry part of the impoundment were simulated similarly to the ponded impoundment, except that values for the first year were set by the model based on average climatic conditions.

The HELP modeling assumed that sluicewater discharge to the impoundment (for the wet impoundment scenario) ceased immediately before the simulation began, the cap was instantaneously placed at the end of the first year, the cap materials and ash had uniform texture and hydraulic properties, there was no lateral groundwater flow into or out of the impoundment, and all leakage to groundwater was vertical. Other assumptions inherent in the model are listed in Schroeder et al. (1994).

[3] Precipitation recorded at the Hutsonville power station and average temperature data recorded at Palestine, Illinois.

Help Model Execution

Two types of HELP simulations were performed: sensitivity analysis and prediction analysis. The sensitivity analysis was performed to identify critical factors affecting performance of the proposed closure scenarios. The prediction analysis was conducted to estimate percolation rates for each closure scenario, which were later input to the groundwater flow model.

Help Model Results

Sensitivity analysis

Sensitivity analysis results are presented in Table 2. The model was sensitive to vegetation assumptions, which affect calculation of evapotranspiration and runoff, and the hydraulic properties of the cap materials. The most sensitive parameters were ash permeability, the vegetation assumption used in the runoff calculation, and placement quality of the synthetic cap material, which changed total predicted flux by 8 to -42 percent, 30 to -36 percent, and 104 to 3 percent, respectively. The large change for placement quality occurred when a defect density for poor placement was assumed. All other parameters changed flux by less than 20 percent. The model was not sensitive, within tested ranges, to the thickness and presence of a gravel subbase and to soil runoff parameters other than vegetation.

This analysis indicates that the model is sensitive to selected input parameters. The parameters used for the prediction runs represent conservatively reasonable estimates and assumptions of current and future conditions at the unlined ash impoundment.

Prediction analysis

Model results for the wet portion of the impoundment show a 97 percent decrease in monthly percolation flux by the end of the first year due to impoundment dewatering (Figure 2a). Differences between the closure scenarios were negligible, compared to the decrease in flux due to dewatering (Figure 2b); however, the scenarios with a clay or synthetic cap performed slightly better than the scenarios with no cap or a native soil cap (Figure 2c).

Model results for the dry portion of the impoundment show no initial decrease (Figure 3a), which is expected since these scenarios did not assume saturated ash or surface ponding. Annual leachate percolation flux after the first year is similar to that predicted for the wet portion of the impoundment (Figures 3b, 3c).

The significance of the predicted differences in leachate percolation flux on groundwater quality near the Hutsonville unlined ash impoundment was tested by inputting these values into a groundwater flow and transport model, which is described below.

Groundwater Flow/Contaminant Transport Modeling

Flow and Transport Model Descriptions

MODFLOW uses a finite difference approximation to solve a three-dimensional head distribution in a transient, multi-layer, heterogeneous, anisotropic, variable-gradient, variable-thickness, confined or unconfined flow system—given user-supplied inputs of hydraulic conductivity, aquifer/layer thickness, recharge, wells, and boundary conditions. The program also calculates water balance at wells, rivers, and drains.

MODFLOW was developed by the United States Geological Survey (McDonald and Harbaugh, 1988), has been extensively tested for accuracy (van der Heijde and Elnawawy, 1993), and is the most widely used code for groundwater model applications (Rumbaugh and Ruskauff, 1993). Major assumptions of the code are: 1) groundwater flow is governed by Darcy's law; 2) the formation behaves as a continuous porous medium; 3) flow is not affected by chemical, temperature, or density gradients; and 4) hydraulic properties are constant within a grid cell. Other assumptions concerning the finite difference equation can be found in McDonald and Harbaugh (1988).

MT3DMS (Zheng and Wang, 1998) is the latest version of MT3D. It calculates concentration distribution for a single dissolved solute as a function of time and space. Concentration is distributed over a three-dimensional, non-uniform, transient flow field. Solute mass may be input at discrete points (wells, drains, river nodes, constant head cells), or areally distributed evenly or unevenly over the land surface (recharge).

MT3DMS accounts for advection, dispersion, diffusion, first-order decay, and sorption. Sorption can be calculated using linear, Freundlich, or Langmuir isotherms. First-order decay terms may be differentiated for the adsorbed and dissolved phases.

The program uses a finite difference solution, third-order total-variation-diminishing (TVD) solution, or one of three Method of Characteristics (MOC) solutions. The finite difference solution can be prone to numerical dispersion for low-dispersivity transport scenarios, and the MOC solutions sometimes fail to conserve mass. The TVD solution is not subject to numerical dispersion and conserves mass well, but is computationally intensive.

For this modeling, the TVD solution was attempted first; however, results outside the area of interest were anomalous (e.g., in the thousands and negative thousands). Therefore, the finite difference solution was used, resulting in similar concentrations as the TVD solution within the area of interest and concentrations near zero outside the area of interest. Zheng and Wang (1998) indicated that the effects of numerical dispersion are minimal when grid Peclet[4] numbers are smaller than 4.0. Since a Peclet number of 3.3 was maintained for this analysis[5], the finite difference solution is acceptable.

MT3D has been tested and verified, and is widely used (van der Heijde and Elnawawy, 1993). Major assumptions are: 1) changes in the concentration field do not affect the flow field; 2) changes in the concentration of one solute do not affect the concentration of another solute; 3) chemical and hydraulic properties are constant within a grid cell; and 4) sorption is instantaneous and fully reversible, and decay is not reversible.

Flow and Transport Conceptual Model

Hydrostratigraphy, developed from boring logs collected during plant construction (1954), original monitoring well installation (1984), and the hydrogeologic assessment (1999) indicate that the upland area near the impoundment consists of sand and gravel of varying thickness,

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[4] Peclet number (Pe) = Grid spacing divided by longitudinal dispersivity.

[5] $Pe = 100 \div 30 = 3.3$

typically 10 to 20 feet, underlain by 15 to more than 30 feet of sandstone. The upper sand appears to grade to a fine-grained silty clay toward the northern portion of the plant site. A thick shale unit underlies the sandstone at an approximate elevation of about 415 to 420 feet. The Wabash River valley contains a relatively fine-grained alluvium from land surface to an elevation of about 410 to 415 feet, underlain by sand and gravel to an elevation of about 350 feet.

The primary direction of groundwater flow is east, discharging into the Wabash River and its tributaries—a regional groundwater sink. There are three sources of water: natural recharge within the model domain, percolation water from the impoundment, and groundwater flow from the west.

Flow and Transport Model Set-up

Modeling was conducted in multiple steps. First, the flow model was calibrated to current conditions (e.g., active use of the impoundment) as represented by heads measured in November 1998. This measurement event was selected because all new wells installed for the hydrogeologic assessment were measured at that time, and because river elevation and groundwater elevation (head) values at older wells were near long-term median values. Next the transport model was run, and model predicted concentrations were calibrated to observed boron concentration values. These calibration runs were conducted assuming steady state flow. Multiple iterations of flow and transport model calibration were conducted to achieve an acceptable match to observed data. Sensitivity analyses were then conducted to test the effect of selected parameters on model results.

Once the model was calibrated and tested for sensitivity, prediction modeling was performed. Monthly leachate percolation rates predicted by HELP were used to simulate dewatering during the first year, then annual percolation rates were used to simulate the effects of the four closure scenarios for 19 years—total simulation time was 20 years. The MODFLOW model allowed use of both HELP cases (ponded and not ponded) at the same time. Decreasing percolation rates were simulated using a time-dependent specified flux (recharge) boundary. Leachate concentrations in percolation (recharge) water were held constant in this analysis. Four prediction scenarios were modeled, one for each closure scenario modeled with HELP.

Grid and Boundaries

A four layer, 56 by 60 node grid was established with variable grid spacing ranging from 100 feet to 500 feet in length parallel to the primary flow direction and 100 feet to 500 feet perpendicular to the primary flow direction (Figure 4). The largest node spacings were near the upgradient and lateral model boundaries, and the finest node spacings were along the river and near the impoundment.

Flow and transport boundaries (Figure 4, Appendix A) were the same for all scenarios. The upgradient edge of the model was a constant head (Dirichlet) boundary. The lower and lateral boundaries were no-flow (Neumann) boundaries. The downgradient boundaries were either MODFLOW river (Mixed) boundaries (layers 2-4) or no flow (layer 1). The upper boundary was a time-dependent specified flux (Neumann) boundary, with specified flux rates equal to the recharge rate or the rate of percolation from the impoundment.

Two types of transport boundaries were used. Specified mass flux (Cauchy condition) boundaries were used to simulate downward percolation of solute mass in areas where the source was above the water table, and constant concentration (Dirichlet condition) boundaries were used in areas where the source (i.e., coal ash) was below the water table. The former boundary condition assigns a specified concentration to recharge water entering the cell, and in this application the resulting concentration in the cell is a function of the relative rate and concentration of water percolating from the ash compared to the rate and concentration of groundwater flow. The latter boundary type assigns the specified concentration to all water passing through the cell.

Flow Model Input Values and Sensitivity

Flow model input values are listed in Table 3 and described below.

<u>Aquifer Top/Bottom.</u> Groundwater in the upper sand aquifer is unconfined, therefore the top of the aquifer was the water table and the elevation of the top model layer was set at 460 feet, a value higher than the water table elevation of 427 to 450 feet. The top of layers 2-4 was the base of the overlying layer.

The base of the upper sand unit was determined by contouring bedrock elevation and importing the contour data into MODFLOW. The corresponding base elevations for layer 1 were between 424 and 450 feet. The base of the second layer corresponded to the base of the sandstone, 418 feet. The base of the third layer corresponded to the top of the valley fill sand unit, 412 feet. The base of the bottom layer (350 feet) corresponded to the base of the unlithified fill in the Wabash River valley.

Layer one of the model included a zone with hydraulic conductivity representing coal ash. This zone was also used as a source area, representing saturated ash, during prediction modeling. The base elevation of this zone was based on contouring, as was the rest of model layer 1. Base elevations were contoured from 424 to 444 feet.

Hydraulic Conductivity. Hydraulic conductivity values (Appendix A) were initially derived from field measured values, then adjusted during calibration. The largest variation from initial field values was for the alluvium, where the modeled value of 30 ft/d (compared to a single field measured value of 0.7 ft/d at MW-7) was necessary for flow calibration; and across the northern portion of layer 1, where a value of 0.1 ft/d (compared to values of 1 to 2 ft/d at MW-9 and MW-10) resulted in best head match.

Vertical anisotropy ratios were set at 2.0 everywhere except the alluvium, where a ratio of 10 was the lowest possible without affecting calibration. The larger Kx/Kz ratio represented expected stratification within the alluvium.

The shale bedrock underlying the sandstone was not discretely modeled. Rather, cells representing shale, all in layers 3 and 4, were set with no-flow boundary conditions. This setting inherently assumed that groundwater flow in the shale was negligible.

Model sensitivity to hydraulic conductivity ranged from negligible to high. The model was most sensitive to the layer 1 sand unit and the layer 2 sandstone, and was generally not sensitive to vertical hydraulic conductivity.

Storage. No field data were available defining these terms, so representative values for similar materials were obtained from Smith and Wheatcraft (1993). The storage term had no effect on model calibration because it was calibrated at steady state, however it did slightly effect the rate at which groundwater elevation decreased as percolation rates decreased (representing dewatering of the pond). This effect on groundwater elevation had a corresponding slight effect on predicted concentrations as the impoundment dewatered, but no effect on long term concentrations. Therefore, the model is insensitive to this parameter.

Recharge. Recharge rates for the unlined impoundment (i.e., percolation) were based on HELP results. For simplicity, HELP results were averaged for periods where there was little change in predicted percolation rate (Figure 5). Recharge rates for the rest of the model domain were set during calibration. Recharge zones are illustrated in Appendix A.

River Parameters. The Wabash River and tributaries were represented by head-dependent flux nodes that required inputs for river stage, width, bed thickness, and bed hydraulic conductivity. The latter three parameters are used to calculate a conductance term for the boundary node. This conductance term was determined by adjusting hydraulic conductivity during model calibration, while bed thickness was set at 1 (i.e., bed hydraulic conductivity represented conductance normalized for river width and bed thickness). River stage for the Wabash River was set near mean stage, the approximate elevation in November 1998, and adjusted slightly during calibration. River stage for the tributaries was determined from USGS topographic maps.

Sensitivity analysis showed that the model was highly sensitive to the presence of the rivers and tributaries, but not very sensitive to the conductance term used.

Transport Model Input Values and Sensitivity

Transport model input values are listed in Table 4 and described below.

Initial Concentration. Initial concentration for the calibration run was set at zero. Initial concentration for the prediction runs was the final calibration concentration.

Source Concentration. Two primary sources were simulated. For calibration runs, which simulated current conditions, the primary source was percolating water from the unlined impoundment. After the impoundment dewaters, the dominant source is expected to be leaching of ash in the unlined impoundment that remains below the water table. Therefore, a second primary source term, representing the saturated ash, was added for prediction scenarios, beginning two years after the impoundment is removed from service. This assumes that mass loading at that time will be primarily from leaching of ash below the water table, rather than percolation from the impoundments. Mass loading for the saturated ash source term was a function of groundwater velocity in the cells representing saturated ash and the saturated thickness of those cells.

Concentrations at several wells were sensitive to the concentration of the percolation source term. Only well MW-8 was sensitive to the concentration of the saturated ash source term, and resulting concentrations at this well varied greatly with changes in saturated source concentration. Concentrations at MW-7 were not significantly influenced by the saturated ash source term during the period simulated.

Secondary sources were the lined impoundment and the coal pile. Concentrations for these two sources were set at 20 and 2 mg/L respectively, based on concentrations in leachate samples obtained during the hydrogeologic investigation.

Effective Porosity. Effective porosity values were based on ranges provided by Mercer and Waddel (1993). Predicted concentrations were not sensitive to this term, so it was not adjusted during calibration.

Dispersivity. One well (MW-3) was highly sensitive to dispersivity values, and the value of 30 ft was selected during calibration based on predicted concentration at that well. Transverse and vertical dispersion were estimated according to ratios developed by Gelhar et al. (1985).

Retardation. Retardation is calculated by the model based on the distribution coefficient (Kd). The Kd value used for the sandy materials in this model (0.17 mL/g) was based on testing performed by NRT for similar materials in another state. The Kd value for the silt materials (0.85 mL/g) was assumed a factor of five higher than for sand. While concentrations at several wells varied with Kd, no concentrations varied by more than 10 percent, so this number was not adjusted during calibration.

Flow and Transport Model Assumptions and Limitations

Several simplifying assumptions were made while developing this model:

- The impoundment dewaters for one year
- For closure scenarios with caps, the cap is placed on the impoundment at the end of the first year
- Leachate is assumed to instantaneously reach groundwater (e.g., migrate through the unsaturated zone)
- River stage and natural recharge are assumed constant over time
- Leachate concentrations are assumed to remain constant over time

The model is limited by the data used for calibration, which adequately define the local groundwater flow system and the sources and extent of the plume. These data are from points near the Hutsonville ash impoundments. Groundwater flow data were representative of data collected during the 1980s and 1990s, while concentration data are mostly representative of data collected during the late 1990s. Therefore, model predictions of transport distant from the impoundment will not be as reliable as predictions of transport near the impoundment, and the reliability of model predictions decreases with increasing time.

Flow and Transport Model Results

Calibration

The model was first calibrated to observed groundwater head data collected in November 1998, and then to observed concentration data mostly collected from November 1998 through May 1998. An exception to the concentration date range was made for wells MW-2 and MW-3. Boron concentrations at these wells were affected by a leaking pipe that was not simulated in the model because the volume of the pipe leak was unknown, the leak was temporary (i.e., transient) and the calibration was performed for steady state conditions. Therefore, these wells were calibrated to the concentration range recorded prior to the pipe leak.

Head calibration results were generally good, with modeled heads generally within 1-foot of target heads (Figure 6a and Figure 7a), particularly between and downgradient of the impoundments. The areas of largest discrepancy were near MW-6, MW-9, and MW-11. The discrepancy at MW-9 is acceptable given its distance from the impoundments and the sparse geologic data in that area. The discrepancies at MW-6 and MW-11 are likely due to the close proximity of these wells to the unlined impoundment, where heads change rapidly over a short distance. Given this observation, and considering that concentration match for these two wells was acceptable, the head discrepancy is also considered acceptable.

Concentration calibration was within the range of observed concentrations at most monitoring wells (Figure 6b and Figure 7b). The model calculated elevated boron concentrations at wells with observed boron concentrations greater than Class I standards, and generally did not show elevated boron concentrations for wells with low boron concentrations. The two notable exceptions, for wells MW-7D and MW-12, were both cases where the model calculated higher concentrations than observed. The low observed concentration at MW-7D could not be replicated without using unrealistically low hydraulic conductivities, and would have probably required several additional model layers to simulate. The high concentration at MW-12 is likely due to model discretization. Concentration match may have improved with a finer grid spacing; however, this result was conservatively high, and such a grid spacing was considered unwarranted. Slightly low concentrations were predicted for MW-6 and MW-13. The concentration discrepancy at MW-6 was likely due to model discretization, similar to MW-12. The discrepancy at MW-13, where observed boron concentration is higher than any other monitoring well on site, is likely related to the pipe leak that was not simulated.

Prediction

Modeling was performed to predict effects of impoundment dewatering and closure on groundwater quality. Closure effects were simulated by decreasing the MODFLOW recharge rate in the area beneath the unlined impoundment and ash laydown area. The recharge rate for the wet and dry portions of the unlined impoundment was decreased as illustrated in Figures 2 and 3. In addition, it was assumed that the ash laydown area would be treated similarly to the dry portion of the unlined impoundment.[6]

[6] A similar result would be expected if the ash was removed from this area.

The results suggest boron concentration decreases of 40 percent to more than 90 percent between the impoundments (Table 5; Figure 8a), but little decrease, and even some increase at downgradient monitoring wells MW-7 and MW-8 (Figure 8b). Long-term change at MW-6 was not predicted by the model because predicted groundwater elevation fell below the bottom of the well. Concentration at downgradient well MW-8 was dependent on the assumed leachate concentration from the saturated ash zone (Figure 9).

Comparison of predicted areal distribution in 2021 (Figures 10-13) to current areal distribution (Figure 7b) shows lower concentration in the area between the impoundments, and less plume extent to the south. Areal differences between the four closure scenarios are primarily reflected in the lower concentrations in the ash laydown area and south of the impoundment, and to a lesser extent, beneath the southern half of the unlined impoundment.

An interesting result of the modeling is the predicted increase in concentration at MW-3, MW-11, MW-7 and MW-8. The slight, temporary increase at MW-3 is due to shifting groundwater flow patterns between the two impoundments. The increase at the other wells is caused by the saturated ash source zone simulated in the model, which has higher concentration than percolation from the unlined impoundment. The effect is temporary at MW-11, which is sidegradient, because the mound eventually dissipates and the effects of the unlined impoundment on this well dissipate with the mound. However, the increase is permanent at MW-7 and MW-8, which are directly downgradient of the saturated ash zone. NRT has observed similar increases at other impoundments during or shortly after dewatering. This concentration increase results from increased water contact time with the ash, which is a result of decreasing percolation rate. For cases where the ash is above the water table, this increase is temporary and concentrations eventually decrease as percolation rates continue to decrease. However, these model results suggest that the effect may be long-term for a case where ash is below the water table.

Groundwater Loading Rate to the Wabash River

The model was used to calculate boron loading rate in groundwater discharge to the Wabash River and tributaries. The results of this analysis indicated an 83 to 89 percent decrease in loading rate 20 years after the impoundment is closed, depending on closure scenario, with the majority of this decrease occurring after the first two years (Figure 14). This decrease in loading rate is similar to the decrease in percolation rate predicted with the HELP model. Based on this observation, the loading rate is most significantly affected by dewatering the impoundment, rather than the presence or type of cap.

Comparison of Closure Scenarios

The model results suggest little practical difference between the closure scenarios. The most noticeable difference occurred in the area between the impoundments (MW-13) where boron concentrations predicted with the clay and synthetic cap scenarios were lower than the Class I standard, while boron concentrations predicted with the no cap and the native soil cap scenarios were higher than the standard. However, no closure scenario resulted in improved groundwater quality in the downgradient wells. This lack of improvement was due to assumed continued leaching from the saturated ash beneath the unlined impoundment. Therefore, downgradient groundwater is predicted to have continuing exceedances of the Class I boron standard for all closure scenarios.

Despite the lack of downgradient concentration decrease, the model predicts decreased boron loading to the Wabash River by almost two orders of magnitude under any of the closure scenarios. This loading rate reduction occurs while downgradient concentrations increase because the hydraulic gradient decreases greatly as the impoundment dewaters, causing a corresponding reduction in groundwater velocity and discharge rate to the river. These model results suggest that:

- None of the closure alternatives will adequately control downgradient boron concentration, although all of the alternatives will reduce loading rate to the Wabash River; and
- Differences in overall performance of the four closure alternatives is not significant compared to the benefit obtained by dewatering the impoundment.

Implications for Other Parameters in Ash Leachate

Other analytes that exceeded Class I standards at the Hutsonville impoundment were iron, manganese, nickel, pH, sulfate, and TDS (NRT, 1999).

Iron exceedances were only found in direct-push samples near the coal pile, while nickel and pH exceedances were found in direct-push samples near the coal pile and in groundwater monitoring wells (MW-11 and MW-13) near localized areas where coal had been spilled or stormwater runoff from the coal pile accumulates. The limited occurrence of these parameters indicates much less mobility in groundwater than boron. Additionally, iron and nickel typically had low concentrations in the ash leachate while pH was neutral to alkaline. Action to control water percolation near MW-11 and MW-13 will likely result in decreasing concentrations of iron and nickel as pH in groundwater increases. Because iron and nickel are less mobile than boron, their rate of decrease may be slower than the rate of boron concentration decrease. No changes in pH, iron, or nickel concentrations would be expected downgradient of the impoundment, where concentrations are within Class I standards.

Manganese exceeds Class I standards throughout the site, including the upgradient wells, and exhibits highest concentration near the impoundments. Since it is present in ash leachate, it is expected that manganese will continue to leach from saturated ash and exceed Class I standards after a closure alternative is enacted. Neither manganese nor iron, nickel, and pH can be reliably modeled because these parameters are highly sensitive to chemical or REDOX conditions that current groundwater transport models do not simulate.

Sulfate is similarly mobile, or more mobile, than boron, and TDS is an indicator based mostly on mobile parameters such as sulfate. Therefore, these parameters can be expected to behave similarly to the modeled boron, and should not be expected to meet standards in downgradient wells. Loading rates to the Wabash River would decrease similarly to boron under the modeled closure scenarios.

CONCLUSIONS

- HELP modeling suggests that dewatering the Hutsonville impoundment will result in a 97 percent decrease in leachate percolation to groundwater from the ponded portion of the impoundment after 1 year. This decrease due to dewatering is considerably larger than the additional decrease attained after simulation of four closure alternatives.
- Modeling of closure alternative performance with a coupled groundwater flow/transport model suggests that no alternative will result in downgradient concentrations meeting

Class I standards because saturated ash in the unlined impoundment will continue to leach.

- Even though model results indicated that Class I standards will not be met, predicted boron mass loading rate to the Wabash River decreased by 83 to 89 percent under the modeled closure scenarios. This decrease occurs because the hydraulic gradient and groundwater velocity are reduced as the impoundment dewaters. The presence or type of cap had minimal effect on modeled mass loading rate.
- For other analytes that exceed Class I groundwater standards; iron, nickel, and pH concentrations should improve, perhaps at a slow rate, if action is taken to limit infiltration in areas where coal was spilled and coal pile runoff accumulates. Manganese, sulfate, and TDS may continue to leach from saturated ash; therefore, downgradient concentrations may not improve after the impoundment is closed, although mass loading rates for these constituents should decrease similarly to that modeled for boron.
- The area of impacted groundwater predicted with the synthetic liner scenario was less extensive than the other scenarios. However, those differences were upgradient and sidegradient of the unlined impoundment. Based on downgradient performance, no closure scenario was inherently better than the others because downgradient concentrations are not predicted to meet Class I groundwater standards, and the boron loading rate to the river decreases similarly under all four scenarios.

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Natural Resource Technology appreciates the opportunity to prepare this modeling report. If there are any questions, please contact the individual listed below.

Bruce Hensel, P.G.
Senior Hydrogeologist

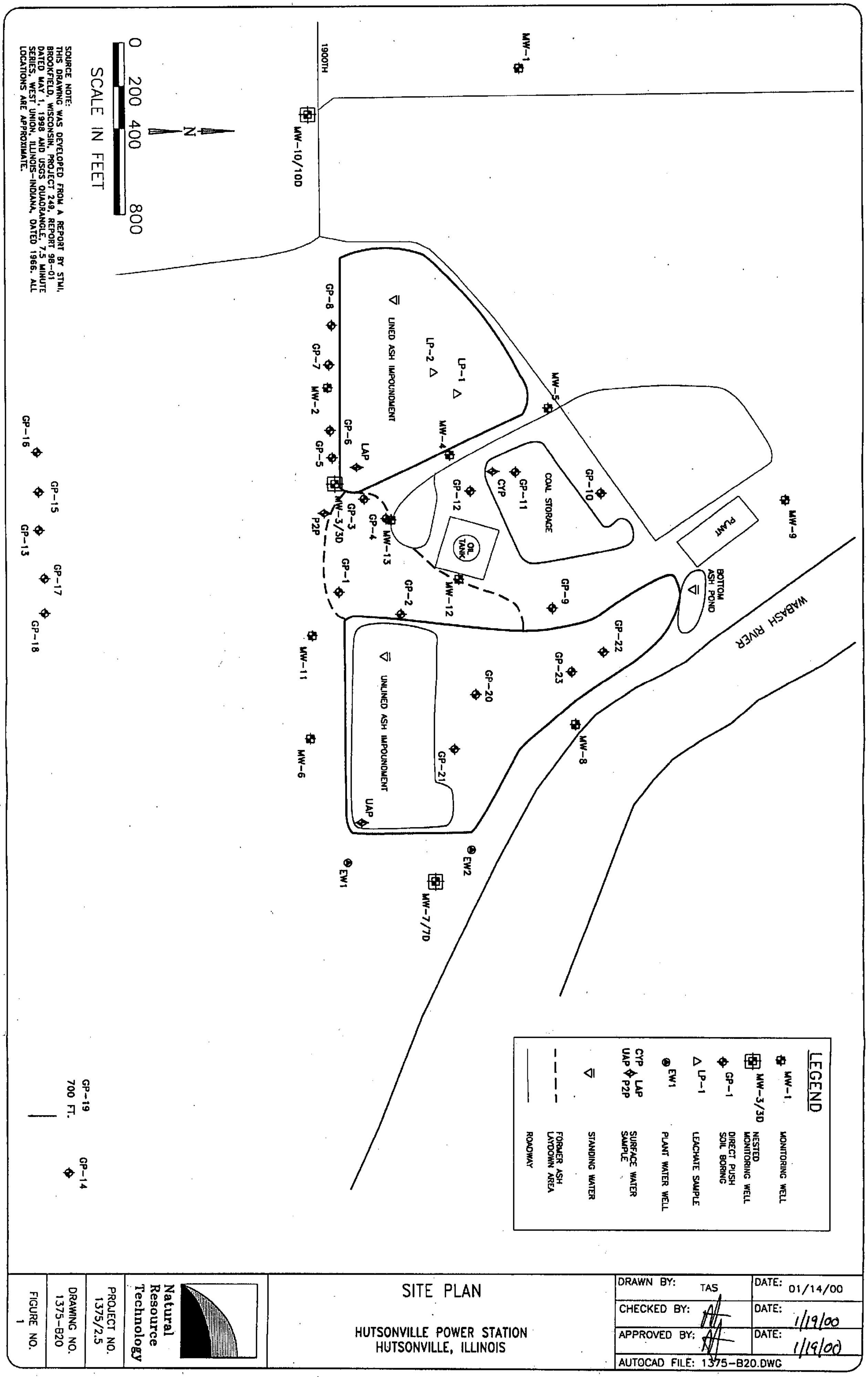
FIGURES

TABLES

APPENDICES

Data disk on back cover

FIGURES


SOURCE NOTE:
THIS DRAWING WAS DEVELOPED FROM A REPORT BY STMI, BROOKFIELD, WISCONSIN, PROJECT 249, REPORT 98-01 DATED MAY 1, 1998 AND USGS QUADRANGLE, 7.5 MINUTE SERIES, WEST UNION, ILLINOIS-INDIANA, DATED 1966. ALL LOCATIONS ARE APPROXIMATE.
0 200 400 800
SCALE IN FEET
N
1900TH
MW-1
MW-10/10D
LINED ASH IMPOUNDMENT
LP-1
LP-2
GP-8
GP-7
MW-2
GP-6
GP-5
LAP
MW-5
MW-4
GP-12
CYP
GP-11
COAL STORAGE
GP-10
PLANT
MW-9
MW-3/3D
GP-3
GP-4
P2P
MW-13
OIL TANK
MW-12
GP-1
GP-2
GP-9
BOTTOM ASH POND
WABASH RIVER
GP-22
GP-23
GP-20
GP-16
GP-15
GP-13
GP-17
GP-18
MW-11
UNLINED ASH IMPOUNDMENT
GP-21
UAP
MW-6
MW-8
EW1
EW2
MW-7/7D
GP-19
700 FT.
GP-14
LEGEND
MW-1 MONITORING WELL
MW-3/3D NESTED MONITORING WELL
GP-1 DIRECT PUSH SOIL BORING
LP-1 LEACHATE SAMPLE
EW1 PLANT WATER WELL
CYP LAP UAP P2P SURFACE WATER SAMPLE
STANDING WATER
FORMER ASH LAYDOWN AREA
ROADWAY
Natural Resource Technology
PROJECT NO. 1375/2.5
DRAWING NO. 1375-B20
FIGURE NO. 1
SITE PLAN
HUTSONVILLE POWER STATION
HUTSONVILLE, ILLINOIS
DRAWN BY: TAS
DATE: 01/14/00
CHECKED BY:
DATE: 1/19/00
APPROVED BY:
DATE: 1/19/00
AUTOCAD FILE: 1375-B20.DWG

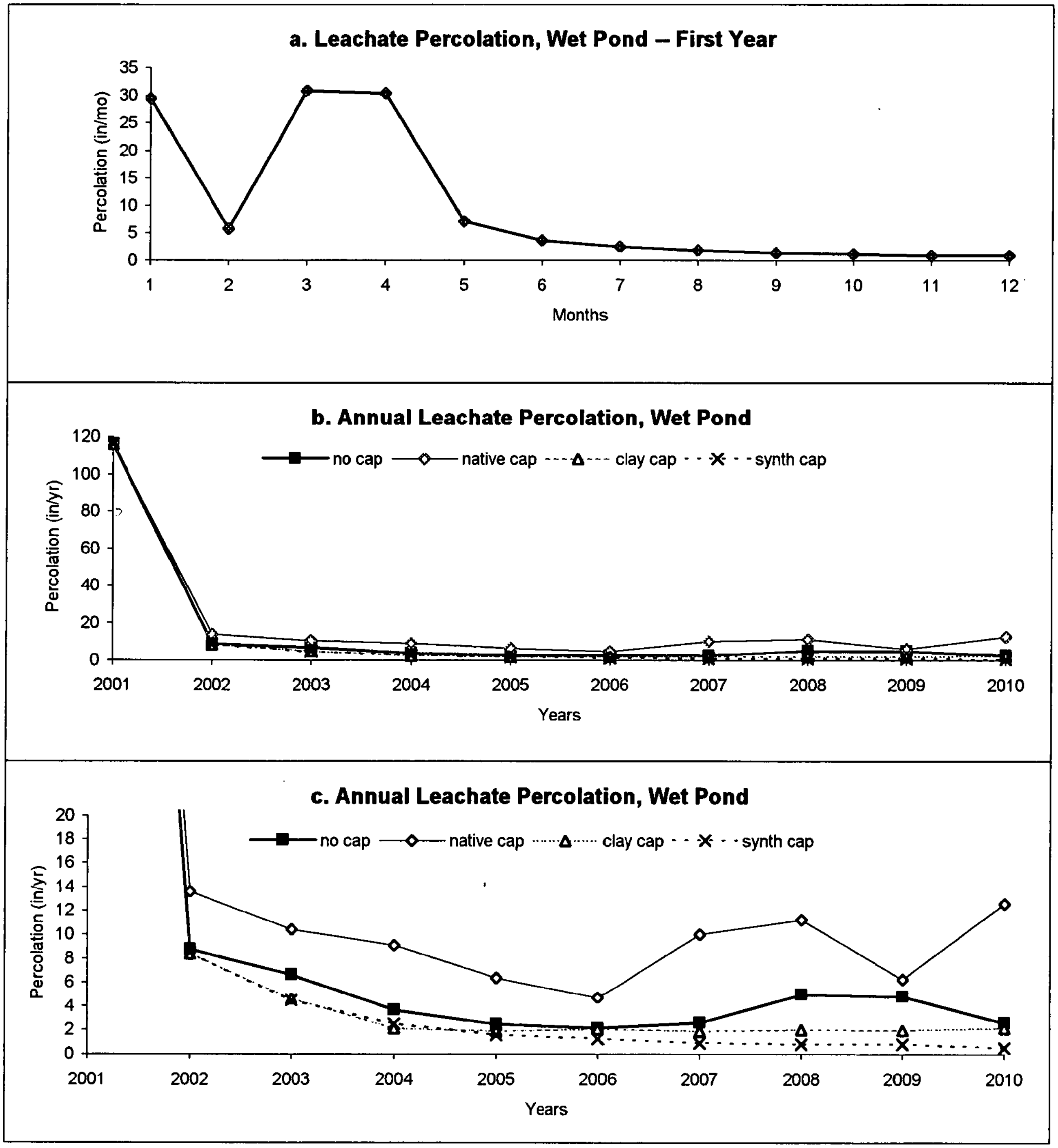


Figure 2. Results of HELP modeling for wet portion of Hutsonville unlined ash impoundment: a) predicted monthly percolation while the impoundment dewaters; b) predicted annual leachate percolation flux over a 10 year period; c) predicted annual leachate percolation flux over a 10 year period with the y-scale truncated at 20 in/yr. The relatively low percolation rate observed for month 2 is due to model simulation of frozen soil conditions. Increases in percolation rate during model years 2007, 2008, and 2010 are due to high modeled precipitation rates.

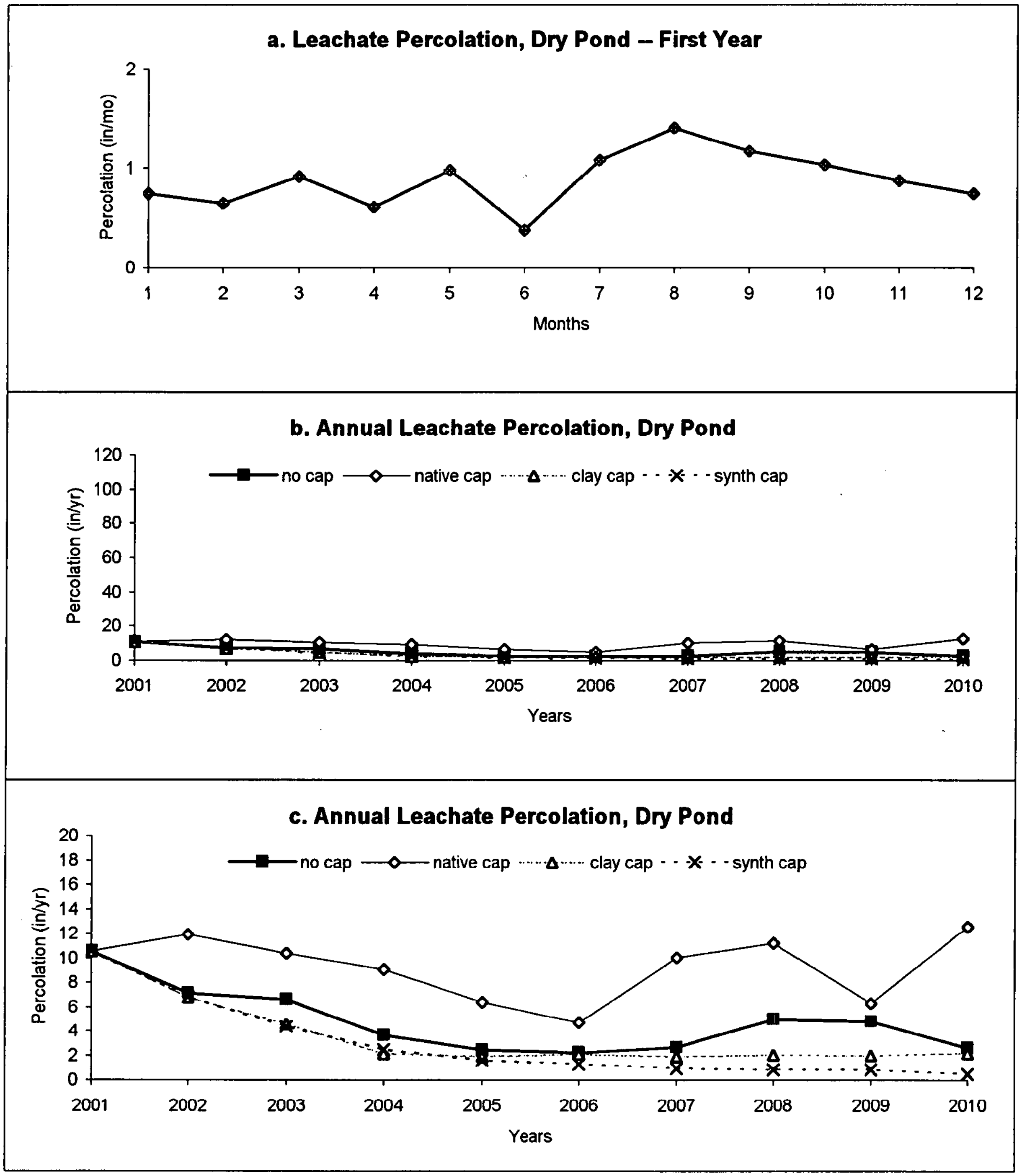


Figure 3. Results of HELP modeling for dry portion of Hutsonville unlined ash impoundment: a) predicted monthly percolation while the impoundment dewaters; b) predicted annual leachate percolation flux over a 10 year period; c) predicted annual leachate percolation flux over a 10 year period with the y-scale truncated at 20 in/yr (for comparison, scales on b. and c. are the same as Figure 2). Increases in percolation rate during model years 2007, 2008, and 2010 are due to high modeled precipitation rates.

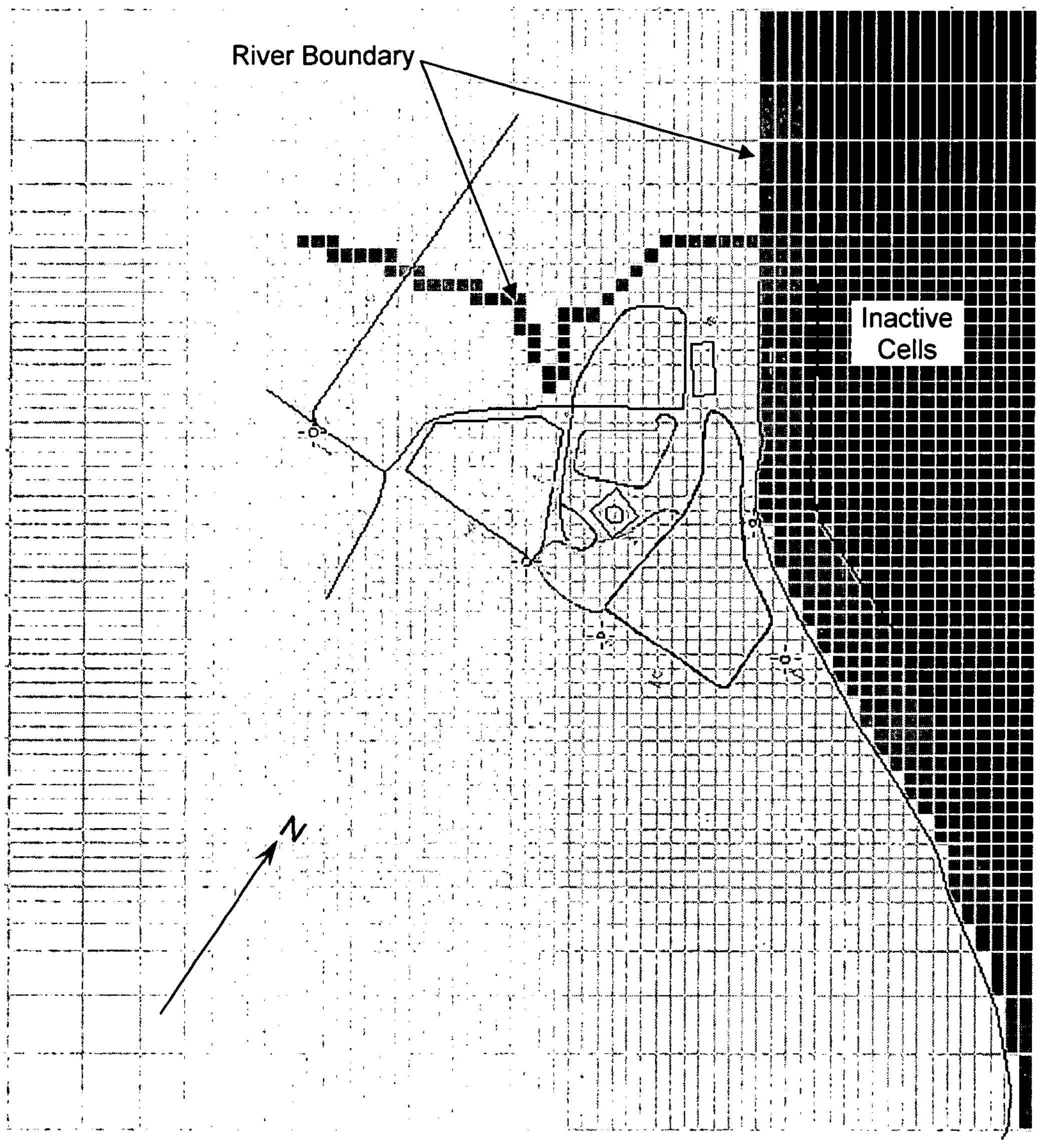


Figure 4. Model grid - Layer 2 - showing boundary conditions. Boundary conditions for layers 1,3,4 are shown in Appendix A.

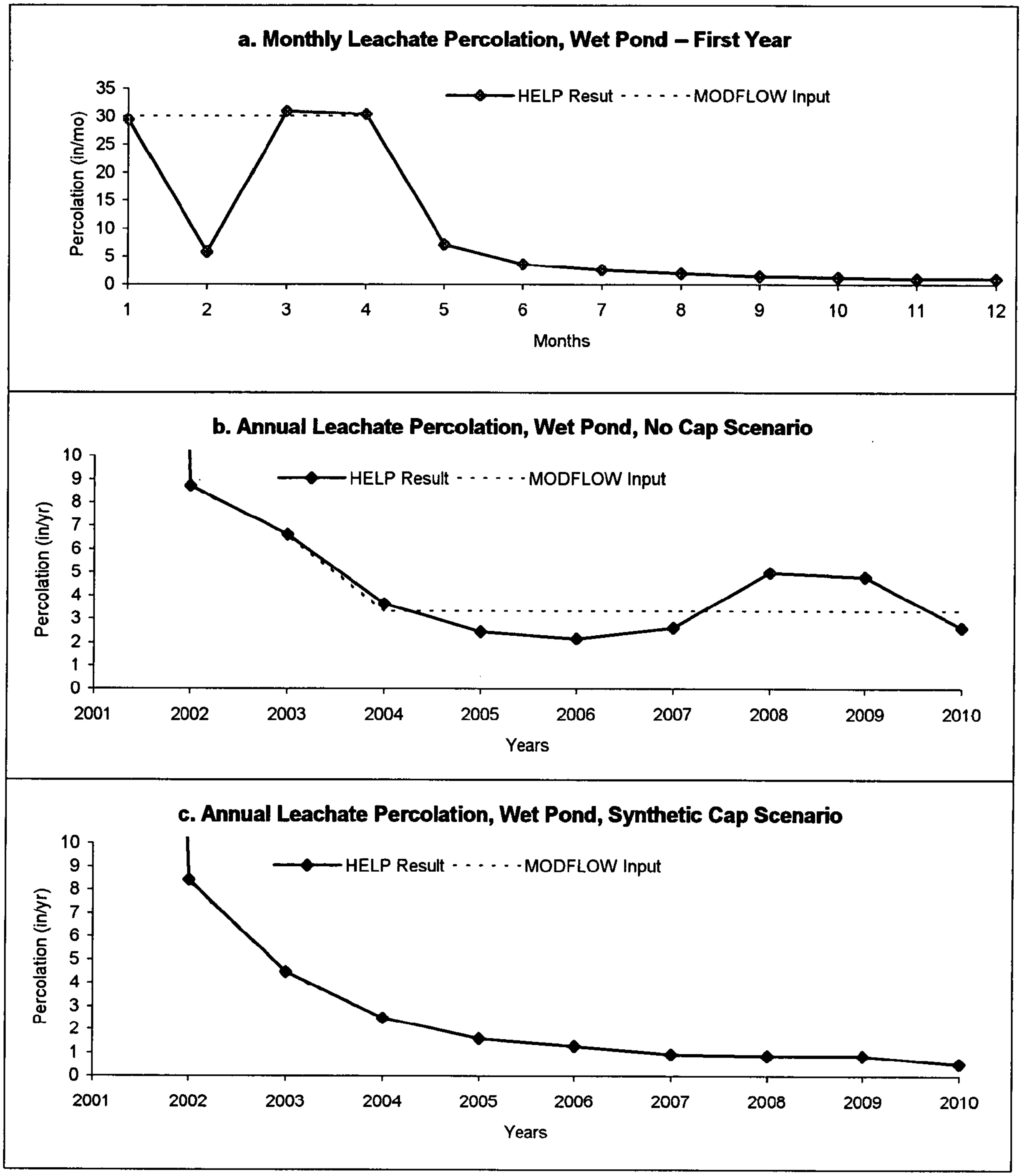


Figure 5. Example simplification of HELP results for input to MODFLOW. Other scenarios were similarly simplified.

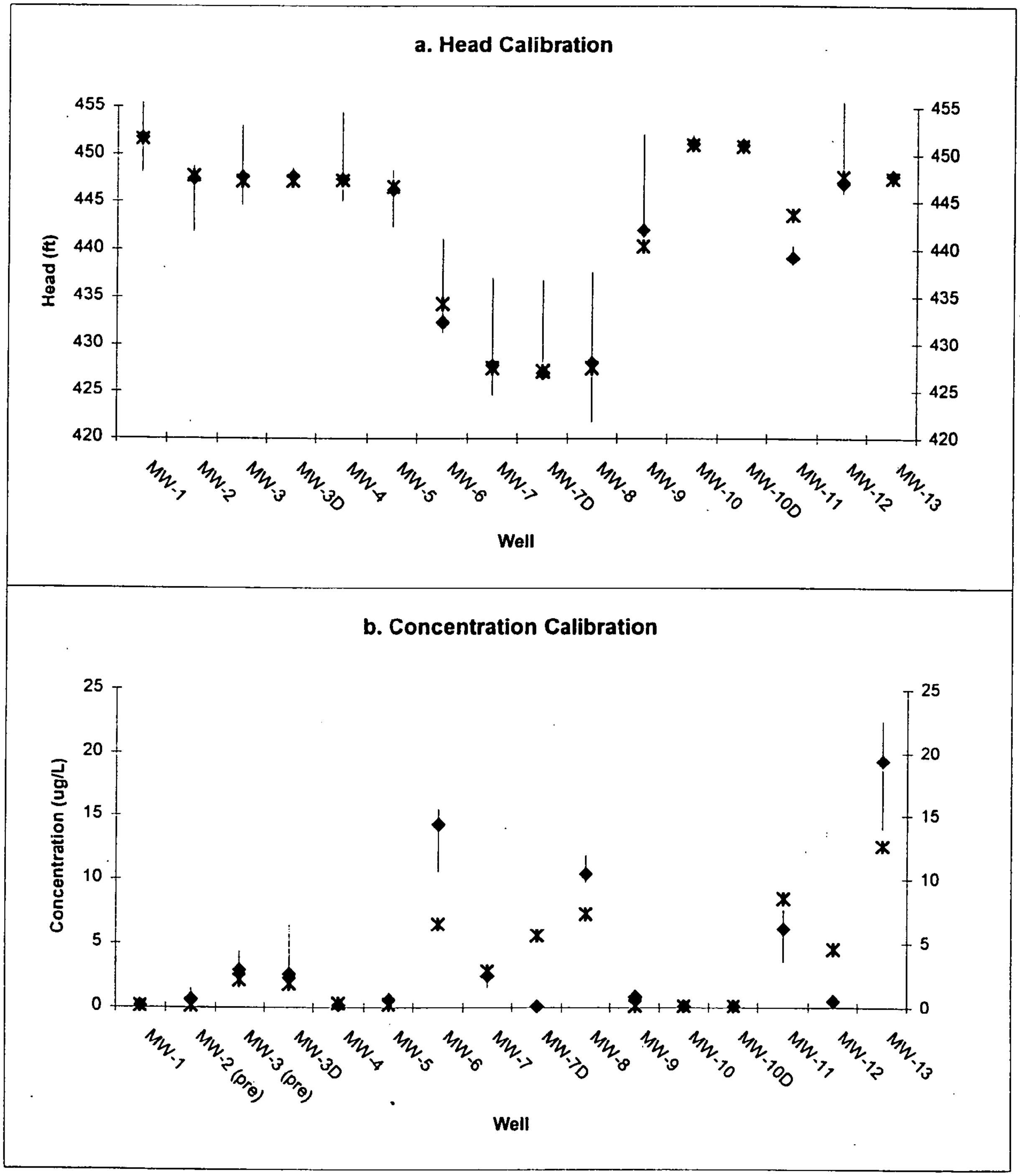


Figure 6. Calibration Results. The vertical bar represents the range of observed values, the diamond symbol represents the calibration target (head in November 1998 or median concentration), and the * symbol is the calibration result.

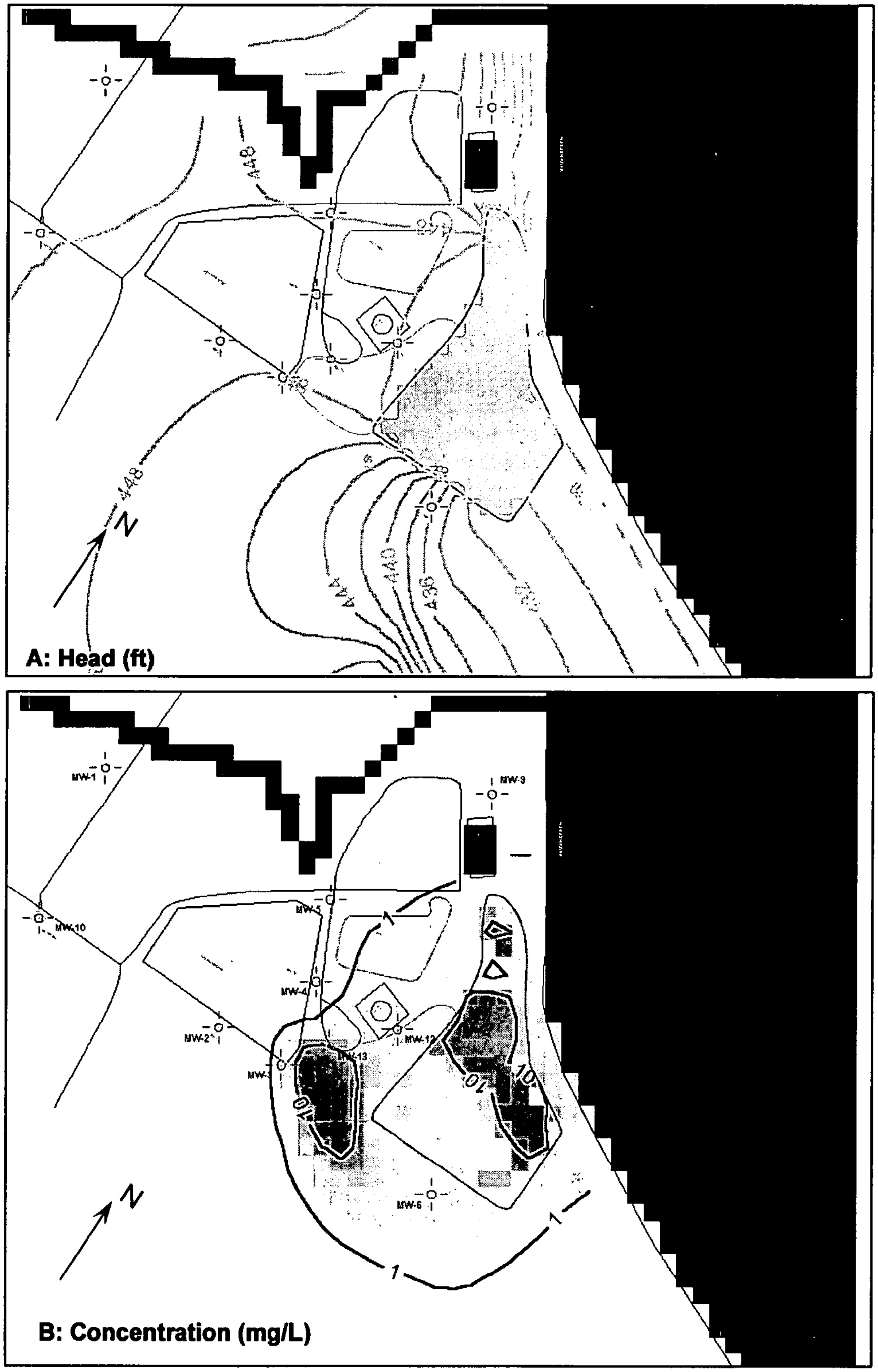


Figure 7. Calibrated head and concentration distribution for Layer 1.

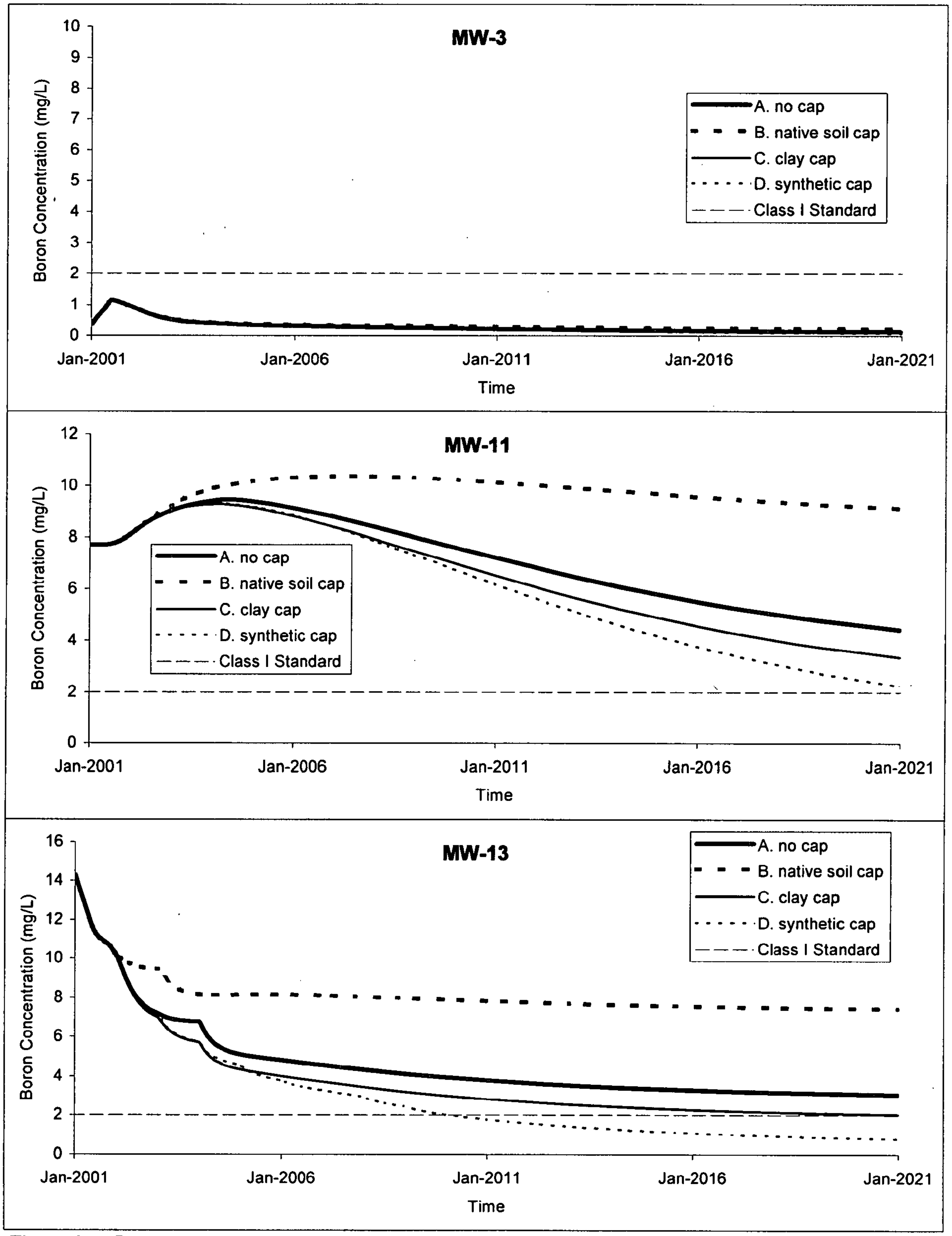


Figure 8a. Predicted concentrations for wells upgradient and sidegradient of the unlined impoundment.

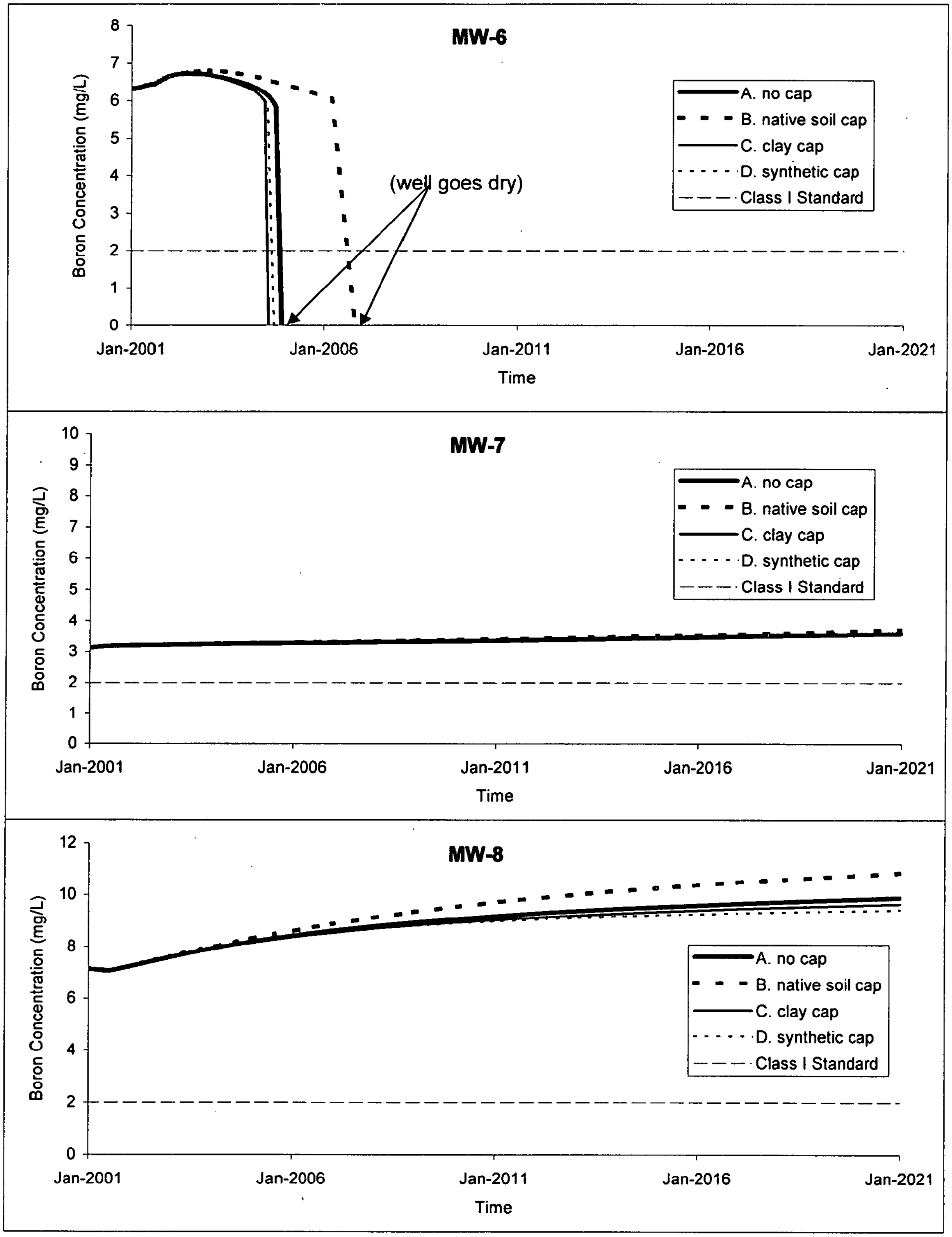


Figure 8b. Predicted concentrations for wells sidegradient and downgradient of the unlined impoundme

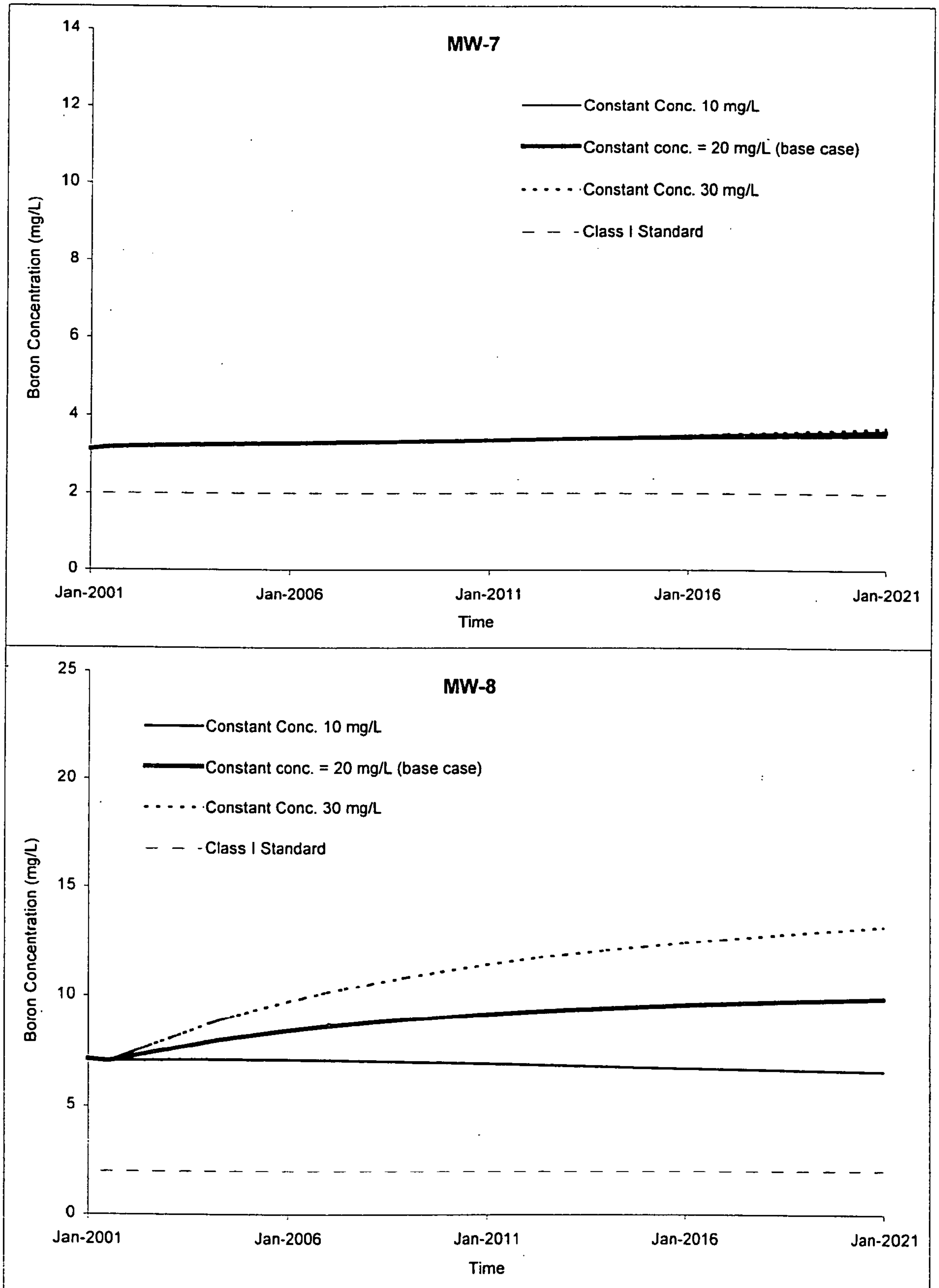


Figure 9. Sensitivity analysis for wells downgradient of the unlined impoundment.

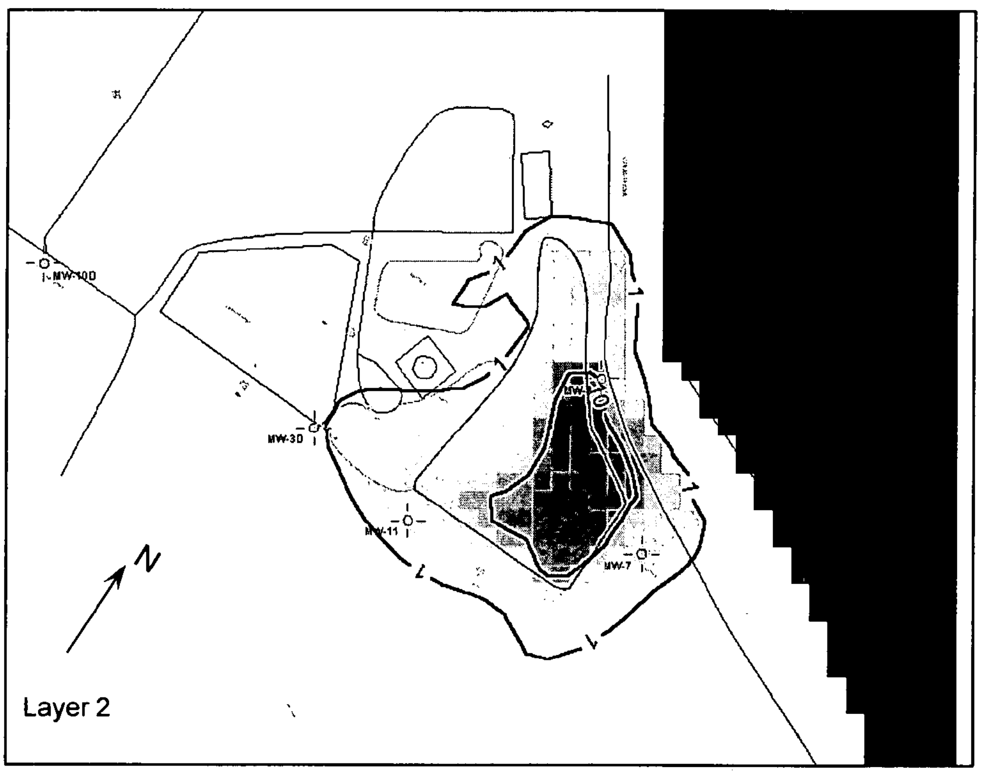


Figure 10. Layer 1 and 2 concentration distribution for no cap scenario at t=20 years (2021)

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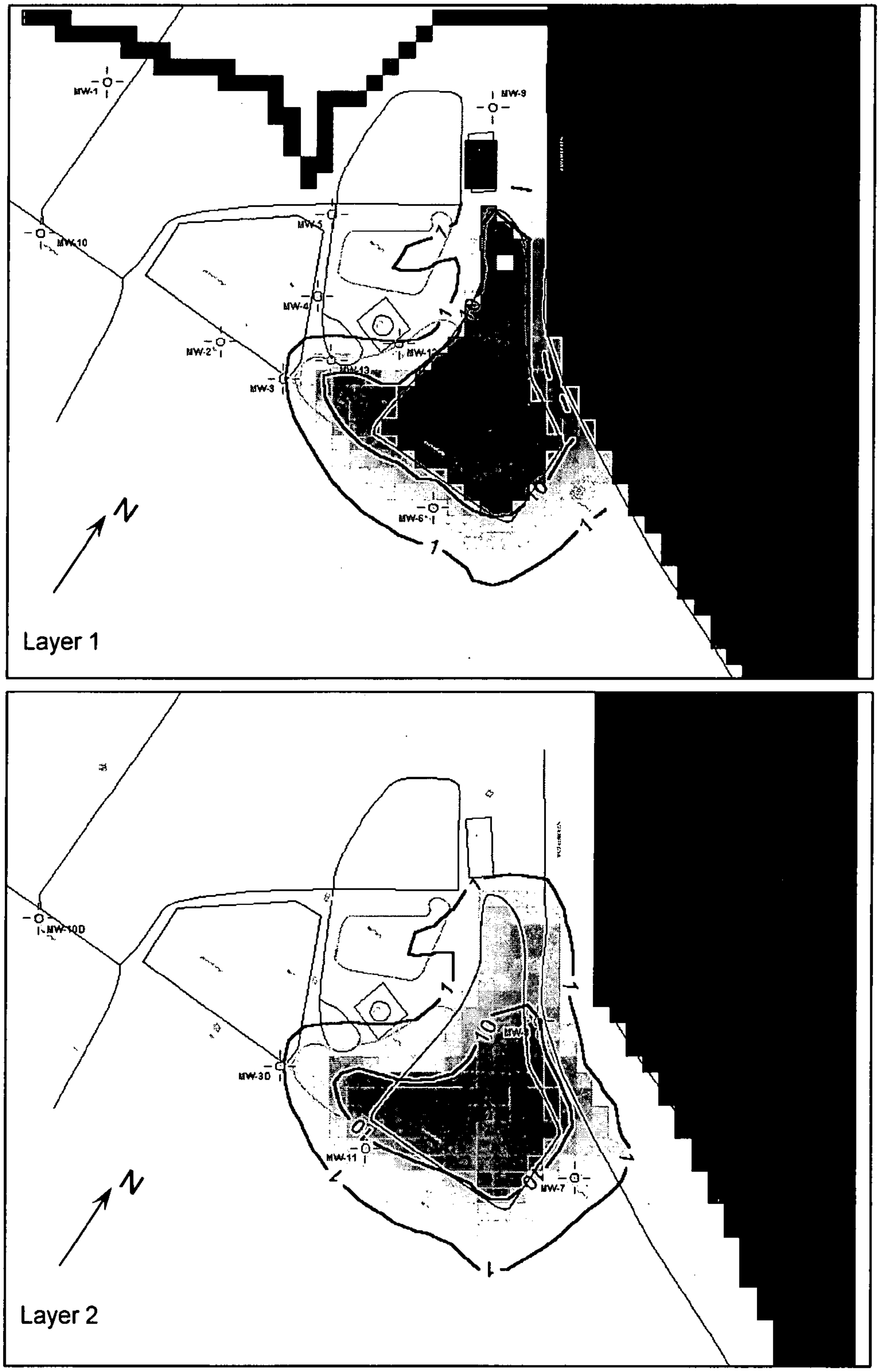

Figure 11. Layer 1 and 2 concentration distribution for native soil cap scenario at t=20 years (2021)

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Figure 12. Layer 1 and 2 concentration distribution for clay cap scenario at t=20 years (2021)

Natural Resource Technology

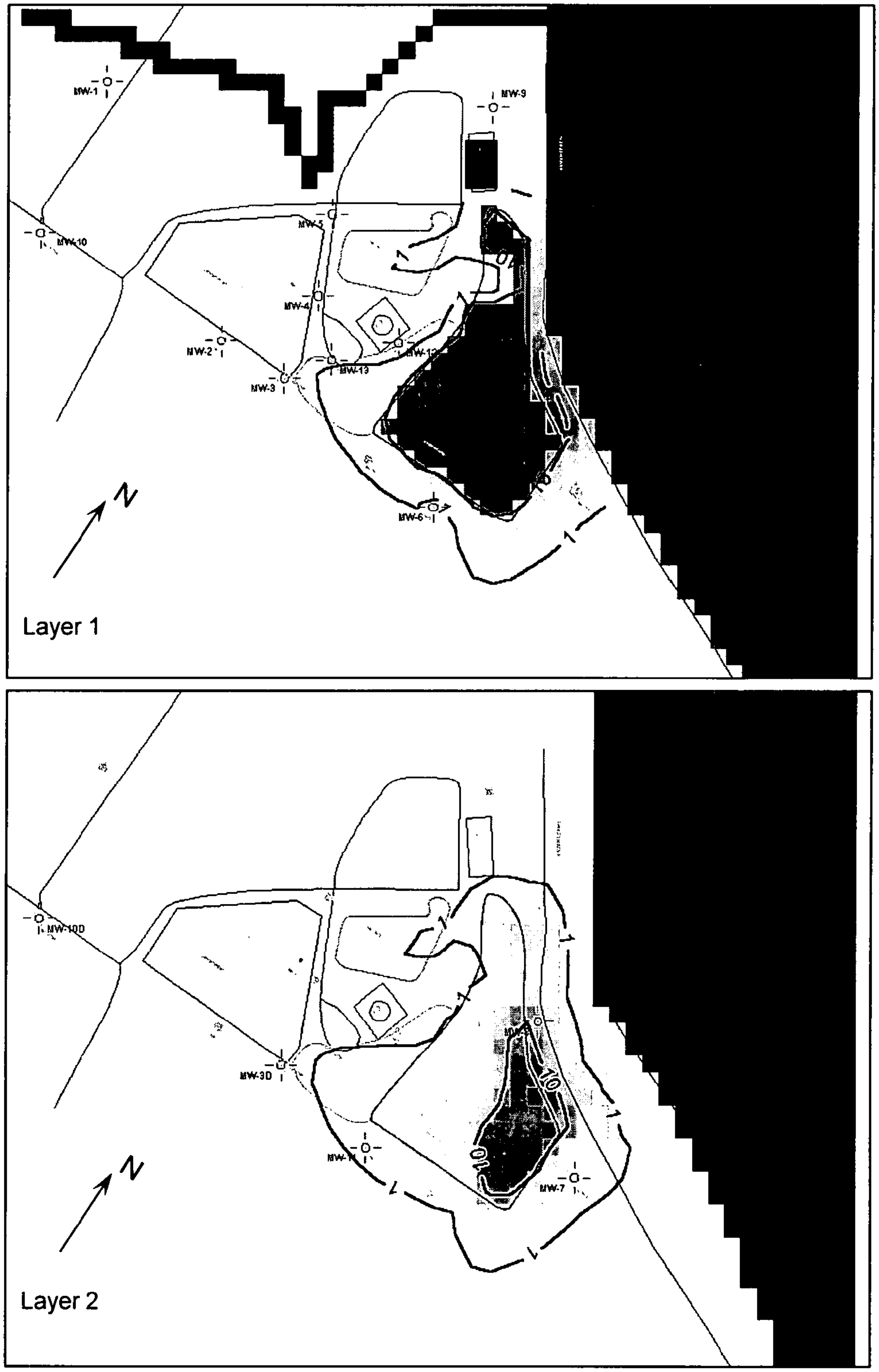


Figure 13. Layer 1 and 2 concentration distribution for synthetic cap scenario at t=20 years (2021)

Natural Resource Technology

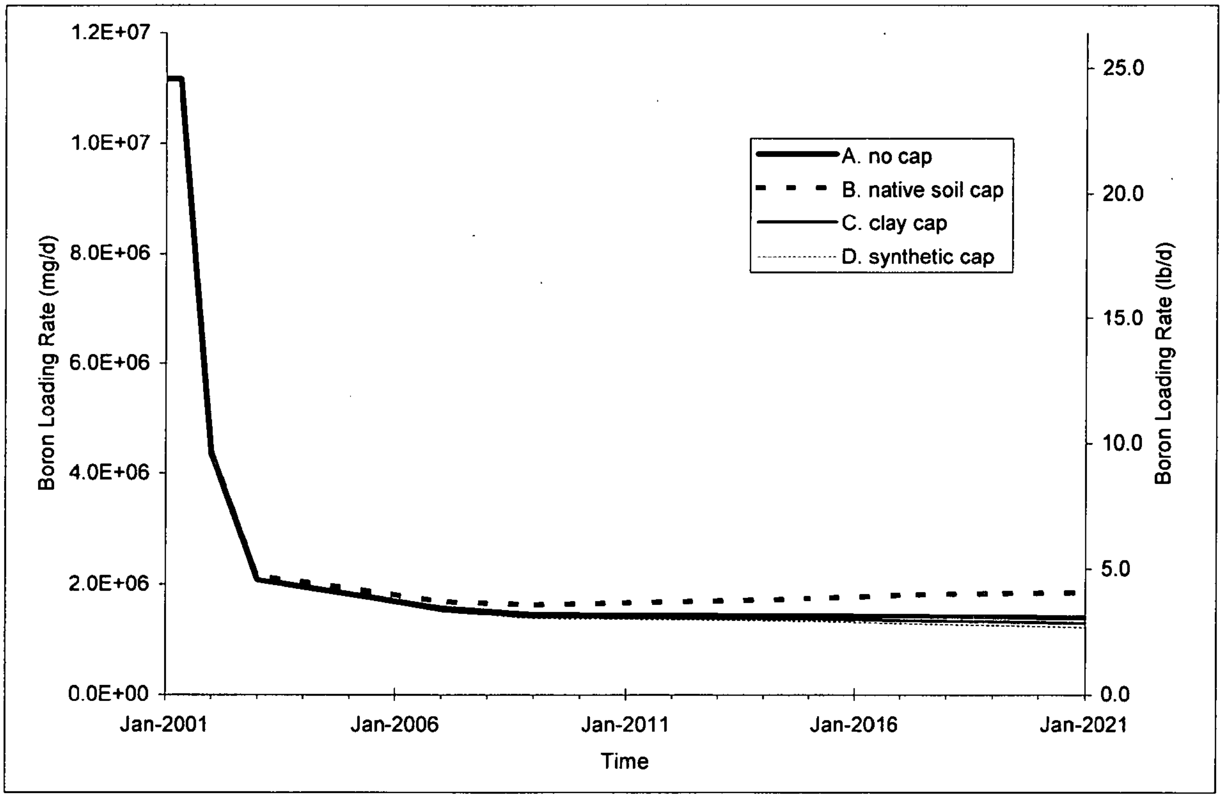


Figure 14. Model-predicted boron loading rate to the Wabash River & tributaries.

TABLES

Table 1
HELP Input Parameters

	Operating Case		Post Closure Scenario				
Parameter	ponded	dry	no cap	native	clay	synthetic	Notes
Climate-General							
City	Evansville IN						
Latitude	39.13						Plant
Evap. Zone Depth (in)	9	15	15	21	21	21	9 - bare ground, 15 - poor grass, 21 - fair grass
Leaf Index	0	1	1	2	2	2	0 - bare ground, 1 - poor grass, 2 - fair grass
All Others							Defaults for Evansville
Climate-precip/temp/ET							
All	see note						Synthetically generated using Evansville defaults, plant 30 yr avg precip, and avg temp in Palestine IL
Soils-General							
Area (acres)	1	1	1	1	1	1	unit area
% where runoff possible	0	0	100	100	100	100	
Specify Initial MC	Y	n	Y	Y	Y	Y	
Surface Water/Snow (in)	6	n/a	*	*	*	*	* = use value at end of year 1
Soils-Layers							
1	ash	ash	ash	native	native	native	
2	ash	ash	ash	ash	clay	synthetic	
3	ash	ash	ash	ash	gravel	ash	
4				ash	ash	ash	
5					ash	ash	
6					ash		
Soil Parameters--native							
Type				1	1	1	
Thickness (in)				36	36	12	
Texture				8	8	8	use default values for loam
Porosity				0.463	0.463	0.463	
Field Capacity				0.232	0.232	0.232	
Wilting Point				0.116	0.116	0.116	
Hydraulic Conductivity				3.70E-04	3.70E-04	3.70E-04	
Moisture Content				0.232	0.232	0.232	set equal to field capacity

Table 1 (continued)
HELP Input Parameters

	Operating Case			Post Closure Scenario			
Parameter	ponded	dry	no cap	native	clay	synthetic	Notes
Soil Parameters--clay							
Type					3		
Thickness (in)					36		
Texture					16		use default values for compacted clay
Porosity					0.427		
Field Capacity					0.418		
Wilting Point					0.367		
Hydraulic Conductivity					1.00E-07		
Moisture Content					0.418		set equal to field capacity
Soil Parameters--synthetic							
Type						4	
Thickness (in)						0.03	
Texture						35	use default values for HDPE (35)
Hydraulic Conductivity						2.00E-13	
Pinhole Density						1	holes/acre (HELP suggested value for "good" placement quality)
Installation Defects						4	holes/acre (HELP suggested value for "good" placement quality)
Placement Quality						3	good
Soil Parameters--gravel							
Type					1		
Thickness (in)					12		
Texture					21		use default values for gravel
Porosity					0.397		
Field Capacity					0.032		
Wilting Point					0.013		
Hydraulic Conductivity					3.00E-01		
Moisture Content					0.032		set equal to field capacity

Table 1 (continued)
HELP Input Parameters

	Operating Case		Post Closure Scenario				
Parameter	ponded	dry	no cap	native	clay	synthetic	Notes
Soil Parameters--ash							
Type	1	1	1	1	1	1	
Thickness (in)	60	60	60	60	60	60	depth to WT
Texture	30	30	30	30	30	30	HELP default for coal ash
Porosity	0.541	0.541	0.541	0.541	0.541	0.541	
Field Capacity	0.187	0.187	0.187	0.187	0.187	0.187	
Wilting point	0.047	0.047	0.047	0.047	0.047	0.047	
Moisture Content	=porosity	*	**	**	**	**	* = HELP Calculated: ** = MC at end of Case n, Year 1
K (cm/s)	5.0E-05	5.0E-05	5.0E-05	5.0E-05	5.0E-05	5.0E-05	
Soils--Runoff							
Equation	N/A	N/A	*	*	*	*	* = HELP Calculated
Slope			0.51%	0.51%	0.51%	0.51%	lowest slope allowed by program
Length (ft)			500	500	500	500	
Texture			30	8	8	8	based on uppermost soil type in column
Vegetation			poor	fair	fair	fair	
Execution Parameters							
Years	1	1	2-10	2-10	2-10	2-10	
Report Daily	y	n	n	n	n	n	
Report Monthly	y	y	y	y	y	y	
Report Annual	y	y	y	y	y	y	

Table 2
HELP Sensitivity Analysis Results

Parameter	Base Scenario	Default Value	Tested Range	Sensitivity	Notes
Climate-General					
Evap. Zone Depth (in)	no cap	15	9 - 21	mod. to high	9 - bare ground, 15 - poor grass, 21 - fair grass
Leaf Index	no cap	1	0 - 2	mod. to high	0 - bare ground, 1 - poor grass, 2 - fair grass
Soil Parameters--native					
Thickness (in)	no cap	36	24 - 48	negligible	
Texture	no cap	8	6 - 10	mod to high	6 - sandy loam; 8 - loam; 10 - sandy clay loam
Thickness (in)	synthetic	12	24 - 36	moderate	percolation *increases* with increasing soil thickness
Texture	synthetic	8	6 - 10	negligible	6 - sandy loam; 8 - loam; 10 - sandy clay loam
Soil Parameters--synthetic					
Placement Quality	synthetic	3	2 - 4	low to high	2 - excellent; 3 - good; 4 - poor. Sensitivity is low for excellent
Installation Defects	synthetic	4	1 - 10	low to high	installation, and high for poor installation
Soil Parameters--gravel					
Thickness (in)	clay	12	0 - 18	low to negl.	
Soil Parameters--ash					
Thickness (in)	no cap	60 x 3	30 x 6 - 90 x 2	negl. to mod.	negligible difference for 30 in by 6 layers (total = 180 in.), compared to default
K (cm/s)	no cap	5.0E-05	1.0E-04 - 1.0E-05	mod. to high	
Soils--Runoff					
Slope	no cap	0.51%	0.75% - 1.00%	negligible	
Length (ft)	no cap	500	250 - 750	low	
Vegetation	no cap	poor	bare - fair	high	

Negligible - less than 1 percent change in total percolation volume relative to base scenario.
Low - 1 to 2 percent change in total percolation volume.
Moderate - 2 to 10 percent change in total percolation volume.
High - greater than 10 percent change in total percolation volume.

Table 3
Flow Model Input Parameters

Horizontal Hydraulic Conductivity		ft/d	cm/s	Sensitivity[1]
Layer 1 ash		0.14	5.0E-05	negligible
Layer 1 silt unit		0.10	3.5E-05	low
Layer 1 sand unit		80	2.8E-02	high
Layer 1, 2, 3 alluvium		30	1.1E-02	moderate
Layer 2 sandstone		4.0	1.4E-03	high
Layer 4 valley fill sand and gravel		136	4.8E-02	moderate
Vertical Hydraulic Conductivity		**ft/d**	**Kh/Kv**	**Sensitivity**
Layer 1 ash		0.07	2.0	negligible
Layer 1 silt unit		0.05	2.0	negligible
Layer 1 sand unit		40	2.0	negligible
Layer 1, 2, 3 alluvium		3.0	10.0	low
Layer 2 sandstone		2.0	2.0	low
Layer 4 valley fill sand and gravel		68	2.0	negligible
Recharge		**ft/d**	**in/yr**	**Sensitivity**
General		0.001	4.4	high
Unlined impoundment - ponded		0.0822	360	high
Unlined impoundment - not ponded		0.0027	11.8	low
Lined impoundment		2.30E-05	0.10	negligible
Ash laydown area		0.0027	11.8	low
Coal pile		0.0027	11.8	negligible
Area between impoundments		0.0027	11.8	low
Lowlands		0	0.0	high
Storage/Porosity		**S_S**	**S_Y**	**Sensitivity**
Layer 1 ash		1.00E-03	0.10	negligible
Layer 1 silt unit		1.00E-03	0.10	negligible
Layer 1 sand unit		1.00E-05	0.20	negligible
Layer 1, 2, 3 alluvium		1.00E-03	0.10	negligible
Layer 2 sandstone		1.00E-06	0.15	negligible
Layer 4 valley fill sand and gravel		1.00E-05	0.20	negligible
River Parameters	**Wabash**	**Trib west**	**Trib east**	**Sensitivity**
Bed Thickness (ft)	1	1	1	not tested
Hydraulic Conductivity (ft/d)	0.7 - 136	0.1	0.01	not tested
Conductance (ft^2/d, normalized per ft^2 area)	0.7 - 136	0.1	0.01	low
River Width (ft)	variable	5	5	not tested
River Cell Length (ft)	variable	variable	variable	not tested
Constant Head Boundary Parameters		**Layer 1 (west)**		**Sensitivity**
Head (ft)		451		moderate

1. Sensitivity Explanation
   - Negligible - had little effect on overall model residuals
   - Low - effect on residuals insufficient to nullify calibration
   - Moderate - extreme values changed residuals sufficiently to nullify calibration
   - High - all tested values changed residuals sufficiently to nullify calibration

Table 4
Transport Model Input Parameters

Initial Concentration (mg/L)	Base Case	Alternatives	Sensitivity[1]
Entire Domain	0.0	not tested	
Source Concentration - Recharge (mg/L)	**Base Case**	**Alternatives**	**Sensitivity**
Unlined Impoundment (ponded)	5	not tested	high[2]
Unlined Impoundment (not ponded)	20	not tested	high[2]
Ash Laydown Area	30	not tested	high[2]
Lined Impoundment	20	not tested	high[2]
Coal Pile	2	not tested	high[2]
Source Concentration - Constant (mg/L)	**Base Case**	**Alternatives**	**Sensitivity**
Saturated Ash Nodes[3]	20	10, 30	high
Effective Porosity	**Base Case**	**Alternatives**	
Layer 1 ash	0.10	0.05, 0.15	low
Layer 1 silt unit	0.10	0.05, 0.15	low
Layer 1 sand unit	0.20	0.15, 0.25	low
Layer 1-3 alluvium	0.10	0.05, 0.15	low
Layer 2 sandstone	0.15	0.10, 0.20	low
Layer 4 valley fill sand and gravel	0.20	0.15, 0.25	low
Dispersivity (ft)	**Base Case**	**Alternatives**	**Sensitivity**
Longitudinal	30	10, 50	high
Transverse	3.75	2, 5	high
Vertical	0.188	0.10, 0.30	high
Retardation	**Base Case**	**Alternatives**	**Sensitivity**
Bulk Density (g/cm^3)	1.6	not tested	
Distribution Coefficient - sand (mL/g)	0.17	0, 0.25	moderate
Distribution Coefficient - silt (mL/g)	0.85	0, 0.5, 1.2	moderate

1. Sensitivity Explanation
   Negligible - little effect on concentrations
   Low - concentrations at one or two wells changed by 2 to 10 percent
   Moderate - concentrations at one or two wells changed by 10 to 20 percent
   High - concentration at one or two wells changed by more than 20 percent or concentration at more than two wells changed by 2 to 10 percent
2. Determined to be highly sensitive during transport model calibration
3. Used only in prediction simulations beginning the third year

Table 5
Model Predicted Change in Boron Concentration: 2001 - 2021

	Cap Scenario			
Well	no cap	native soil cap	clay cap	synthetic cap
MW-3	-68%	-42%	-74%	-83%
MW-3D	-80%	-64%	-84%	-89%
MW-6	n/a	n/a	n/a	n/a
MW-7	15%	19%	14%	13%
MW-7D	-65%	-54%	-67%	-69%
MW-8	39%	52%	35%	32%
MW-11	-43%	18%	-57%	-71%
MW-12	-89%	-85%	-90%	-91%
MW-13	-78%	-48%	-86%	-94%

Only listed for wells with calibrated concentrations > 1.0 mg/L.

APPENDIX A

MODEL FIGURES

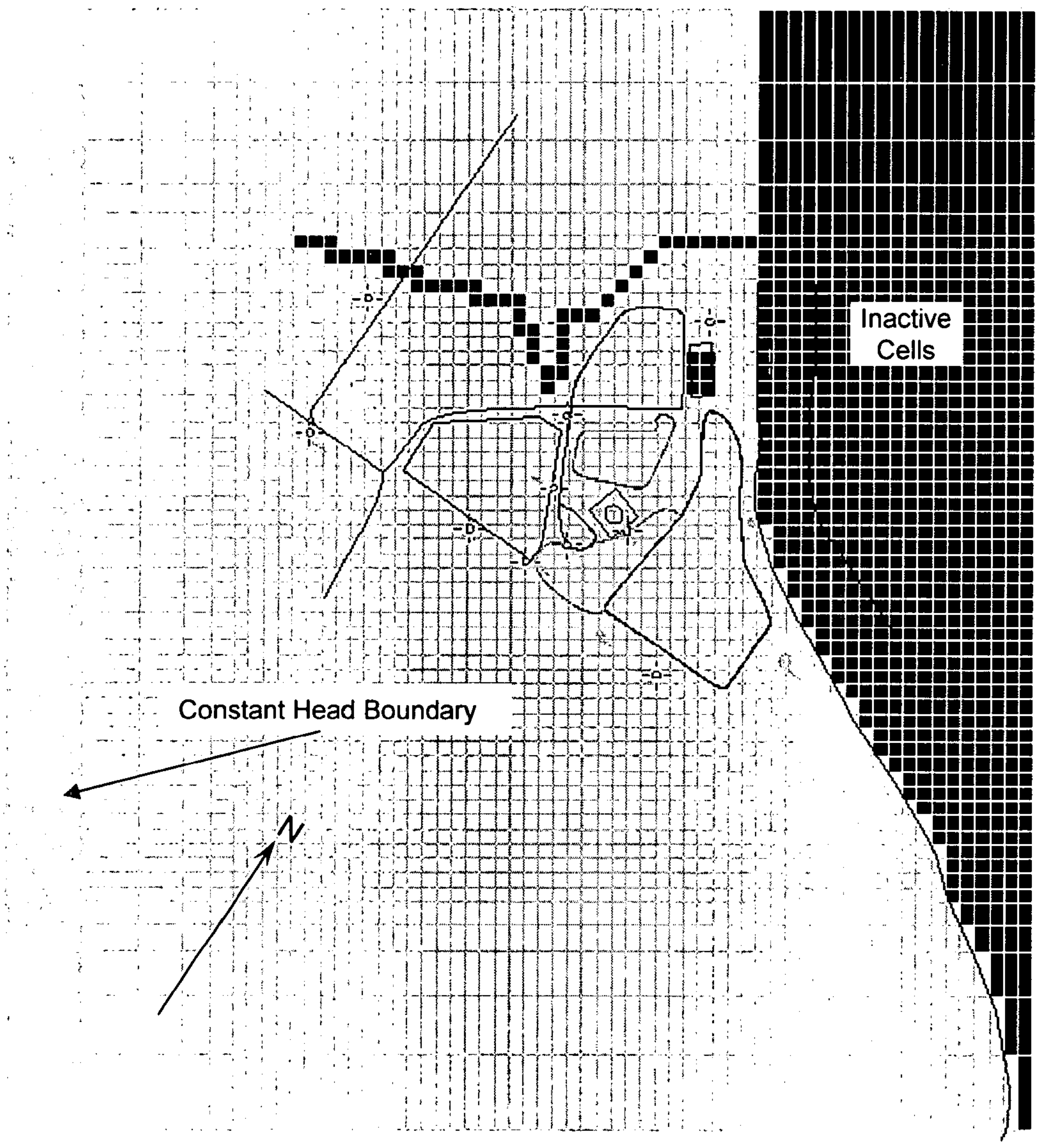


Figure A1a. MODEL grid - Layer 1 - showing boundary conditions.

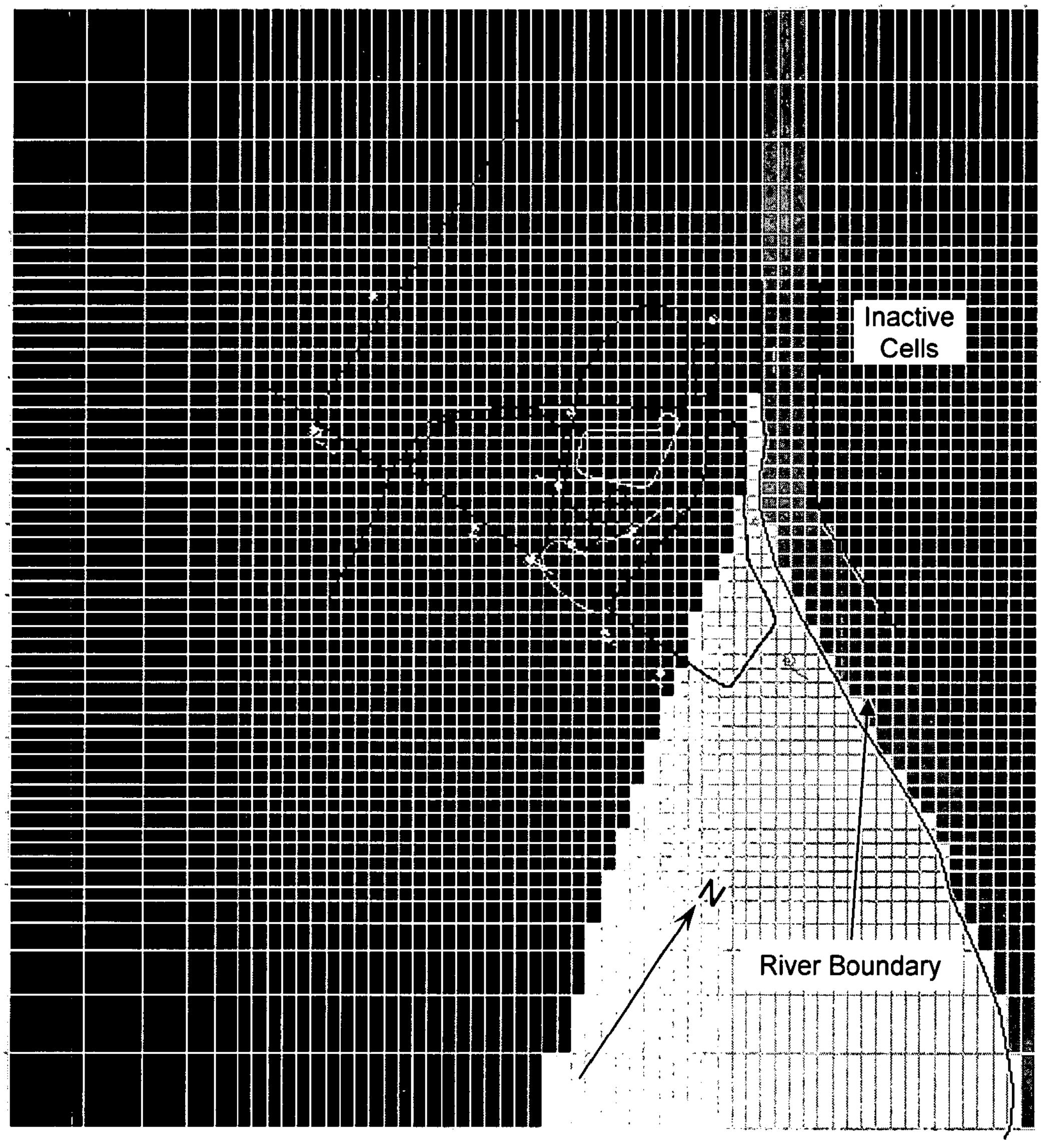


Figure A1b. MODEL grid - Layer 3 - showing boundary conditions.

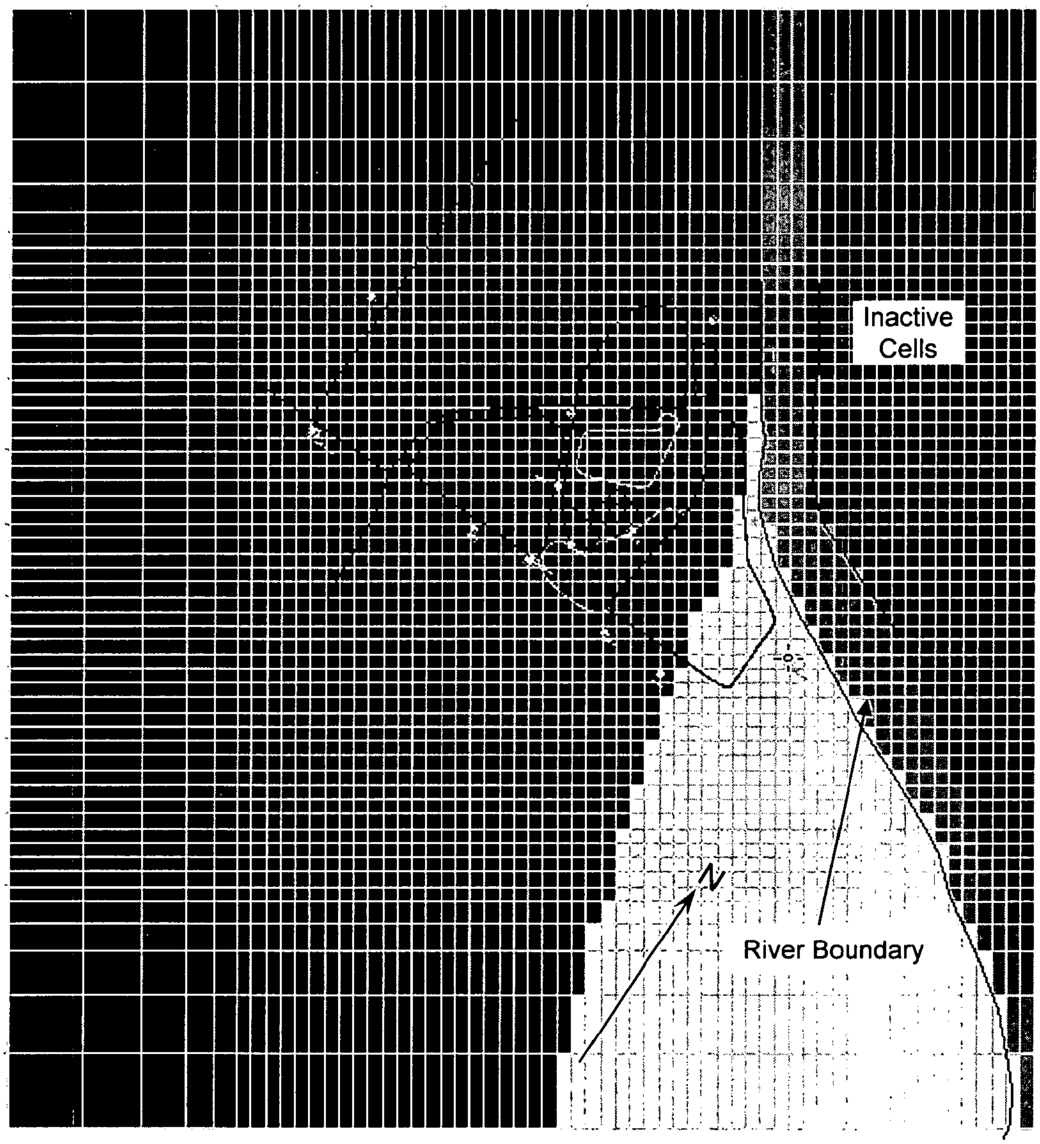


Figure A1c. MODEL grid - Layer 4 - showing boundary conditions.

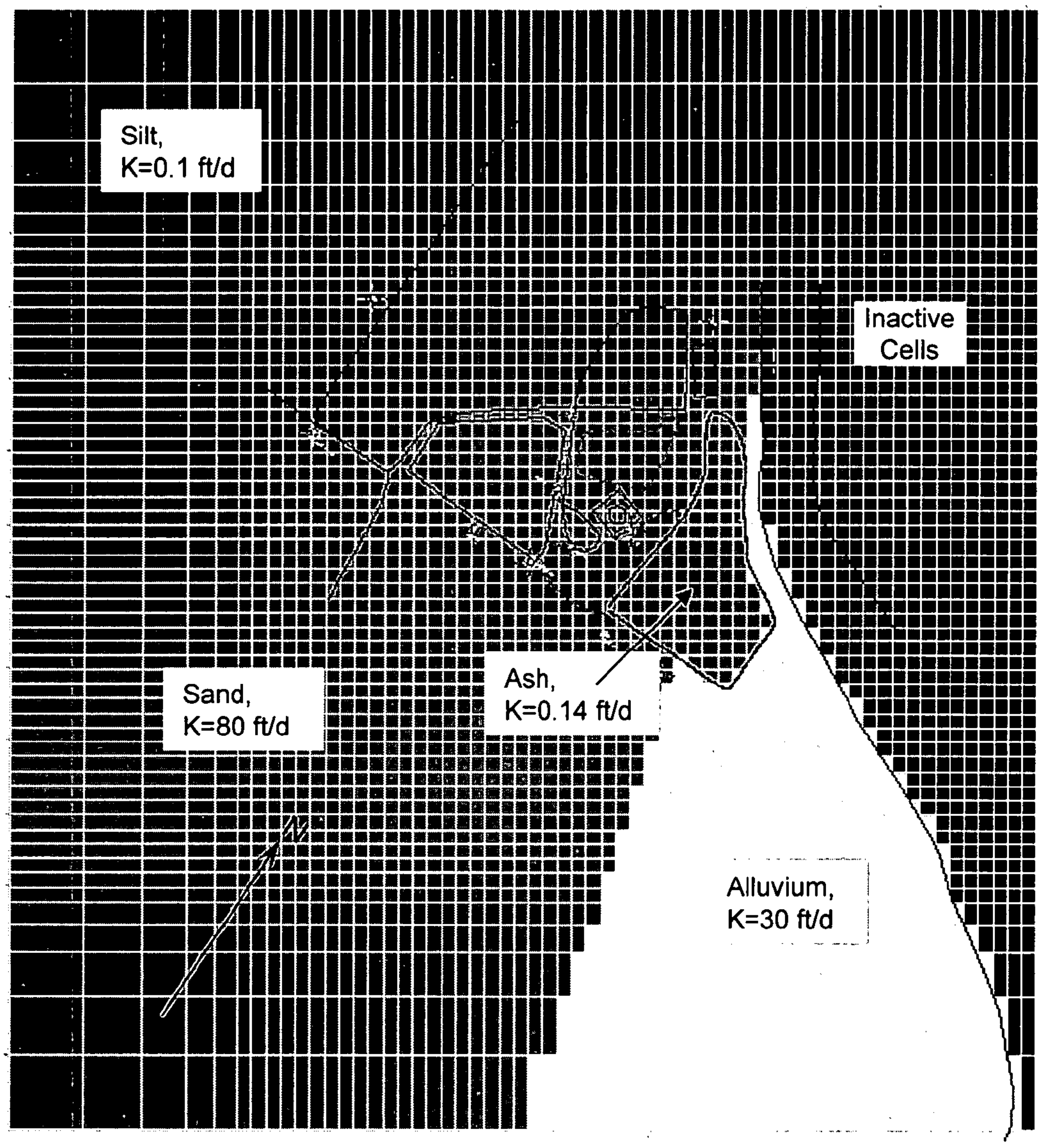


Figure A2a. Hydraulic conductivity array - Layer 1.

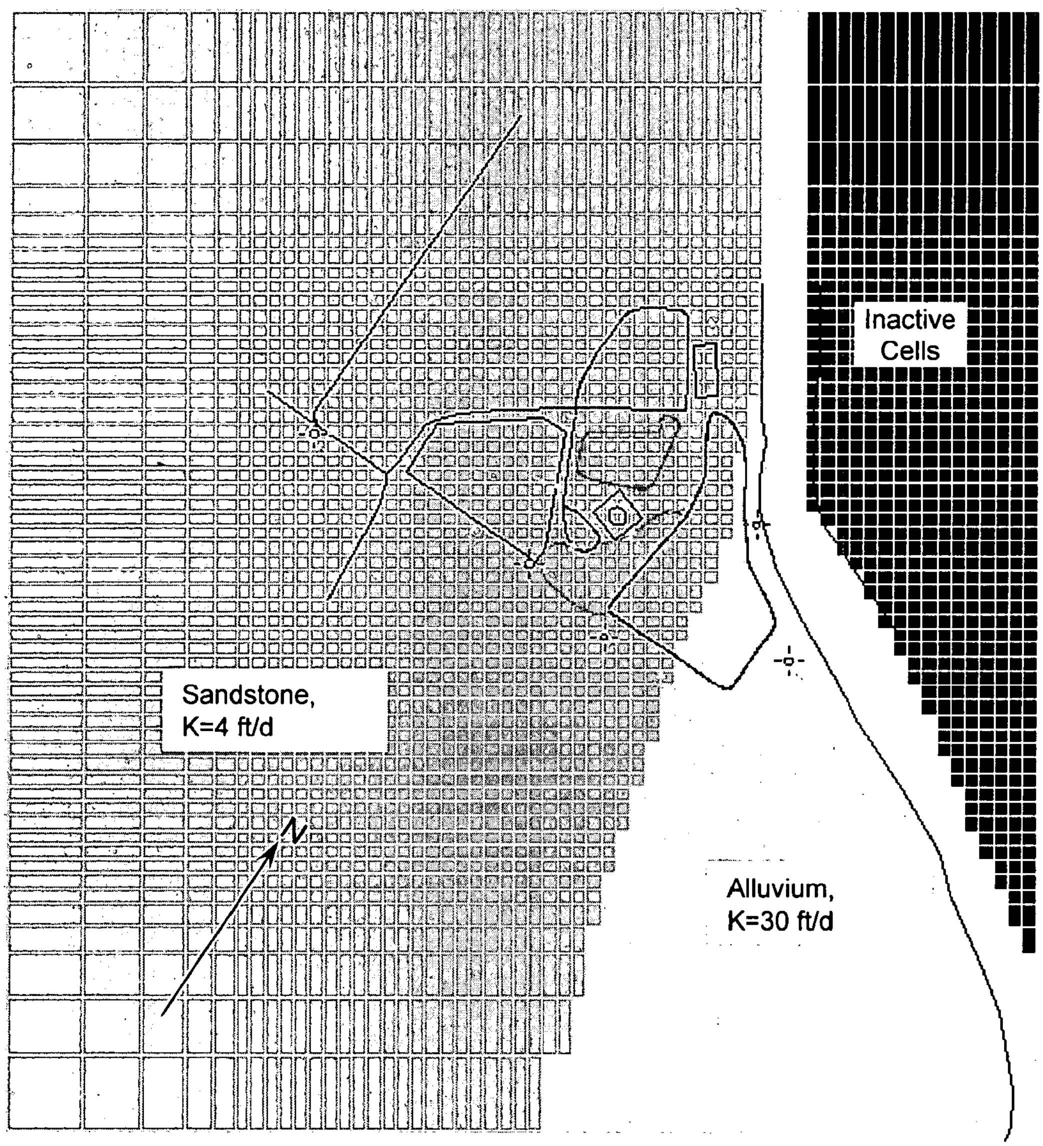


Figure A2b. Hydraulic conductivity array - Layer 2.

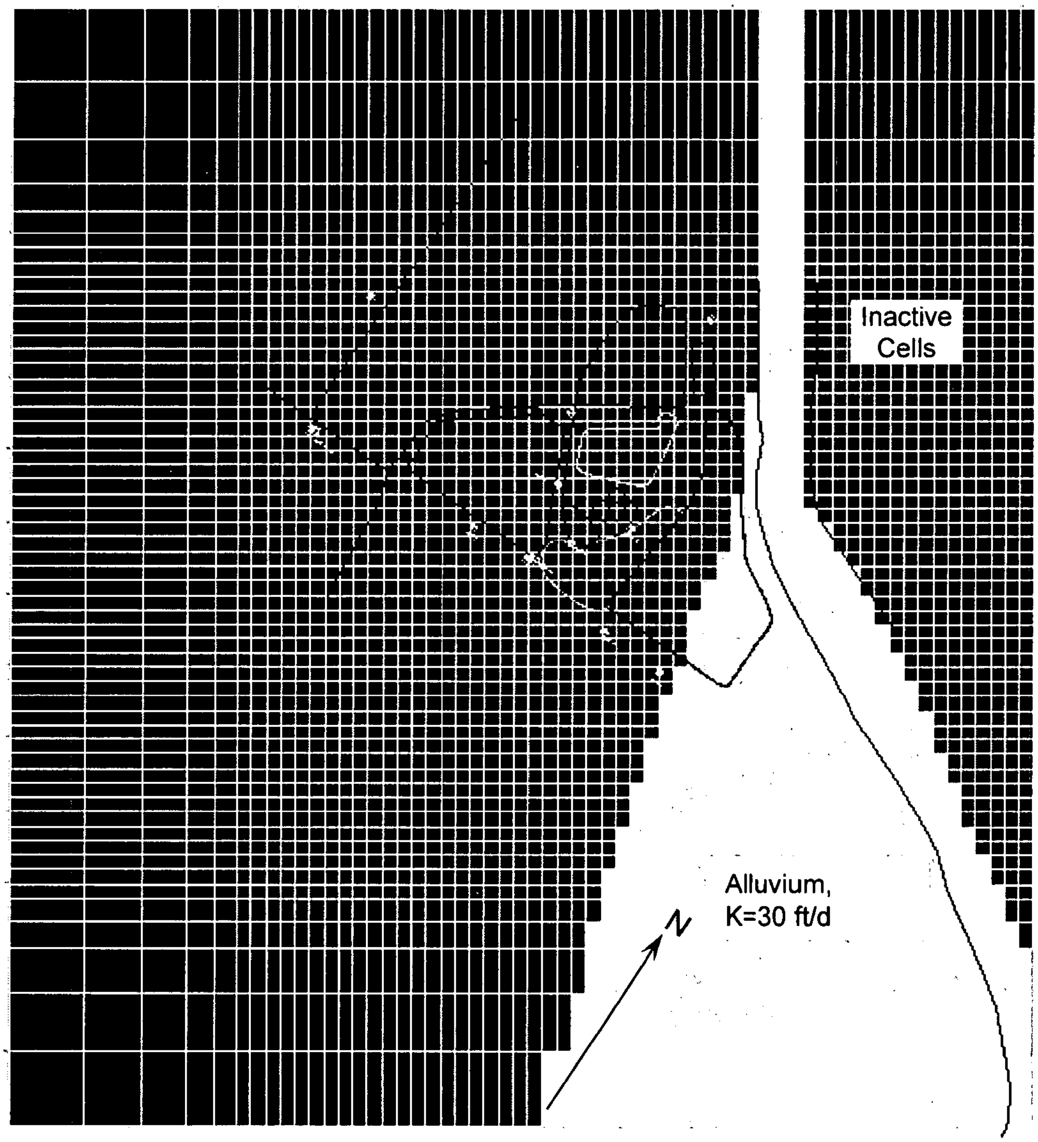


Figure A2c. Hydraulic conductivity array - Layer 3.

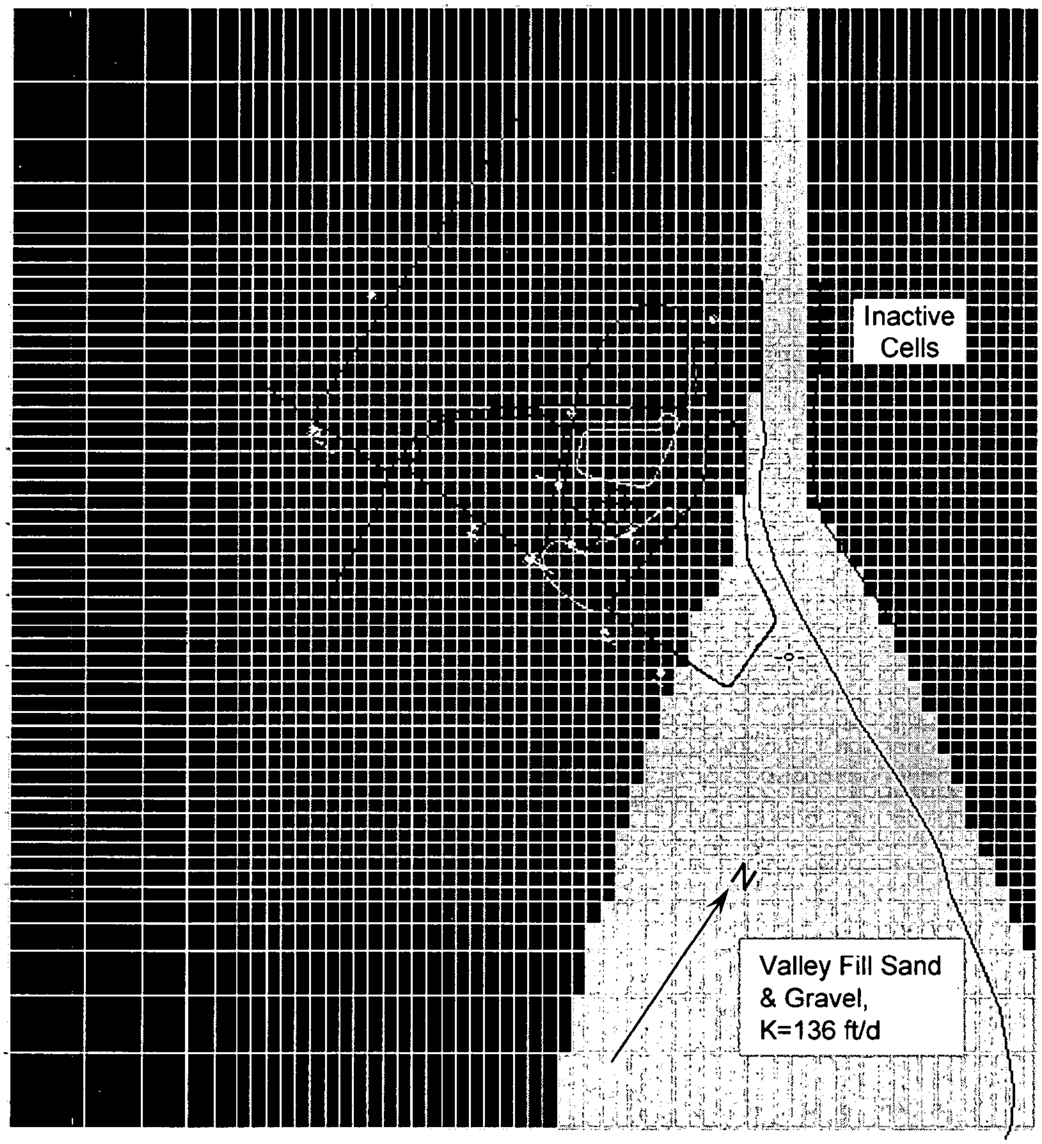


Figure A2d. Hydraulic conductivity array - Layer 4.

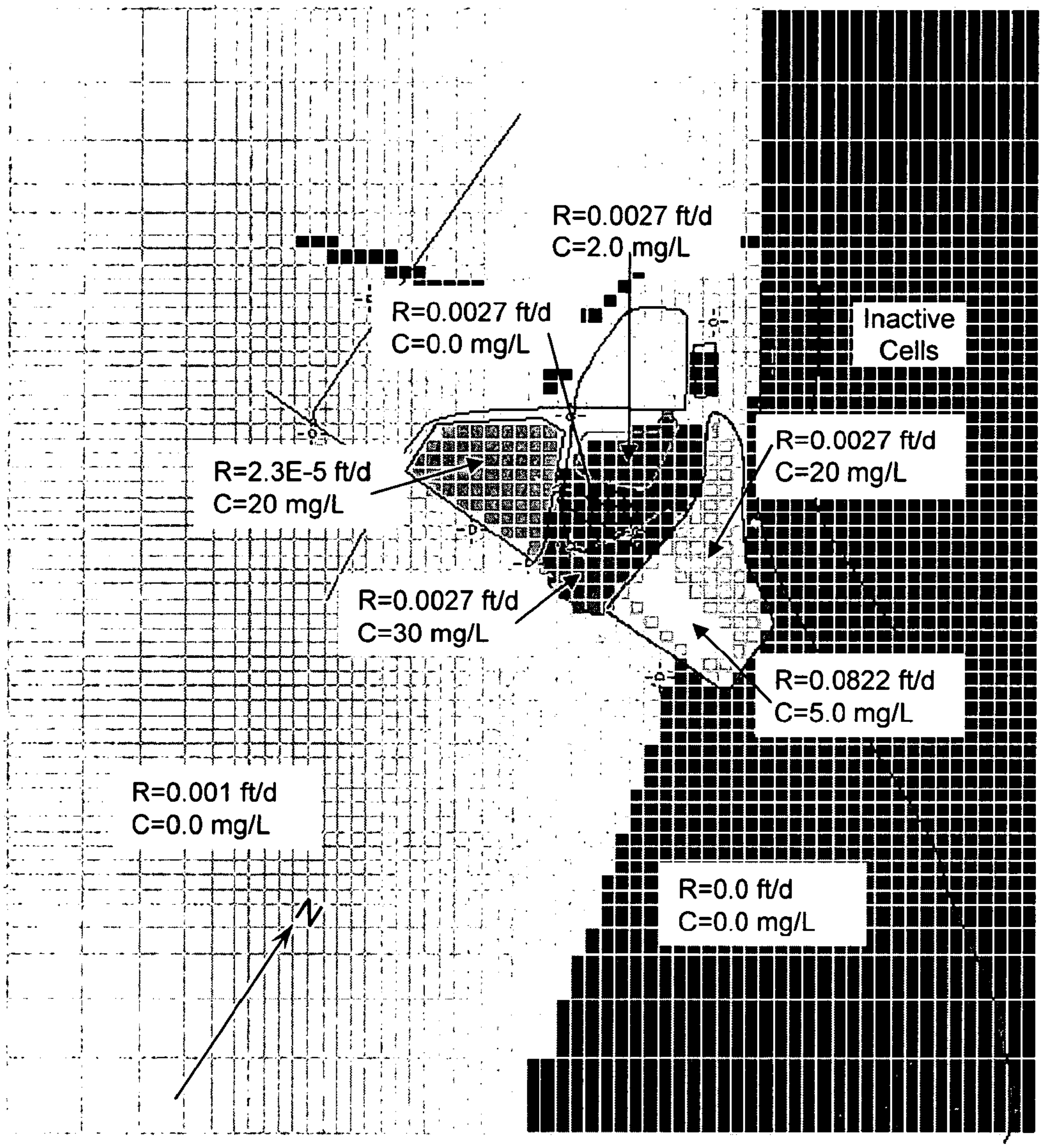


Figure A3. MODFLOW recharge and MT3DMS recharge concentration array.

APPENDIX B

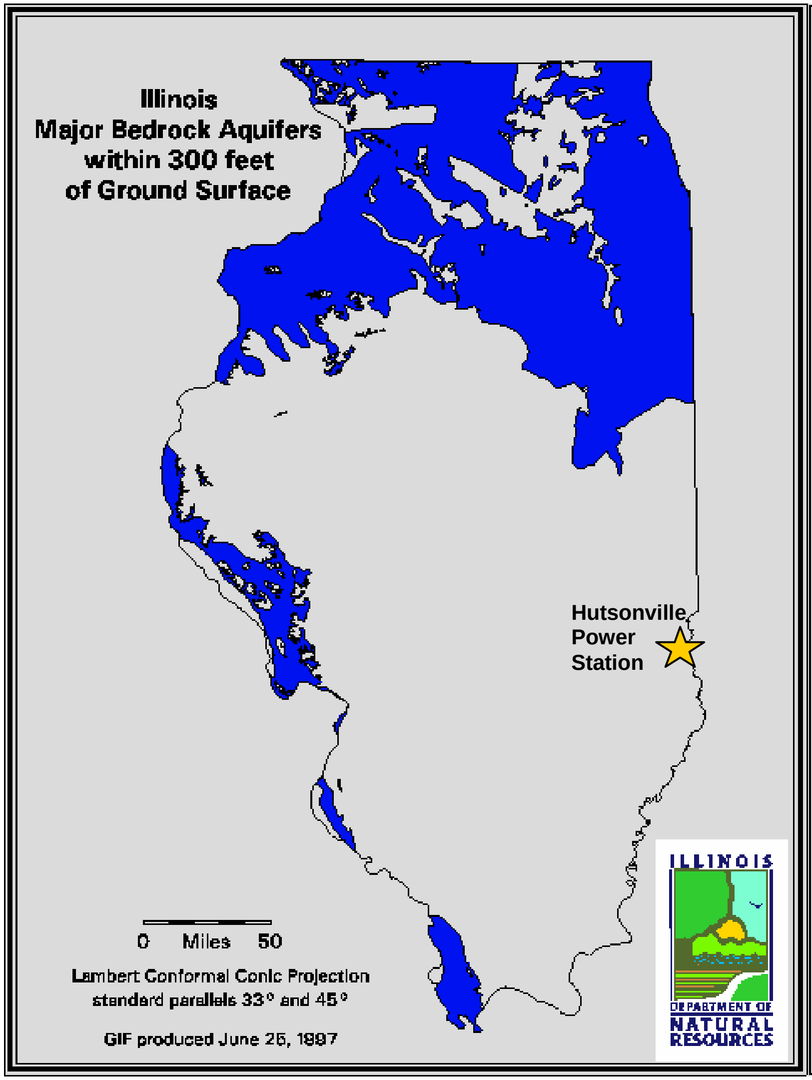
MODEL DATA FILES

The disk in the binder attached to this report contains the ASCII input files and output files used and generated by HELP, MODFLOW, and MT3D for each scenario. The output files are named as follows:

HELP input/output files are in the HELP directory

MODFLOW/MT3DMS files are organized as listed below.

Cap Scenario	Directory
Active site (calibration)	Hut5
No-cap scenario	Hut5a
Native soil scenario	Hut5b
Clay cap scenario	Hut5f
Synthetic cap scenario	Hut5e
Steady state sensitivity analyses	Hut5tnn (where nn=01, 02, ..., 11)
Transient sensitivity analyses	Hut5aSn (where n=1 or 2)



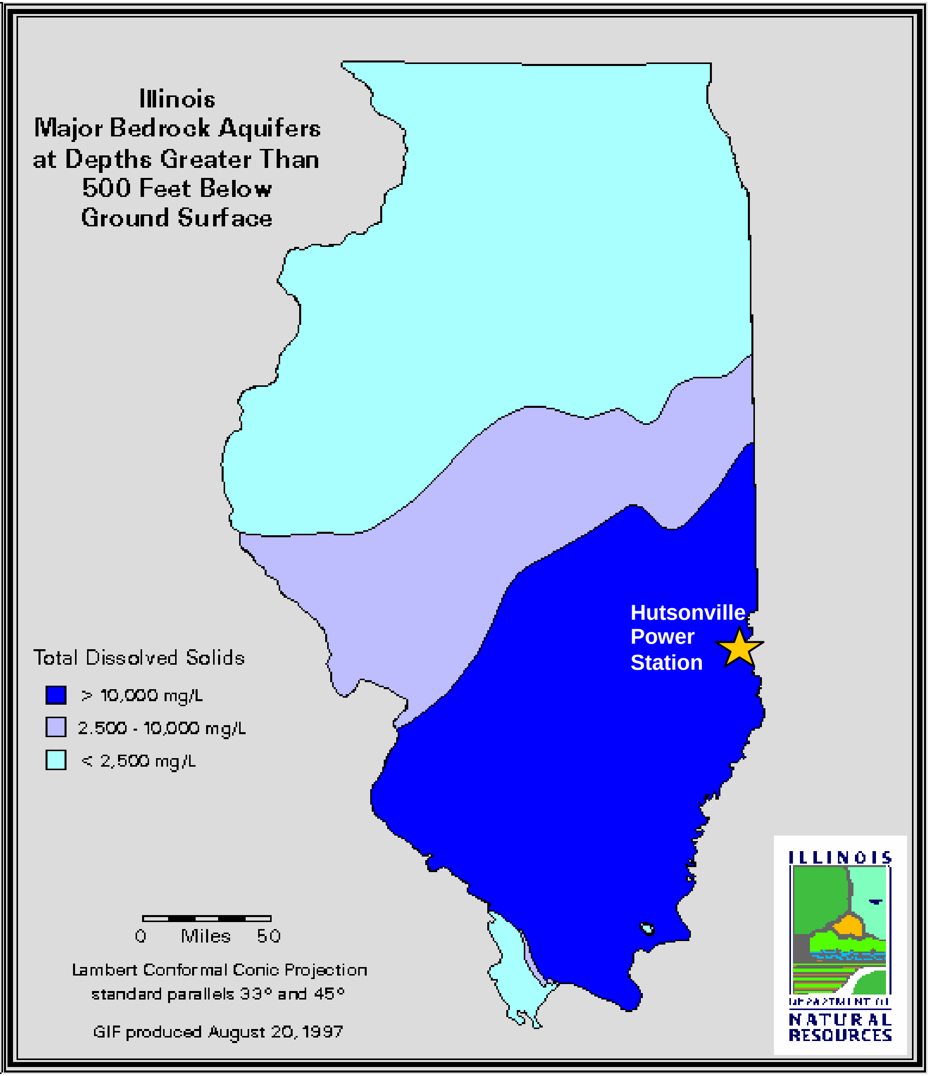
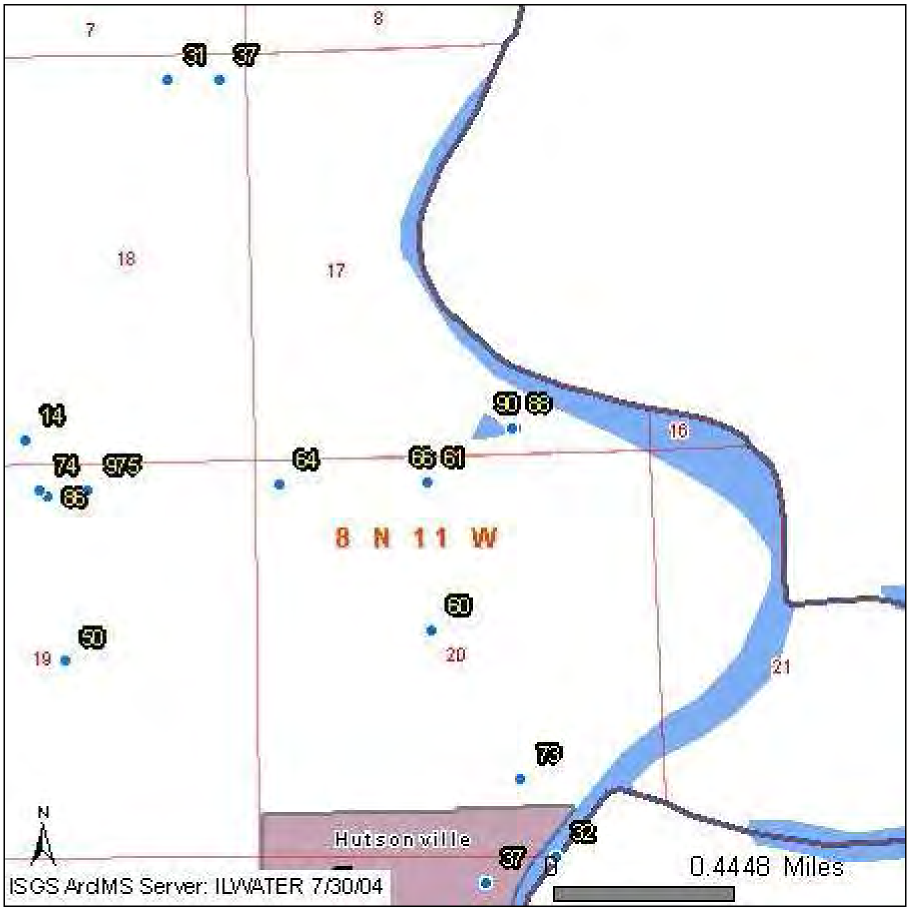


Exhibit 6. Statewide aquifer maps showing no major bedrock aquifers within 300 feet of ground surface at Hutsonville and total dissolved solids concentration greater than 10,000 mg/L in aquifers deeper than 500 feet below ground surface.

CH2\2470678.1

Exhibit 7 – Potable Well Search Results



Map and related well records from: http://meltwater.isgs.uiuc.edu/website/ilwater/viewer.htm

On June 16, 2005, NRT conducted a search for potable well records within a ½ -mile radius of Pond D using the Illinois State Geological Survey's (ISGS) online interactive map of well records at the website above. Hutsonville Power Station Plant wells #1 and #2 are numbered 90 and 88 on the map above. Wells 60, 61, and 64 are owned by Margaret Dement and are used for irrigation (64 does not appear to be correctly located on the map). Well number 66 is also used for irrigation and is owned by Duane Wampler. Well 73, a City of Hutsonville water supply well, is approximately one mile south of Pond D.

The following landowners were identified within approximately ½ mile of Pond D: J.P, Allison (three residences), J.Grimes, Slaughter, M. Kelly, M. Dement. Records for potable wells servicing these landowners could not be located through the ISGS. Representatives from the Hutsonville Power Station field inspected these residences; no well heads were observed at the three residences to the south (Slaughter, Kelly, Dement). There are wells servicing the residences to the west (Allison, Grimes). These wells are upgradient of both the plant and upgradient monitoring wells MW-10 and 10D.

	A	B	C
1	**Exhibit 8**		
2	**Mixing Calculation Showing Effect of Boron Loading on Wabash River Quality at Low Flow**		
3			
4			
5	**7-day 10-year low flow at Hutsonville Station**	1234	cfs
6	$Q_{7,10}$ =	3.0E+09	L/day
7			
8	**Boron loading rate while Pond D was in service**	25	lb/day
9	L1 =	1.1E+07	mg/day
10			
11	**Boron loading rate after Pond D is dewatered and capped**	5	lb/day
12	L2 =	2.3E+06	mg/day
13			
14	**Boron concentration increase in Wabash River at low flow due to loading from Pond D**		
15	When Pond D was in service	0.0038	mg/L
16	After Pond D is dewatered and capped	0.0008	mg/L
17			
18	Median boron concentration in Wabash River at City of Hutsonville	0.0550	mg/L
19	Typical boron laboratory detection limit	0.0038	mg/L
20			
21	**Conclusion:**		
22	The calculated boron concentration increase in the Wabash River at ***low flow*** due to groundwater loading while Pond D was in service was an order of ma		
23	increase from loading predicted to occur after dewatering and capping Pond D is well below the detection limits of boron analytical methods. These calcula		
24	Wabash River at Pond D are negligible.		
25			
26			
27			

	D	E	F	G
1				
2				
3				
4				
5	Source: ISWS CR 441, 1988			
6				
7				
8	Source: Exhibit 4, Fig. 14			
9				
10				
11				
12	Source: Exhibit 4, Fig. 14			
13				
14				
15	= L1/$Q_{7,10}$			
16	= L2/$Q_{7,10}$			
17				
18	Source: Exhibit 12			
19	Source: USEPA SW-846 Method 6010c			
20				
21				
22	gnitude lower than median observed concentrations. The calculated concentration			
23	tions indicate that the effects of boron loading in groundwater discharge to the			
24				
25				
26				
27				

Natural Resource Technology, Inc.

MEMORANDUM

TO: Michael Bollinger, Ameren Services

FROM: Bruce Hensel

DATE: August 19, 1999

RE: STORET Data, Wabash River near Hutsonville, IL

Wabash River water quality data from the STORET database were not included in the hydrogeologic assessment for the Hutsonville ash impoundments because the closest downstream station with relevant parameters is in Hutsonville, about two river miles downstream, and because there are no upstream data with relevant data for comparison. However, I thought you might be interested in these data as an overview of general water quality in the Wabash River; therefore, they are summarized in this separate memorandum.

The STORET data contained records from Station 3341920, "Wabash River at Hutsonville", for boron, manganese, iron, and nickel. Only one other nearby station contained boron data, and records for that station, which was just downriver of the station I used, had no records after 1980. There was also one station that, based on latitude, may have been at the plant; however, boron, iron, manganese, and nickel were not monitored at that station (although sulfate was). Two agencies reported duplicate samples to the database for the station that I used, so I queried it to only report records for the agency with the most records. The results are provided in Table 1.

The results in Table 1 show that maximum Wabash River concentrations at the City of Hutsonville are similar to the 95th percentile concentrations of background groundwater quality presented in Table 7 of the hydrogeologic assessment, and median concentrations are lower than or similar to the medians displayed on Figures 10, 13, 14, and 15 of the hydrogeologic assessment.

I also included a plot of boron concentration in the Wabash River at Hutsonville versus time, and the resulting graph appears to indicate annual peaks occurring at the end of almost every year. Whether these peaks are due to river stage or some other cause are unknown.

Overall, Wabash River water quality appears to be good at this station, relative to background groundwater concentrations observed at the plant; however, it is difficult to determine possible plant impacts on Wabash River water quality because there are no upstream data for comparison.

Table 1
Wabash River Water Quality Statistics from STORET Database

a. Statistics

	Sulfate	Boron	Iron	Manganese	Nickel
Count	0	113	118	118	117
Max (mg/L)		0.204	0.100	0.049	0.025
Median (mg/L)		0.055	0.050	0.015	0.015
Average (mg/L)		0.071	0.051	0.012	0.013
Min (mg/L)		0.005	0.010	0.005	0.005

b. STORET Station Information

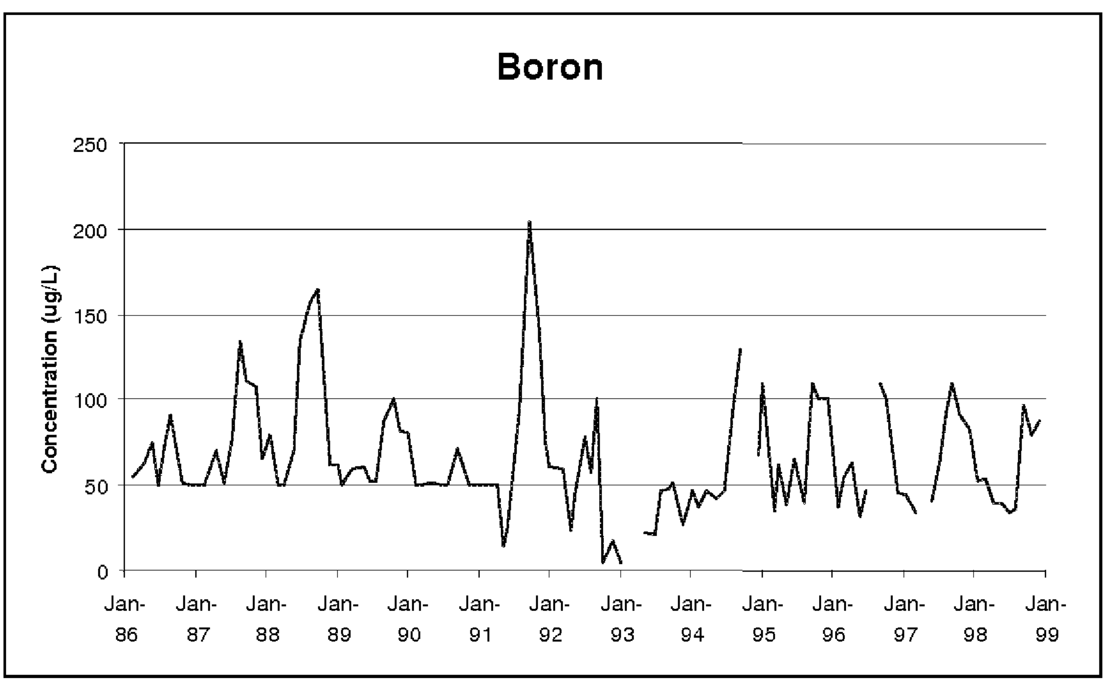
AGENCY	STATION NO	LAT	LONG	LOCATION NAME
21ILAMB	3341920	390637	873918	WABASH RIVER AT HUTSONVILLE IL

c. Period of Record

Station
10/8/69 through 12/15/98

d. Data Distribution of Selected Parameters (based on iron count)

Year(s)	Number of Records	Records/yr
1969 - 1979	0	0
1980	2	2
1981 - 1985	0	0
1986 - 1989	35	9
1990 - 1998	81	9



Conceptual Development Of a Pozzolanic Cap For the Closure of Basin D at the Hutsonville Power Station

VFL Technology Corp.
16 Hagerty Boulevard
West Chester, Pennsylvania 19382
(610) 918-1100 - PHONE
(610) 918-7222 - FAX

FINAL REPORT

CONCEPTUAL DEVELOPMENT OF A POZZOLANIC CAP FOR CLOSURE OF BASIN D AT THE HUTSONVILLE POWER STATION HUTSONVILLE, IL

Prepared for:

Natural Resource Technology
23713 W. Paul Road
Pewaukee, WI 53072

Prepared by:

VFL Technology Corporation
16 Hagerty Boulevard
West Chester, PA 19382

(610) 918-1100

March 25, 2003

TABLE OF CONTENTS

Final Report

Conceptual Development of a Pozzolanic Cap for the Closure of Basin D at the Hutsonville Power Station

1.0 Background

Basin D at the Hutsonville Power Station is an inactive ash disposal area that needs a cap for final closure (Photo #1). Natural Resources Technology (NRT), Pewaukee, Wisconsin, contracted the services of VFL Technology Corp. (VFL) to determine the feasibility of developing a concept for the creation, manufacture, and placement of a pozzolanic cap for Basin D at the Hutsonville Station.

The purpose of this report is to present a final summary of the information, findings and test results that have been generated for the conceptual development of the pozzolanic cap for the closure of Basin D at the Hutsonville Power Station in Hutsonville Illinois.

The Program Goals of this study were to:

- Attempt to develop a pozzolanic cap material that would achieve a permeability of 1 x 10^{-7}cm/sec, and have an unconfined compressive strength of approximately 150 psi.
- If the 1 x 10^{-7}cm/sec permeability goal is unrealistic or unachievable with these materials, estimate the most realistic performance of these materials under field conditions.
- Produce a cost-effective pozzolanic cap material that can be easily handled and placed with common earth moving equipment.
- Attempt to minimize the amount of regarding needed to prepare Basin D for the cap, while maximize the use of Basin A fly ash as a stable fill material and as a construction material for the development of the pozzolanic cap.

To accomplish these goals, VFL and NRT developed a scope of work for the project. VFL employed the help of GeoSystems Consultants Ind. to assist with the geotechnical engineering portion of the program. The scope of work basically included:

- A field assessment of the site (VFL and GeoSystems);

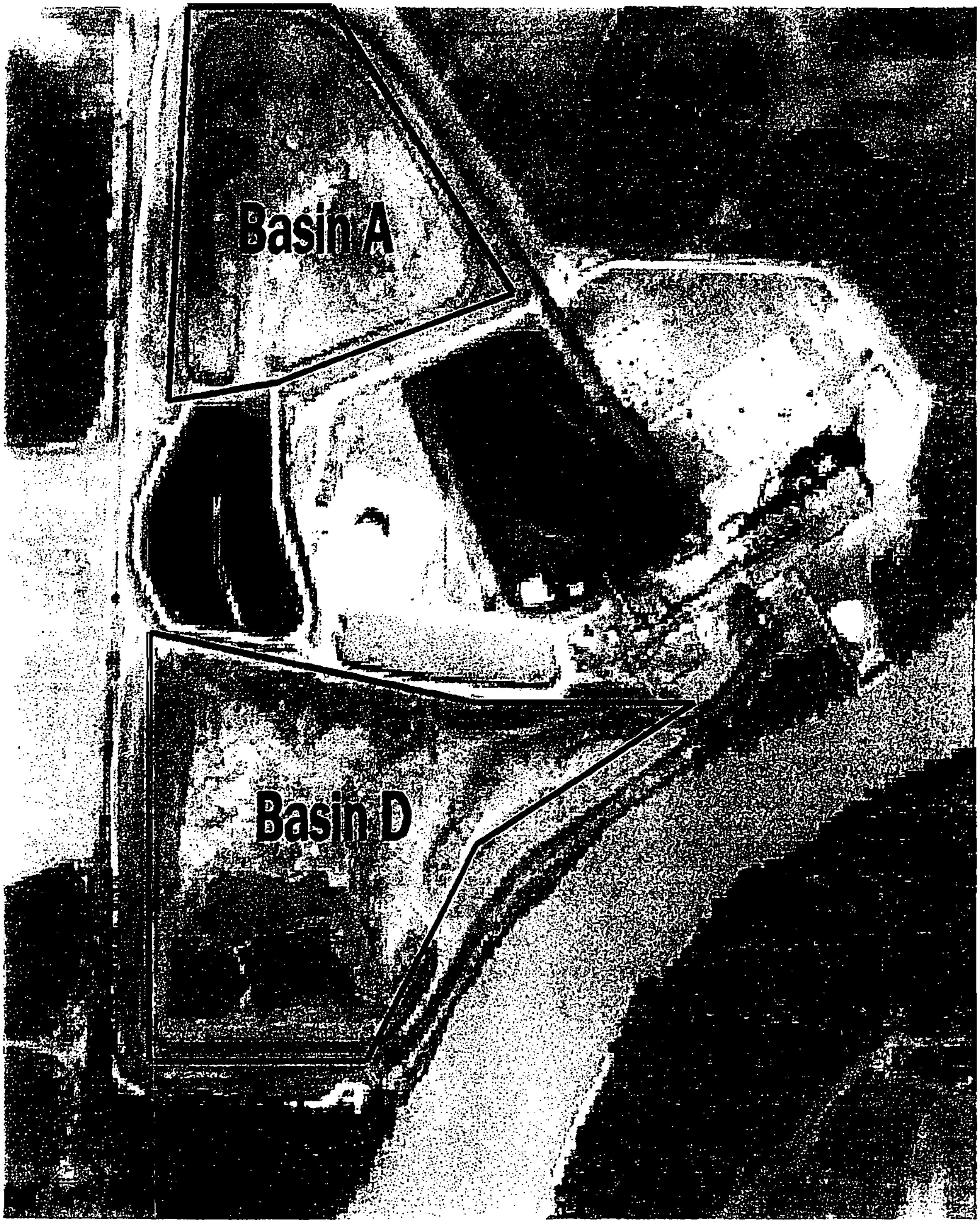


PHOTO 1 Hutsonville Power Station Basins A and D

- A review of existing geotechnical data of the site to determine if additional information is needed to finalize the cap design and construction (GeoSystems).
- Collect samples of the Basin materials (VFL).
- Conduct a treatability study to determine if a pozzolanic cap can be developed to meet the current design guidelines for closure cap construction and develop an operational approach to construct the cap (VFL).
- Conceptual development of the basic cap design, appearance and estimated volumes of material to be used in the cap construction (GeoSystems).

On March 5 and 6, 2002, representatives of VFL Technology Corp. and GeoSystems Consultants Ind. visited the Hutsonville site. Samples from the two basins were collected, and existing geotechnical data was reviewed. The Hutsonville ash samples were tested at VFL's Corporate lab in West Chester Pa. using a variety of locally available stabilization reagents.

2.0 Overall Program Conclusions

- The preliminary geotechnical evaluation indicates that the construction of a pozzolanic cap is definitely feasible; however, some additional, more refined analyses are needed to finalize the engineering and design of the cap system.

- The results of the Treatability Study program show that it is feasible to construct a structurally stable, environmentally acceptable Pozzolanic Cap and use this cap in the final closure of Basin D at the Huntsville Power Station. Although the permeability results do not meet the original goal of 1×10^{-7}cm/sec, the results of several mixes are in the mid to low 10^{-7}cm/sec range.

- By using Basin A ash as a construction material for the pozzolanic cap, approximately 160,000 yds^3 of ash can be utilized, which significantly extends the life of Basin A.

- All of the mixes that were considered potential candidates for cap construction easily met the unconfined compressive strength goal of 150 psi.

3.0 Geotechnical Investigation

As indicated above, the geotechnical data review, conceptual design, material volume estimates, preliminary settlement and slope stability analyses were conducted by GeoSystems. The report of their findings and analyses has been included in Appendix 1 of this report.

In summary, GeoSystems believes the construction of a pozzolanic cap is feasible and will be an effective system; however, some additional information is needed to complete the final engineering and design of the cap system.

An overview of the conclusions of the GeoSystems report indicate:

- .... A parametric analysis varying cap permeability from1 x 10^{-5}cm/sec to 1 x 10^{-7}cm/sec yielded "effectiveness" ranging from 78% to 97%........
- .....As the slope of the final cover increases from 1% to 5%, the volume of regarding reduces from 110,000yds^3 to 75,000 yds^3 ......
- .....With a 5% slope, the volume of ash fill material needed from Basin A is estimated to be 160,000 yds^3............
- .....The volume of the pozzolanic cap (3 feet thick) is estimated to be 100,000 yds^3 and varies little as the slope varies from 1% to 5%..........

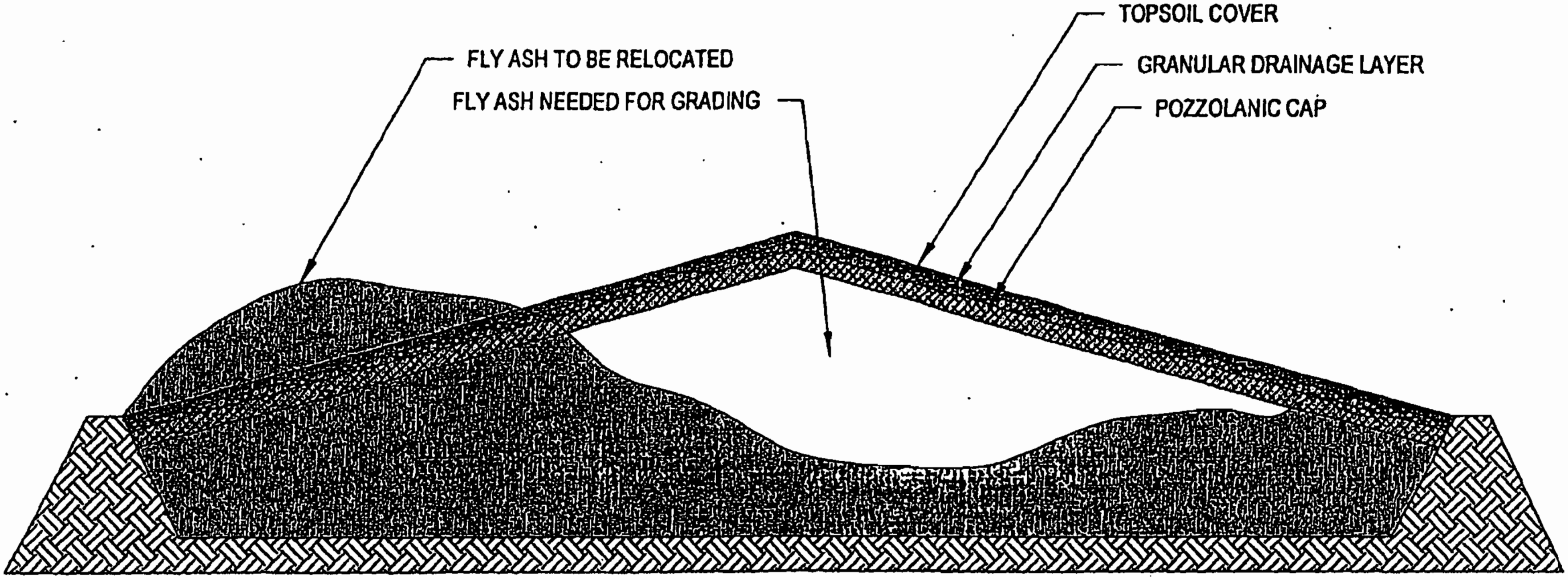
A graphical presentation of a conceptual, representative cross section of Basin D showing the cap design, regarding requirements, needed fly ash fill material from Basin A, etc. was developed by GeoSystems (part of GeoSystems report - see Appendix 1) and has been included here as Figure 1 for reference purposes.

4.0 Treatability Study

A few "Performance Goals" were established for the final pozzolanic cap material. The intent was to see if the stabilized materials could meet the existing cap design specifications, and if not, determine how well they performed against these existing specifications. The "Performance Goals" for this project were to:

- Develop a permeability of 1 x 10^{-7}cm/sec, or determine how close the stabilized materials can realistically come to these specifications.
- Develop approximately 150 psi unconfined compressive strength.
- Attempt to develop a cost-effective mix design that can be easily implemented an constructed in the field.
- Develop a cap system that was environmentally acceptable (minimizes leaching).

VFL's treatability study can be broken down into four basic areas: Raw Materials Characterization; Reagents; Mix Design Development and Mix Design Performance Testing. Each of these areas is discussed further in the following sections of this report.



REPRESENTATIVE CROSS SECTION
POND D
HUTSONVILLE POWER STATION
HUTSONVILLE, ILLINOIS

GeoSystems Consultants, Inc.

PROJECT NO.: 02G106	FIGURE 1
APRIL 2002	

REVISED 12-26-02

4.1 Raw Materials Characterization

During the site visit, VFL collected six (6) samples of ponded ash from different locations in Basin A, and two (2) samples of ash from different locations in Basin D. The six samples from Basin A and two samples from Basin D were individually tested for moisture content, pH, density and Loss on Ignition (LOI).

The natural solids content of the ash excavated from Basin A ranged from 71.4% to 74.2% solids (40.0% to 34.8% moisture – dwb). The pH values for Basin A ranged from 8.4 to 11.0, while the LOI's for Basin A ranged from 2.1% to 8.9%. All ash samples showed varying degrees of bleeding (draining of free liquids from the material).

As indicated previously, the intent is to use material from Basin A to produce the pozzolanic cap for the closure of Basin D. In order to simulate full-scale operations, the "as received" samples of ash from Basin A were allowed to decant/drain. This was done to estimate the handling and solids content characteristics of the ash that will be used in the full-scale operations. The data showed that some of the ash samples decanted/drained nicely, while others did not decant/drain as well. The decanted/drained solids content of the Basin A materials ranged from 73.9% to 81% solids (35.3% to 23.5% moisture – dwb), or a 1.4% to 8.8% increase in solids content.

The two samples of ash collected from Basin D showed a solids content range of 72.9% to 82.6% solids (37.2% to 21.1% moisture – dwb). The sample that showed the high solids content was taken from a stockpile of material that was sitting on the Basin (age unknown). The pH's for the two samples collected from Basin D were 8.8 and 8.2 respectively. The results of the physical analysis of the ash samples can be found on Table 1 of this report.

TABLE 1
Physical Characterization of the Hutsonville Ash

Basin	Sample Number	Sample ID	As Received [illegible]	Solids [illegible]	Drained Solids	Loss on Ignition	Particle Size 100	200	325	Density [illegible]	[illegible]
A	A-1	#1, Inflow	10.4	72.7	80.8	3.1	95.9	83.8	64.1		
A	A-2	#2 Inflow +1	9.6	74.2	80.8	2.1					
A	A-3	#3 Inflow +2	11.0	72.2	81.0	4.5	90.4	78.0	63.1		
A	A-4	#4 Inflow +3	11.0	71.4	79.3	2.6					
A	A-5	#5 Inflow +4	8.6	72.3	78.2	2.5					
A	A-6	#6 Outfall	8.4	72.5	73.9	8.9	93.0	79.5	66.0		
A	A-7	Composite A1-A6	10.0	NA	79.6		95.9	85.6	71.4	87.6 / 69.7	115.2 / 91.7
D	D-1	Basin D	8.8	72.9		5.2					
D	D-2	56K Stkpl.	8.2	82.6	NA	4.0					

In addition to the physical characterization of the ash samples listed above, an elemental analysis and TCLP leachate analysis for the 8 RCRA metals was run on a composite sample of the Hutsonville ash. The composite sample was generated by combining equal portions of ash samples A-1 through A-6. The results of the chemical analyses are listed below in Table 2. The actual data reports from Dalare Labs in Philadelphia, Pa. have been included in Appendix A-2.

TABLE 2
Elemental and TCLP Analysis of the Hutsonville Ash

PARAMETER	[illegible] Ash Composite CHEMICAL ANALYSIS TOTAL	LEACHABLE
Arsenic	34.4	0.020
Barium	95.0	0.056
Cadmium	< 1.0	0.01
Chromium	24.3	< 0.01
Lead	55.6	0.12
Mercury	0.076	< 0.001
Selenium	18.3	0.013
Silver	< 1.0	< 0.01

Notes: Total = Total Elemental Concentration in mg/kg
Leachable = TCLP Leachable Metals in mg/l
< = Less than

4.2 <u>Reagents</u>

VFL has used numerous reagents in the development of pozzolanic construction materials. VFL reviewed these various reagents and based on previous full-scale experience with similar projects, selected what it believes to be the best performing, commercially available (in large quantities), and most cost-effective reagents for this project, from sources in the vicinity of the job site. These reagents include:

- Portland Cement,
- Class C Fly Ash (self-setting type)
- Fluidized Bed Residue Ash
- Quicklime
- FGD Scrubber Sludge (used to make the particle size of the mix design finer, which improves permeability)
- Native Soils (used to make the particle size of the mix design finer, which improves permeability).

VFL experienced a few minor delays in the treatability study portion of the project. These delays are directly attributed to the delays in receiving some of the samples of reagents from the various vendors. One of the most problematic was the FGD Scrubber Sludge, which was finally received on date *06/06/02*.

4.3 Mix Design Preparation

In order to simulate full-scale conditions, VFL combined the six (6) decanted/drained samples of ash from Basin A into one (1) composite ash sample that was used to prepare all of the mixes. The solids content of this composite sample was approximately 79% solids (26.6% moisture – dwb).

All mix designs were prepared in a laboratory mixer and mixed to the consistency expected to be achieved using full-scale processing equipment. All mix designs were damp, granular, soil-like materials that could be easily handled and placed with common earth moving equipment. All of the mixes were prepared on the "wet side of optimum moisture" to assure that there was enough moisture in the mix for reagent hydration and proper compaction. This "wet side of optimum moisture" consistency also minimizes the potential for dusting during full-scale operations. See Table 2 for the mix designs developed this project.

Solids contents, as well as wet and dry compacted densities were recorded for all mixes. These values will be used as operating specifications during full-scale production and placement operations.

All mixes were compacted into standard size compaction molds, labeled, and stored in sealed plastic bags to insure proper curing and prevent moisture loss during their curing cycle.

4.4 Mix Design Performance Testing

Immediately after mix preparation, all of the mixes were evaluated for consistency, handlability, and constructability. As mentioned above, all of the mixes had a damp, granular, soil-like consistency. All mixes could be easily handled, transported and placed with common earth moving equipment. All of the mixes could support heavy equipment traffic immediately after placement and compaction. This means that multiple lifts of stabilized material could be sequentially placed on top of each other throughout the day during full-scale operations.

As proposed, all of the mixes were tested for unconfined compressive strength (UCS) in accordance with ASTM C - 39. All compressive strength cylinders were tested in duplicate and capped prior to UCS testing. The mix designs and UCS test results can be found in Table #3 of this report.

Overall, the mixes generally performed as expected, with the exception of the quicklime mixes. All mixes showed good solids contents as well as wet and dry compacted densities. Based on the mix densities, costs, UCS results, etc, the best performing mixes were selected for the next phase of permeability testing. These mixes were:

Mix 1 – 10% cement
Mix 2 – 5% cement
Mix 5 – 5% fluidized bed residue
Mix 9 – 6.3% cement + 15% native soils
Mix14 – 30% FGD Filtercake + 10% cement
Mix 16 - 30% FGD Filtercake + 10% quicklime

Triaxial permeability tests were run on the above listed mixes after 28 and 84 days of curing. The results of these tests are listed in Table #3 of this report. During the 84 day permeability testing, a problem was discovered in the test results. All of the test specimens showed higher (more permeable) values than the 28 day results. In some cases, it was over an order of magnitude. This data trend is extremely unusual for pozzolanic reaction mechanisms, which are known to improve with time. It was concluded that the entire set of cylinders must have been damaged during transport and handling. Companion cylinders were tested again after curing 84 days and these permeability values fell in the expected range.

The only mix that did not show the normal permeability improvement characteristics was Mix #16. All of the indicator parameters for this Mix looked promising (consistency, compaction characteristics, densities, strength development, etc.), yet the permeability data did not follow the usual trends.

At this point, it should be remembered that the mixes prepared in this program are considered to be excellent indicator mixes to examine the feasibility of the program and provide data to determine the basis for a final mix design. Further refinement of the mix design can be assessed to improve performance, permeability, and cost-effectiveness of the pozzolanic cap material as necessary.

After reviewing all of the permeability data listed in Table #3, it appears that the realistic performance range for these types of pozzolanic materials is the low 10^{-6}cm/sec to the mid→low 10^{-7}cm/sec range for materials to be produced under full-scale field conditions. The typical 1×10^{-7}cm/sec liner spec means that the material must be in the 10^{-8}cm/sec range so as not to exceed the1 x 10^{-7}cm/sec spec under field conditions. These types of values are extremely difficult to meet with most materials under field conditions.

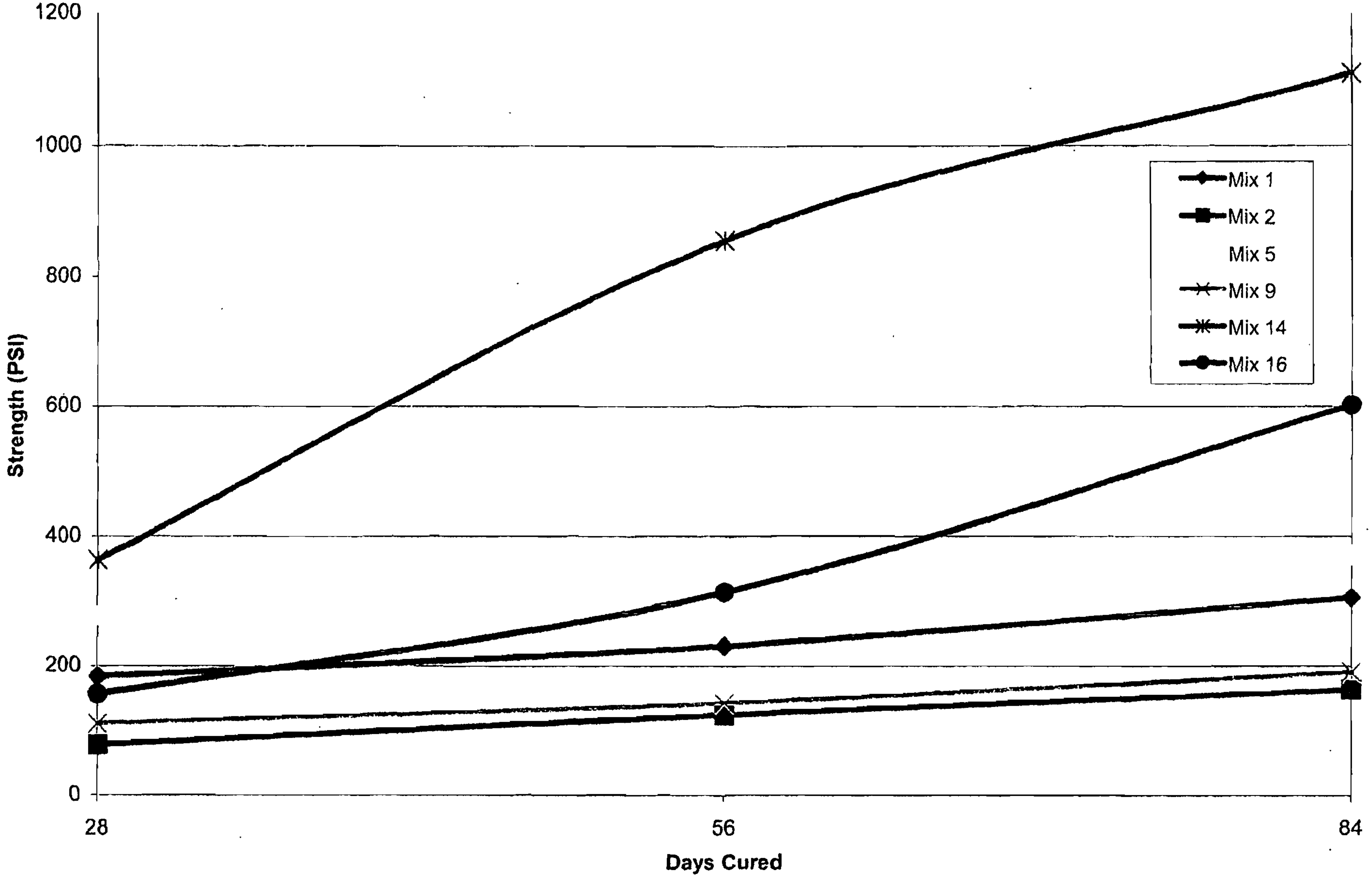
TABLE 3
TREATABILITY STUDY SUMMARY SHEET

Mix Number	Mix Design % Fly Ash (Comp 1-6)	Mix Design % Filter Cake[2]	Mix Design % Soil[3] (Black Sand)	Reagents[4] Cement (Lafarge)	Reagents[4] C Ash (Newton)	Reagents[4] FBR (ADM)	Reagents[4] Q-lime (Miss.)	Solids (%)	pH (SU)	Density Wet (lbs/ft³)	Density Dry (lbs/ft³)	UCS[1] 28 day (PSI)	UCS[1] 56 day (PSI)	UCS[1] 84 day (PSI)	Permeability K20 - (cm/sec) 28 day	Permeability K20 - (cm/sec) 84 day
1	100	-	-	10.0	-	-	-	81.5	11.9	116.0	94.5	184	231	305	5.37E-07	7.64E-07
2	100	-	-	5.0	-	-	-	80.3	11.7	116.5	93.5	79	125	165	5.03E-06	4.74E-06
3	100	-	-	-	15.0	-	-	82.3	10.9	113.4	93.3	31	41	37	-	-
4	100	-	-	-	30.0	-	-	83.5	11.4	107.5	89.8	81	124	114	-	-
5	100	-	-	-	-	10.0	-	82.2	12.3	106.4	87.5	277	276	372	1.75E-06	5.84E-06
6	100	-	-	-	-	20.0	-	84.3	12.5	97.7	82.4	291	583	609	-	-
7	100	-	-	-	-	-	10.0	81.1	12.5	107.1	86.9	38	70	138	-	-
8	100	-	-	-	-	-	5.0	80.5	12.3	113.4	91.2	22	27	82	-	-
9	85	-	15	6.3	-	-	-	83.5	11.7	114.2	95.4	110	142	191	1.99E-06	1.30E-06
10	85	-	15	12.5	-	-	-	83.4	11.9	117.4	97.9	320	416	380	-	-
11	85	-	15	-	-	-	6.3	83.5	12.4	110.7	92.4	26	42	48	-	-
12	85	-	15	-	-	-	10.0	81.9	12.6	113.1	92.6	35	84	82	-	-
13	70	30	-	5.0	-	-	-	77.3	11.6	112.4	86.9	123	168	164	-	-
14	70	30	-	10.0	-	-	-	77.9	12.0	113.0	88.0	364	856	1110	1.22E-07	1.38E-07
15	70	30	-	-	-	-	6.6	79.9	12.8	114.2	91.2	130	194	304	-	-
16	70	30	-	-	-	-	10.0	81.1	12.9	112.4	91.2	157	314	603	4.32E-05	2.91E-05

Note: *Reagent added on a dry weight basis to soil-fly ash blend.*
Stockpile time for all mixes was 30 minutes.

[1] *UCS strength data is average of 2 cylinders.*
[2] *FGD sludge added on a wet weight basis to ash.*
[3] *Soil added on a wet weight basis.*
[4] *Reagents added on a dry weight basis*
[5] *Second set of permeability results for mixes 14 and 16 are at 56-day cures.*

FIGURE 2
Unconfined Compressive Strength Development for Selected Mixes



Based on all of the above data, the four (4) mixes best performing mixes in the study were then tested for leachate characteristics using the TCLP leaching procedure. The results of the TCLP leaching tests are presented in Table #4 of this report.

TABLE 4
TCLP Leachate analysis of the Treated Ash

PARAMETER	Untreated Fly Ash	TREATED ASH			
		Mix #2	Mix #5	Mix #9	Mix #14
Arsenic	0.020	< 0.010	< 0.010	< 0.010	< 0.010
Barium	0.56	0.28	0.25	0.14	0.11
Cadmium	0.01	< 0.01	< 0.01	0.01	< 0.01
Chromium	< 0.01	0.06	< 0.01	0.05	< 0.01
Lead	0.12	< 0.02	< 0.02	< 0.02	< 0.02
Mercury	< 0.001	< 0.001	< 0.001	0.001	< 0.001
Selenium	0.013	0.019	0.010	< 0.010	< 0.010
Silver	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Notes: *Treated material cured for 84 days*
All results expressed in PPM. unless otherwise noted.
PPM = Parts per Million
< = Less than

As can be seen in Table #4, all of the mixes showed very low leaching potential. One interesting trend to observe is the fact that all of the stabilized mixes reduced the leachable level of arsenic, barium and lead when compared to the original, untreated ash. This is a common trend seen in the leachate characteristics of pozzolanic stabilization matrices.

Upon reviewing all of the data generated in the study, the most promising reagents and material blends to produce a pozzolanic cap under field conditions appear to be:

- Basin A fly ash and cement (Mix 1 and 2)
- Basin A fly ash, onsite soil and cement (Mix 9 and 10)
- Basin A fly ash, FGD Filtercake and cement (Mix 14)

FBR was not included in the final selection for several reasons. FBR has been used in the past for various construction needs including permeability which is why we have included it in this treatability study. FBR is quite useful when handled properly and used in the correct application. Recently, there have been reports on several construction projects that some FBR's are susceptible to expansion problems. Situations where it should be avoided are employing it where slight expansion is not acceptable.

FGD sludge is a good additive for most mix applications. However, FGD sludge from each power plant can be very different (chemically and physically) based on the coal source and type of boiler used. Another issue that VFL has with FGD sludge, in this specific application, is making sure that it is mixed thoroughly with the other ingredients. FGD sludge is a very sticky material. It is difficult to accurately feed it into a portable processing system because the FGD sludge has a tendency to adhere to the sides of feed hoppers that are used on portable pugmill plants (known as bridging). In most construction applications, where precise mix designs are not required, this is not a problem.

The mixes containing cement tend to be the easiest to quality control in field construction applications. Cement is a manufactured product and varies very little. Further optimization testing is recommended for the final mix design prior to full-scale operations. VFL would recommend that a test pad be constructed with full-scale equipment and sampled in substantial conformance with 35 Illinois Administrative Code (IAC) Part 816 to evaluate the proposed process equipment train and optimized the final mix design.

5.0 Extrapolation to Full-Scale Operations

The basic full-scale operational approach that VFL would use to construct the pozzolanic cap for Basin D's closure would conform to the following schedule of events:

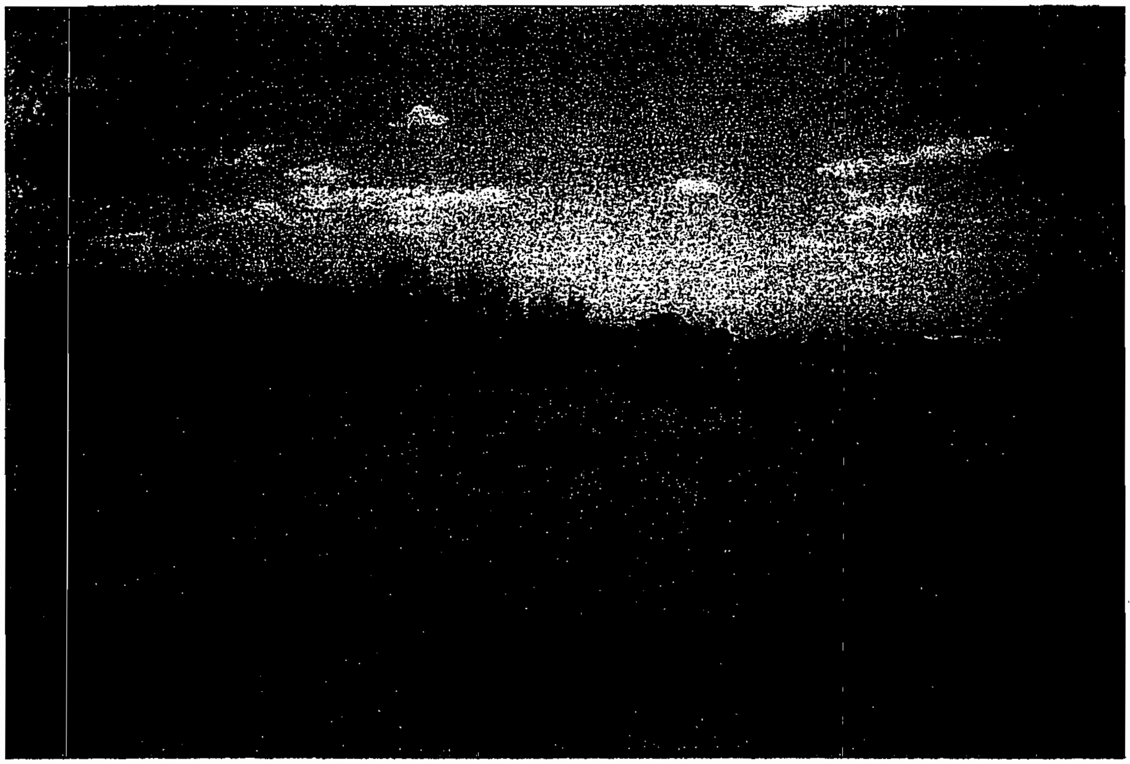
- Regrade Basin D to the lines and grades specified by the Engineer.
- Excavate the fly ash from Basin A and allow it to drain to the proper moisture content before using it in the mix design. Run On/Run Off to and from the area will be controlled and water drained from the ash will be routed back through the plants pond system.
- Construct a processing area in the vicinity of the two Basins. Erect the processing plant, silos and any other ancillary processing equipment needed. Construct haul roads to and from the placement area.
- Process the designated mix design.
- Place and compact the stabilized cap mix as soon as possible to the lines and grades established by the Engineer for the final cap design.

- Cover the placed material with the cover soils to protect the pozzolanic cap from severe weather events.
- Place the topsoil and vegetate as soon as possible.

To develop the necessary documentation for submittal to the State Regulatory Agencies, the basic Quality Control program for the pozzolanic cap construction would involve:

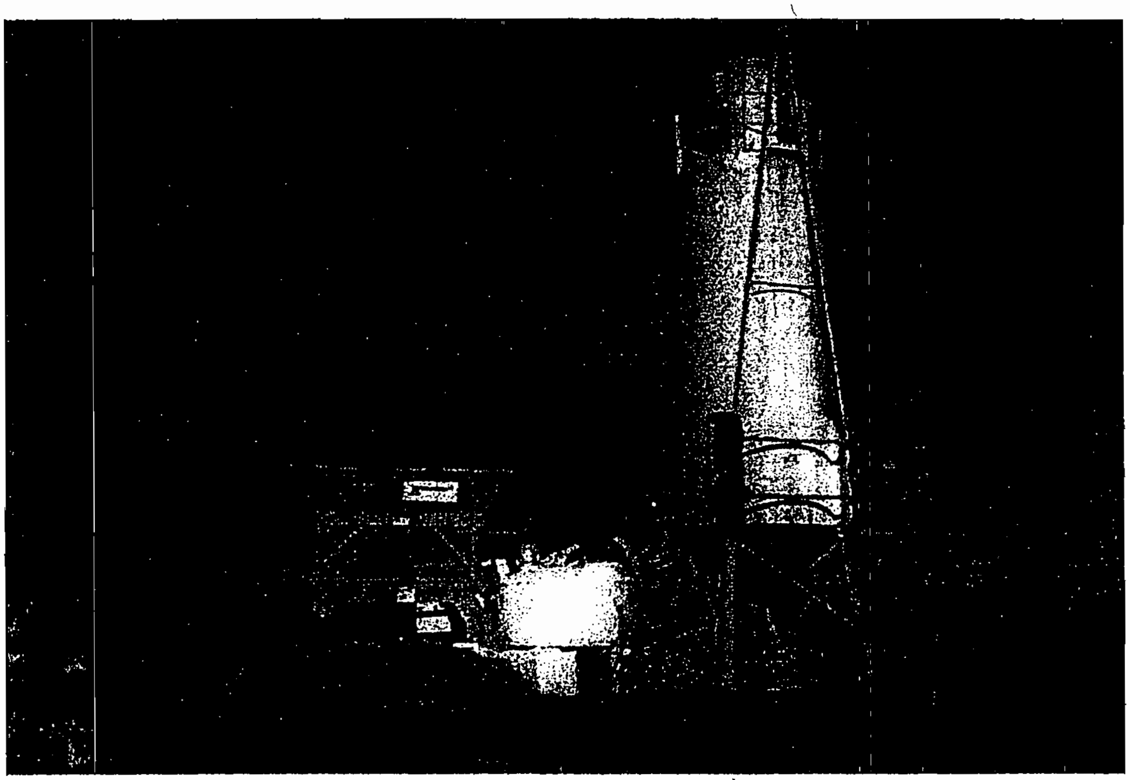
- Quality Control conformation testing on the materials to be used in the cover system and their placement.
- Process control testing of the mix design during production in substantial conformance with 35 IAC Part 816.
- Quality Control of the cap mix design during placement and compaction in substantial conformance with QA/QC procedures outlined in 35 IAC Part 816.
- Moisture monitoring on the excavated and drained Basin A fly ash. Control and QC confirmation checks on the reagents and any other materials of construction that will be used in the mix design
- Plant calibration.
- Insure that Basin D has been regraded to the lines and grades specified.
- Insure that the cover system has been installed to the lines and grades specified.

The cap construction activities listed in this section have been used by VFL on several other pozzolanic cap projects. To demonstrate this, the following photos of a pozzolanic cap system that VFL constructed on an industrial landfill in New Jersey have been included for review.



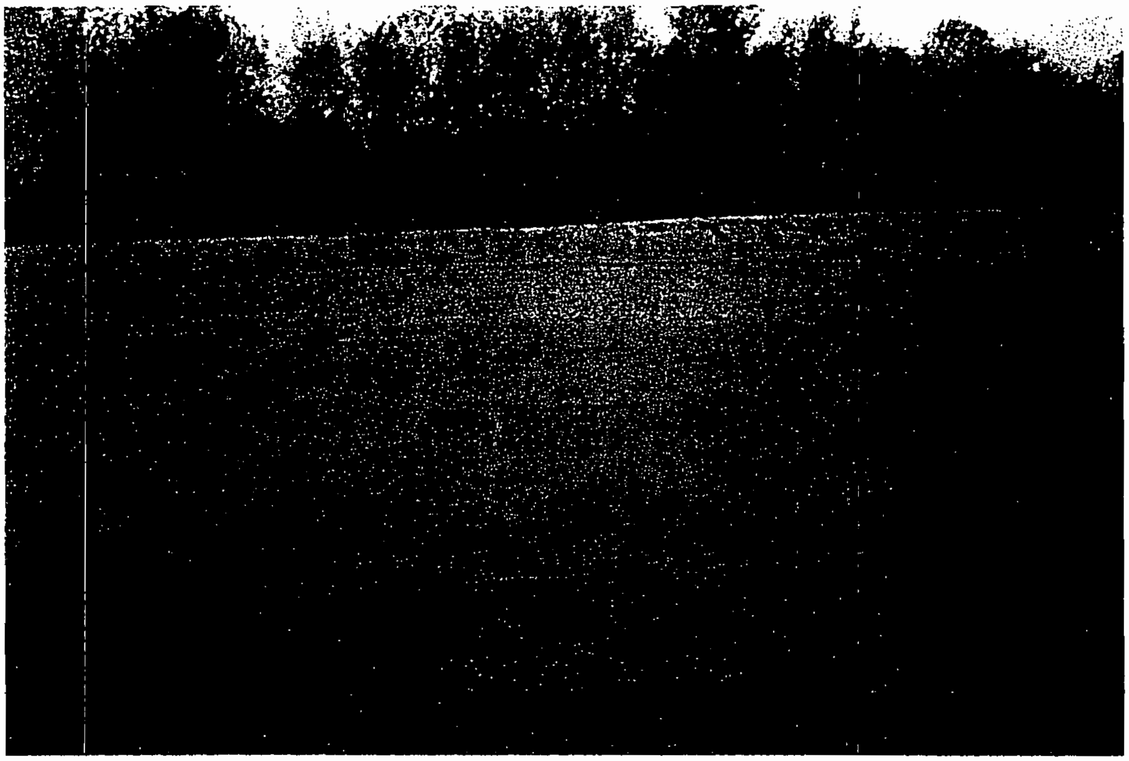
PLACEMENT OF THE DRAINAGE LAYER
AND TOP SOIL FOR COVER SYSTEM

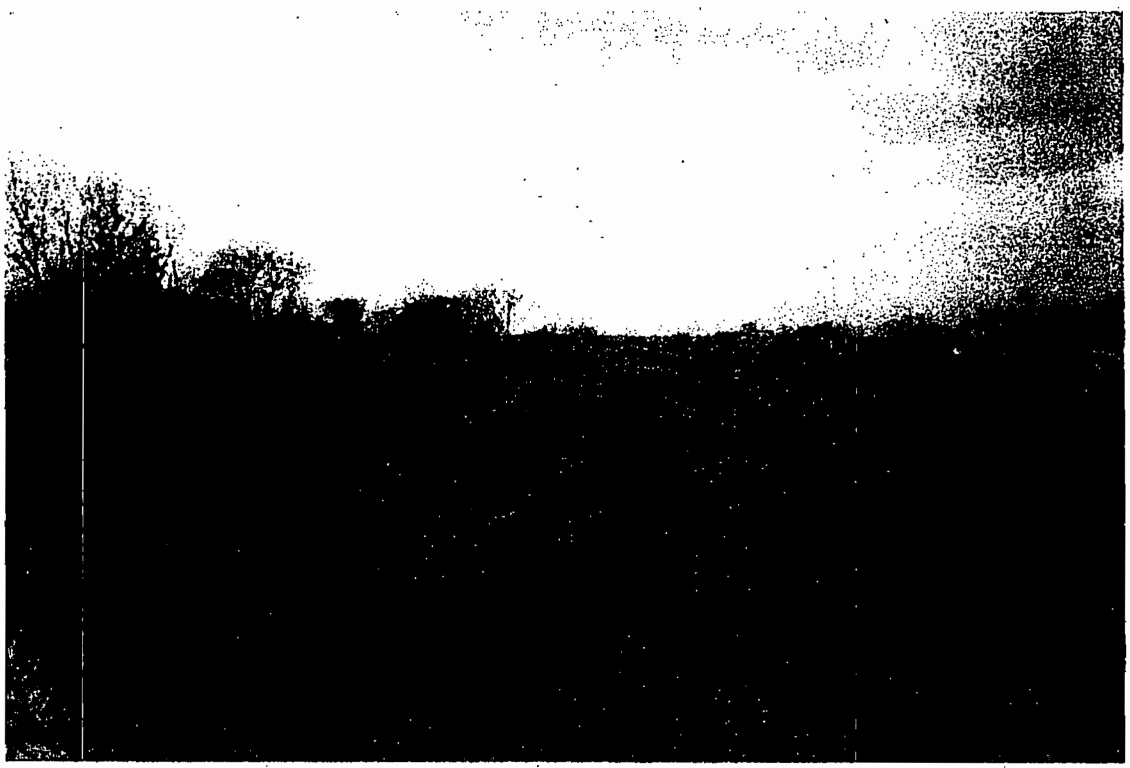
REGRADING LANDFILL



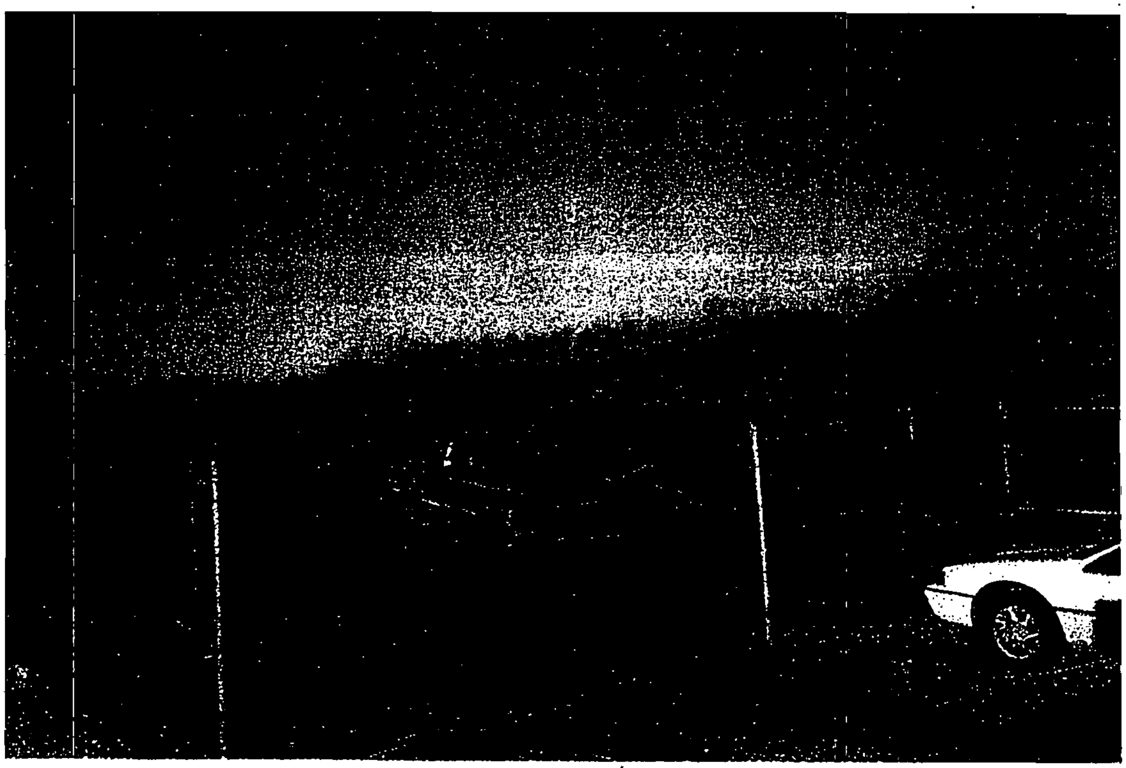
PROCESSING EQUIPMENT

PLACEMENT AND COMPACTION OF THE
POZZOLANIC CAP MATERIAL





COMPACTED AND GRADED
POZZOLANIC CAP MATERIAL



FINISHED LANDFILL

Task 2: Review Readily Available Geotechnical Data

Mr. C.A. Robb of NRT submitted selected geotechnical data regarding the subsurface conditions, site drawings, and tables containing volumetric data for Basin "D." A list of these documents is included as Attachment 1. These documents were reviewed to ascertain subsurface conditions in the vicinity of Basin "D." Several inferred subsurface cross section and the associated test boring logs were evaluated. These data were then used to develop an "Idealized Cross Section" of the completed Basin closure at the location GeoSystems believes is the critical section with respect to slope stability. Soil strength characteristics were estimated based on information presented in relevant test boring logs. Where soil (strength) data was not available, GeoSystems used engineering judgment to select reasonable strength values for subsurface and embankment soils and impounded flyash.

GeoSystems also obtained and reviewed selected sections of the State of Illinois Title 35: Environmental Protection, Subtitle B (Waste Disposal Part 816, Alternative Standards for Coal Combustion Power Generating Facilities Waste Landfills), and Subtitle G (Waste Disposal Part 811, Standards for New Solid Waste Landfills).

Task 3: Engineering Consultation Services

GeoSystems provided Engineering Consulting Services regarding the geotechnical issues for the project. Specifically the following issues were addressed:

<u>Field Investigation Program</u>

GeoSystems identified data gaps in the geotechnical information provided with respect to performing the design evaluation. These deficiencies include insufficient laboratory data that characterizes physical and engineering properties of the impounded flyash, containment dikes, the various soil strata underlying the site, and the stratigraphy in the areas judged to be critical with respect to slope stability. It is our opinion that at least 6 additional test borings are required to develop adequate cross sections in critical areas and to obtain samples for physical and engineering property laboratory testing. These data would be used to perform analyses regarding slope stability and settlement.

<u>Alternate Cap Effectiveness</u>

Based on a review of the pertinent sections of the State of Illinois Title 35 Code, a pozzolanic barrier layer is an acceptable alternate cover system in lieu of using a goemembrane cover system. To evaluate the effectiveness of the pozzolanic cover system, the HELP computer model was used.

USEPA's computer model HELP (Hydrologic Evaluation of Landfill Performance) has been used to perform a water balance to estimate the quantity of fluid percolating through the final cover system to the basin materials, estimate the amount of runoff, and head on the cover system barrier layer.

HELP uses a water balance method to estimate the quantity of precipitation which will theoretically penetrate the basin final cover system and percolate through the waste. Site-specific climatological and design data can be input into the model in order to assess final cover performance.

To determine the quantity of rainfall penetrating the final cover, the model estimates runoff, cover system drainage, and evapotranspiration. These calculations are generally based on assumptions made regarding the runoff coefficient, root zone depth, quality of plant cover, soil porosity, field capacity, and initial water content. All rainwater remaining after runoff, cover system drainage, and evapotranspiration can either become leachate or can be incorporated into the waste.

The HELP model is generally accepted as a useful tool in the evaluation of cap and liner designs. To simplify the analysis of these designs, it makes several assumptions. These include steady state flow and homogeneous isotropic layers. Steady state flow may be achieved in an unknown number of years after the site has been closed and final cover installed. The non-homogeneous nature of the basin materials could result in rainwater channeling through voids, resulting in non-uniform flow. The effect of rainwater absorption by the waste or trapped rainwater remaining from active operations can be accounted for by setting the initial water content of the waste. These assumptions make the HELP model useful as a tool to compare various design options.

The information needed to run the HELP model includes climatologic, design, soil, and runoff data. To assist the user in operating the HELP model, the program can generate synthetic climatologic data for 20 years using internal databases with weather conditions for 139 cities throughout the United States (Evansville, IN was used for present study, which is about 90 miles from the site), 7 vegetation cover types, and 18 soil types. The user may select default values from these databases that best represent the expected site-specific conditions. Details of data input and modeling results (using the 20-year synthetic weather generator) are presented in Attachment 2.

HELP analyses were performed using a 6-foot thick cap section (3 feet pozzolanic cap, 3 feet cover soil: 0.5 to 1.5 feet drainage, 2.5 to 1.5 feet cover soil). Permeability of the pozzolanic cap was varied from $1x10^{-5}$ to $1x\ 10^{-7}$ cm/sec, and final cover slopes varied from 1% to 5%.

Based on the results of the modeling, the proposed cover design for Hutsonville Flyash Basin "D" for the flat cap area would result in a range of 78 to 97 percent effectiveness in eliminating drainage through the cover system to the basin materials. These percentages are based on the average total precipitation for one year and the "percolation from base of cover" values calculated using the HELP model (see Table 1). The "percolation from base of cover" is assumed to be the amount of leachate, which is a conservative required Slope Stability analyses for submission to the state.

Volume Calculations

Volume calculations for fly ash utilization associated with the various slopes (1% to 5%) for the finale closure configurations were performed. The results are presented in Attachment 3. Based on the analyses performed, the following conclusions have been developed:

- As the slope of the final cover increases from 1% to 5% the volume of soil to be regraded reduces from 110,000 yd^3 for 1% to 75,000 yd^3 for 5%.
- As the slope of the final cover increases from 1% to 5%, the volume of structural fill increases from 0 yd^3 for 1% to 160,000 yd^3 for 5%.
- The volume of protective soil cover (3 feet including vegetative support layer and drainage layer) varies little with the change in final cover grade from 1% to 5% (~100,000 yd^3).
- The volume of pozzolanic cap (3 feet thick) varies little with the change in final cover grade from 1% to 5% (~100,000 yd^3).
- Utilization of flyash from Basin "A" increases with increasing slope from 1% to 5%.

Erosion Potential

Erosion control of the cover system is important, because loss of the soil cover overlying the barrier layer increases the potential for damage by gnawing/burrowing animals, thus decreasing the effectiveness of the barrier. Erosion may be wind- and/or water-induced. The potential for erosion by these two environmental factors should be evaluated using the Universal Soil Loss Equation (USLE) and the Wind Erosion Equation (WEE). Erosion calculations are highly dependent upon the type and condition of vegetation anticipated after closure. Erosion loss due to wind and water can be calculated based on the anticipated short and long term condition of the cover system. No calculations were performed for this phase of the design process.

Freeze-Thaw Effects

The maximum estimated frost penetration depth in Central Illinois is 30 inches and the average depth of frost penetration is about 10 inches. A conceptual cover system design for the flat area could provide for soil depth above the barrier. A final cover will not be sensitive to freeze-thaw effects when properly designed

Air Emission Control

Airborne migration of landfill materials will be predominantly migration of dust particles during closure subgrade preparation and initial placement of the general fill layer. As the general fill layer (variable thickness) installation proceeds, the potential for fugitive dust containing landfilled materials would lessen and then be virtually eliminated once the general fill has been partially completed over the entire site.

CONCLUSIONS

Additional field investigation is necessary to better define the geotechnical properties of the impounded flyash, containment dikes, and various soil strata underlying the site, as well as better defining the stratigraphy for the critical sections identified.

A pozzolanic cap having a minimum thickness of 3 feet (0.91 meters) can be constructed. A parametric analysis varying cap permeability from $1x10^{-5}$ cm/s to $1x10^{-7}$ cm/s yielded "effectiveness": ranging from 78 percent to 97 percent. The permeability of the cap greatly influences its "effectiveness."

Post-closure settlement has been estimated to be about 1 foot for the cases evaluated. This is a rough estimate based on interpretation of engineering properties from soil descriptions presented in the boring logs provided, and assumed properties of the impounded flyash. Laboratory test data were available for use in these evaluations.

Based on review of results from the Preliminary Analyses, insufficient data are available to perform a comprehensive evaluation at this time. A supplemental field investigation designed to obtain relevant soil property data is needed to perform the required Slope Stability analyses for submission to the state.

LIMITATIONS

The conclusions and recommendations presented in this report are based on the assumptions that the subsurface conditions at the site and the assumed soil properties do not deviate appreciably from those disclosed by the test boring data provided and that the proposed design is substantially in conformance with the project description. GeoSystems Consultants should be notified immediately should differing conditions be encountered or if significant changes in design are contemplated, so that appropriate revisions can be made to the recommendations.

We sincerely appreciate the opportunity to submit this Progress Report for this challenging project. If you have any questions, please do not hesitate to contact us.Very truly yours,

GEOSYSTEMS CONSULTANTS, INC.

Craig R. Calabria, Ph.D., P.E.
Principal

Table 1: Pozzolanic Cap Effectiveness

% Effectiveness			
Cases	Pozzolanic Cap Permeability (cm/s)		
	$1x10^{-5}$	$1x10^{-6}$	$1x10^{-7}$
Case 1A	78%	78%	95%
Case 1B	78%	79%	95%
Case 2A	78%	81%	96%
Case 2B	79%	86%	97%

Case 1A: 30" topsoil, 6" sand at $1x10^{-3}$ cm/s, 36" pozzolanic cap on a 1% slope

Case 1B: 30" topsoil, 6" sand at $1x10^{-3}$ cm/s, 36" pozzolanic cap on a 5% slope

Case 2A: 18" topsoil, 18" sand at $1x10^{-2}$ cm/s, 36" pozzolanic cap on a 1% slope

Case 2B: 18" topsoil, 18" sand at $1x10^{-2}$ cm/s, 36" pozzolanic cap on a 5% slope

Attachment 1

Natural Resource Technology, Inc.

TRANSMITTAL

To: VFL Technology Corporation
16 Hagerty Boulevard
West Chester, PA 19382

Date: March 11, 2002
Project No: 1375
From: Christopher A. Robb
Re: Data Transfer –Soil Borings, Topography, etc.
Ameren Services - Hutsonville Power Station

Attn: Mr. Doug Martin

x For Your Files x As Requested x For Review ☐ Approve and Return

Copies:	Description
1	Boring Logs – EW-1, MW-6, MW-7, MW-7D, MW-8, GP-20 to GP-23, MW-11, MW-11R, SB-101 to SB-103, MW-14, TW
1	Sheet Pile Wall Site Plan (S-350) and Details (S-351): (PARTIAL COPY)
1	Figure No. 3 - Geologic Cross Sections (1375-B12)
1	Figure No. 4 – Bedrock Elevation Contours (1375-B11)
1	Figure No. 5 – Alternative No. 3: Earthen Final Cover (1375-B33C)
1	Figure No. 2 – Site Plan (1375-B30), via electronic mail
1	Table 3-2 – Areal Extent and Volumes of Unsaturated and Saturated Ash In Pond D
1	Table 3-3 – Final Cover Alternatives Material Balance Analysis
1	Title 35 IAC Part 811 and 816, via electronic mail

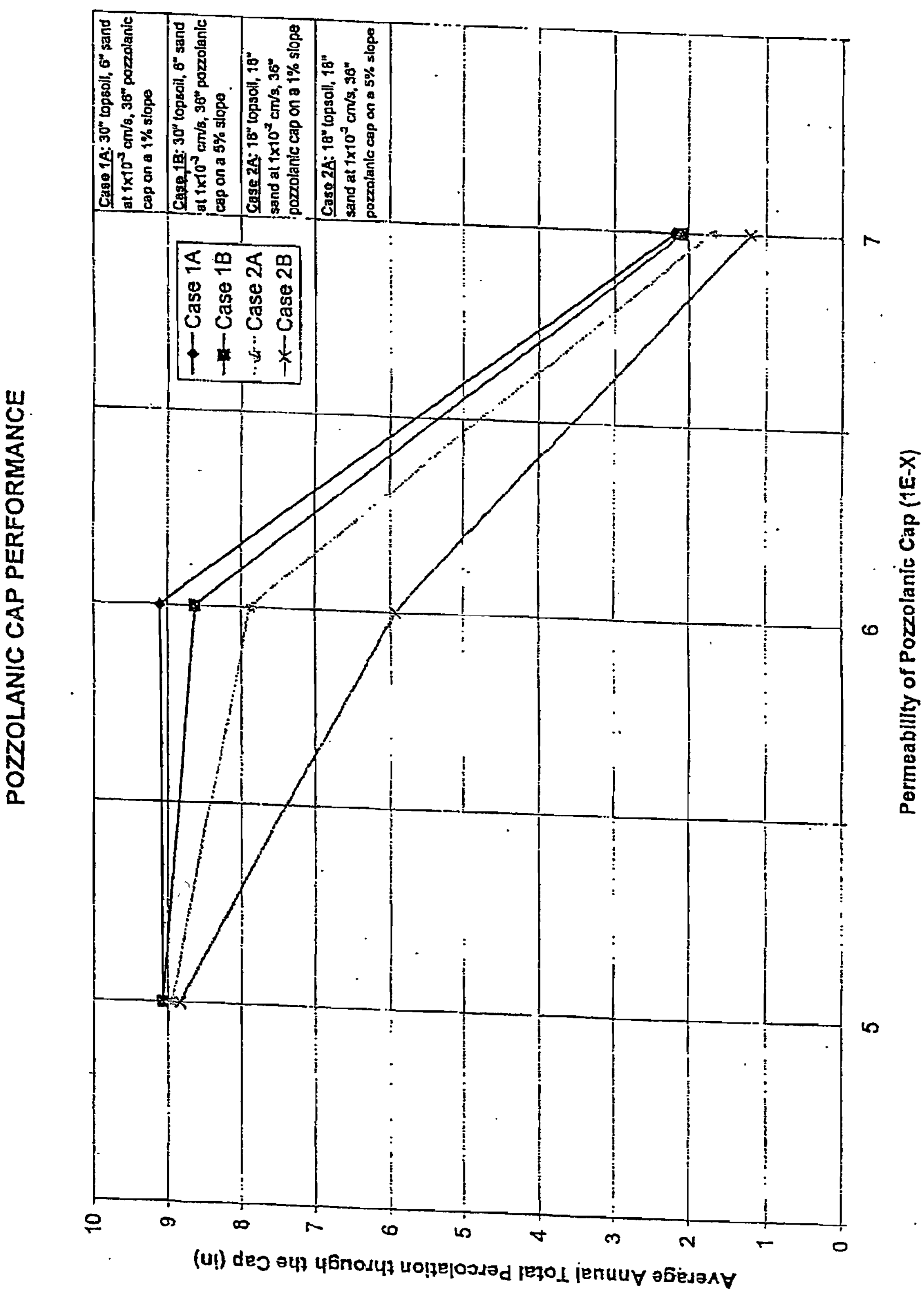
Comments:

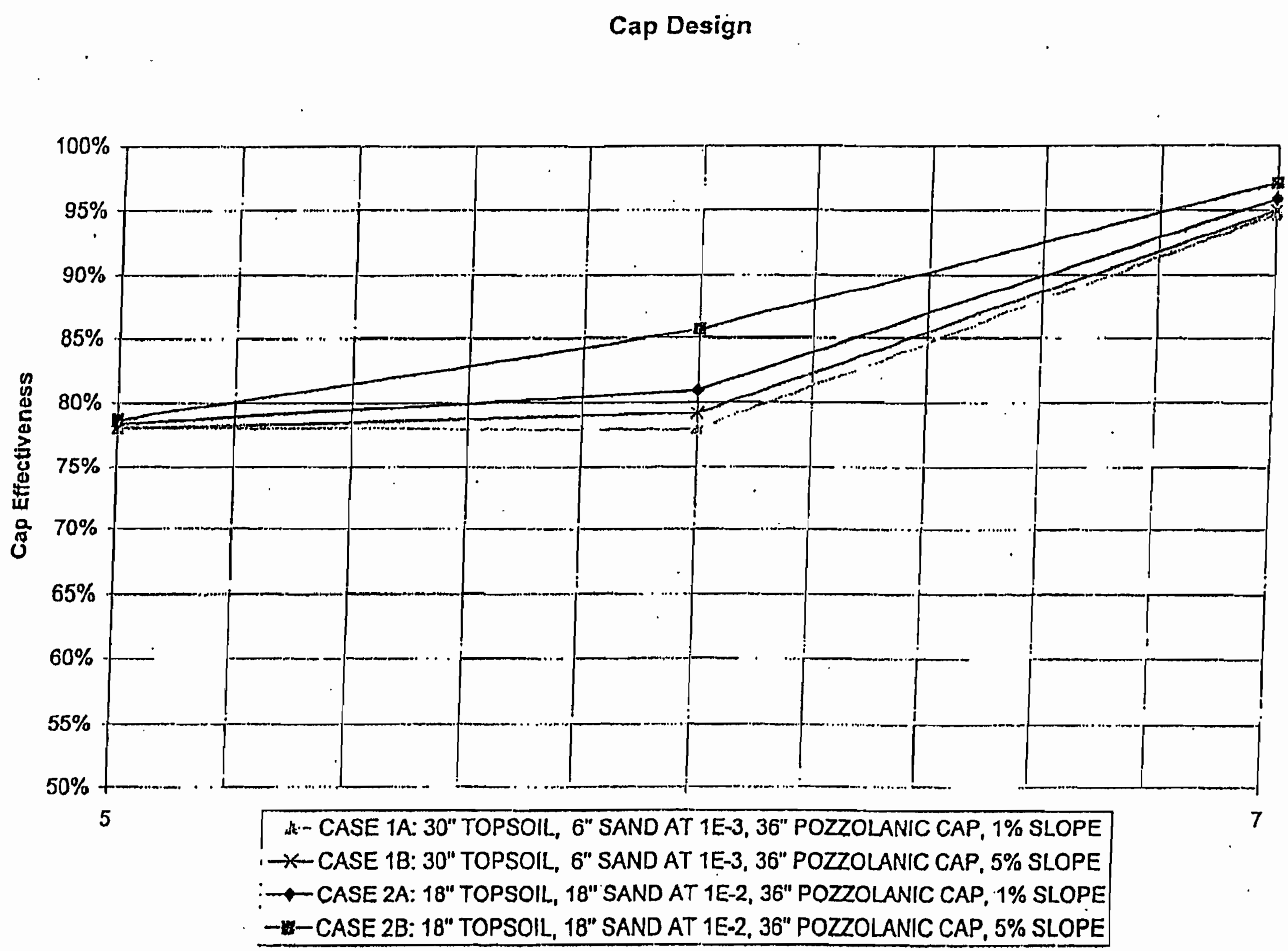
Doug,
Please find enclosed copies of the above listed materials. The following is a quick list of some additional potentially useful information:

- GP-20, 21, 22 and 23 are inside of the unlined ash impoundment (Pond D).
- No soil borings were performed in Pond D's berm.
- For Pond D fill: estimated approximately 15,500 cy fill below water surface.

23713 W. Paul Road, Pewaukee, WI 53072 ■ Phone 262/523-9000 ■ Fax 262/523-9001

Attachment 2


POZZOLANIC CAP PERFORMANCE
Average Annual Total Percolation through the Cap (in)
Permeability of Pozzolanic Cap (1E-X)
10
9
8
7
6
5
4
3
2
1
0
5
6
7
Case 1A
Case 1B
Case 2A
Case 2B
Case 1A: 30" topsoil, 6" sand at 1x10^-3 cm/s, 36" pozzolanic cap on a 1% slope
Case 1B: 30" topsoil, 6" sand at 1x10^-3 cm/s, 36" pozzolanic cap on a 5% slope
Case 2A: 18" topsoil, 18" sand at 1x10^-2 cm/s, 36" pozzolanic cap on a 1% slope
Case 2B: 18" topsoil, 18" sand at 1x10^-2 cm/s, 36" pozzolanic cap on a 5% slope


Cap Design
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
Cap Effectiveness
5
7
CASE 1A: 30" TOPSOIL, 6" SAND AT 1E-3, 36" POZZOLANIC CAP, 1% SLOPE
CASE 1B: 30" TOPSOIL, 6" SAND AT 1E-3, 36" POZZOLANIC CAP, 5% SLOPE
CASE 2A: 18" TOPSOIL, 18" SAND AT 1E-2, 36" POZZOLANIC CAP, 1% SLOPE
CASE 2B: 18" TOPSOIL, 18" SAND AT 1E-2, 36" POZZOLANIC CAP, 5% SLOPE

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0
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      M:\ENGINE~1\HELP-M~1\DATA4.D4
TEMPERATURE DATA FILE:        M:\ENGINE~1\HELP-M~1\DATA7.D7
SOLAR RADIATION DATA FILE:    M:\ENGINE~1\HELP-M~1\DATA13.D13
EVAPOTRANSPIRATION DATA:      M:\ENGINE~1\HELP-M~1\DATA11.D11
SOIL AND DESIGN DATA FILE:    M:\ENGINE~1\HELP-M~1\DATA10.D10
OUTPUT DATA FILE:             M:\ENGINE~1\HELP-M~1\VFL-15.OUT


TIME:  16:55     DATE:   3/27/2002


******************************************************************************

     TITLE:  VFL/Ameren Services-Hutsonville Power Station

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   8
     THICKNESS                     =      18.00   INCHES
     POROSITY                      =      0.4630 VOL/VOL
     FIELD CAPACITY                =      0.2320 VOL/VOL
     WILTING POINT                 =      0.1160 VOL/VOL
     INITIAL SOIL WATER CONTENT    =      0.2404 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =  0.369999994000E-03 CM/SEC


                                LAYER  2
                                --------

                      TYPE 2 - LATERAL DRAINAGE LAYER
```

VFL-15.OUT

MATERIAL TEXTURE NUMBER 5

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4570	VOL/VOL
FIELD CAPACITY	=	0.1310	VOL/VOL
WILTING POINT	=	0.0580	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1477	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	375.0	FEET

LAYER 3

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	36.00	INCHES
POROSITY	=	0.5410	VOL/VOL
FIELD CAPACITY	=	0.1870	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5410	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 375. FEET.

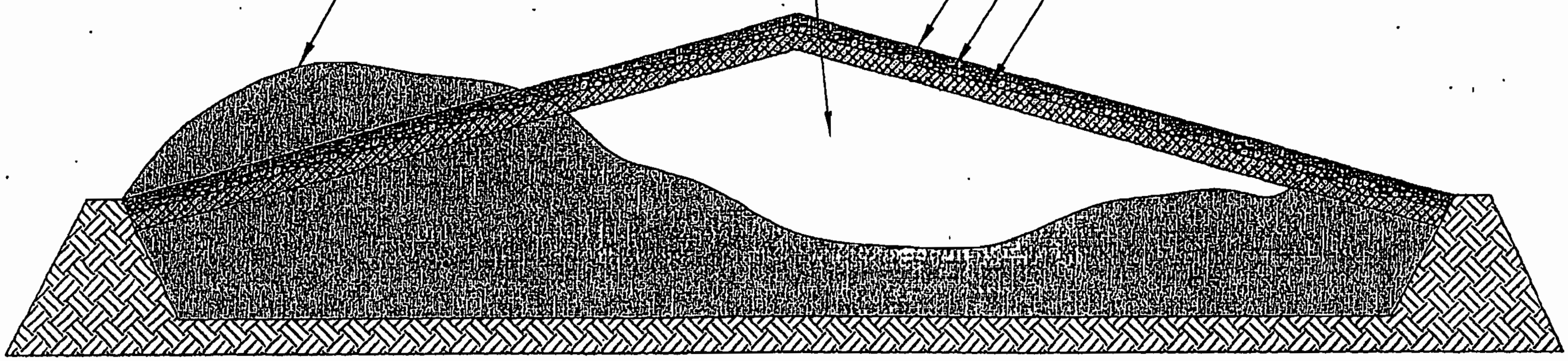
SCS RUNOFF CURVE NUMBER	=	78.50	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.014	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.705	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.262	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	26.462	INCHES
TOTAL INITIAL WATER	=	26.462	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
EVANSVILLE INDIANA

STATION LATITUDE	=	38.03	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	96	
END OF GROWING SEASON (JULIAN DATE)	=	300	
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES

Attachment 3



REPRESENTATIVE CROSS SECTION
POND D
HUTSONVILLE POWER STATION
HUTSONVILLE, ILLINOIS

GeoSystems Consultants, Inc.

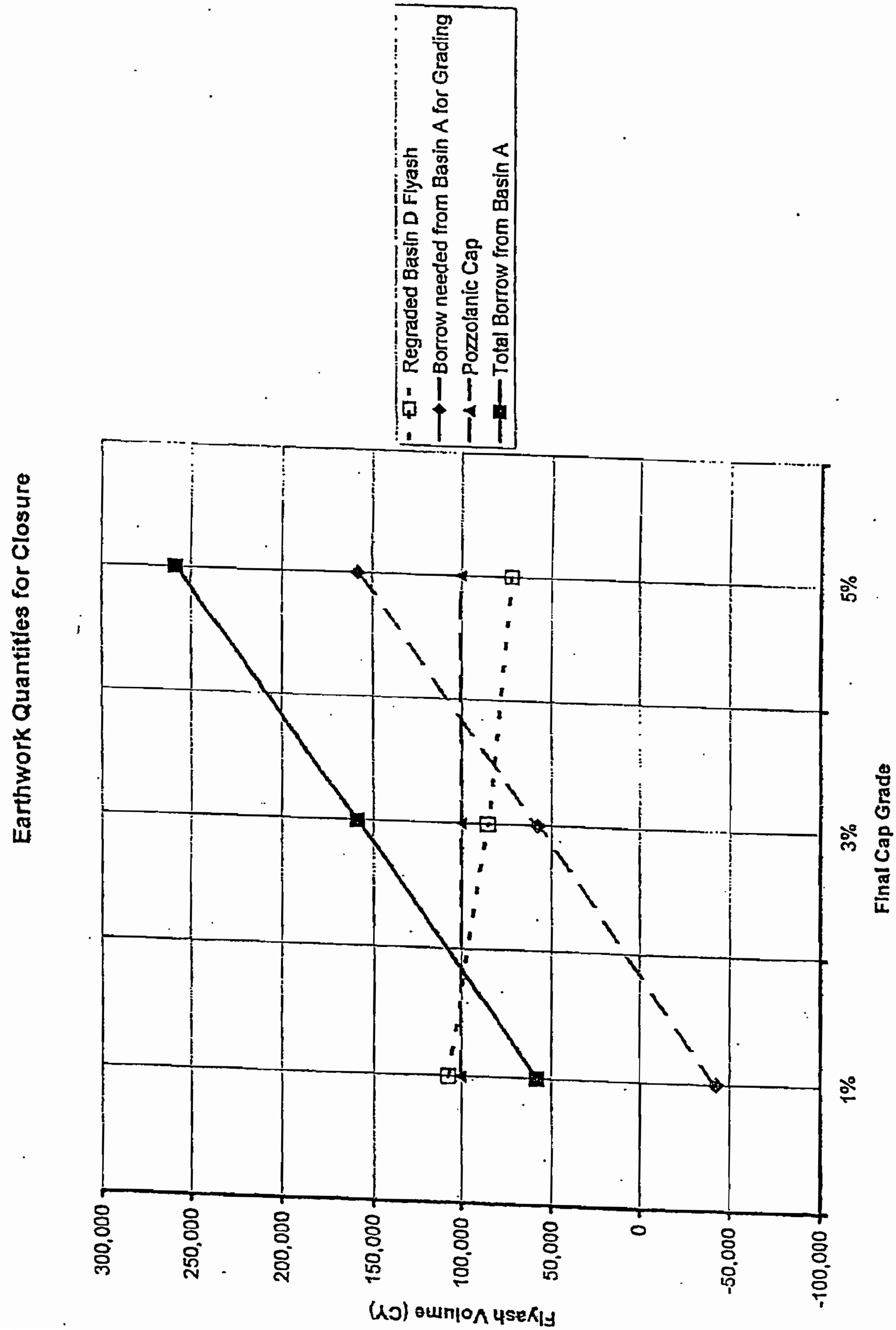
PROJECT NO.: 02G106	FIGURE 1
APRIL 2002	

ED 12-26-02

Attachment 4

Ameren Services - Hutsonville Power Station
Basin "D" Closure
EARTHWORK QUANTITIES

VOLUMES	SLOPE		
	1%	3%	5%
GRADING			
Basin "D" Flyash to be relocated	107,561	85,751	71,811
Calculated fill from Basin "A"	(57,828)	42,338	142,531
Material needed to fill basins	15,500	15,500	15,500
Total borrow material from Basin"A"	(42,328)	57,838	158,031
CAP			
Total Cap	201,047	200,745	200,960
36" Pozzolanic Cap	100,524	100,373	100,480
18" Drainage Layer	50,262	50,186	50,240
18" Topsoil	50,262	50,186	50,240
TOTAL FLYASH BORROW REQUIRED	58,195	158,211	258,511


Earthwork Quantities for Closure
Regraded Basin D Flyash
Borrow needed from Basin A for Grading
Pozzolanic Cap
Total Borrow from Basin A
300,000
250,000
200,000
150,000
100,000
50,000
0
-50,000
-100,000
Flyash Volume (CY)
1%
3%
5%
Final Cap Grade

Appendix A –2

Analytical Laboratory Reports from Dalare Laboratories Philadelphia Pa.

Dalare Associates Inc.
217 S. 24th Street / Philadelphia, PA. 19103
Telephone 215 - 567 - 1953 / Facsimile 215 - 567 - 1168

ANALYTICAL AND ENVIRONMENTAL TESTING

April 25, 2002

VFL Technology
Attn.: Rocus Peters
16 Hagerty Blvd.
West Chester, PA 19382

Dear Mr. Peters:

We have examined the sample submitted and would report our findings as follows:

Date Received: 4/2/02

Analytical Report # 328

Hutsonville Power
Fly Ash (3/28/02)

Total Metals:		
Arsenic	34.4	mg/Kg
Barium	95.0	mg/Kg
Cadmium	< 1.0	mg/Kg
Chromium	24.3	mg/Kg
Lead	55.6	mg/Kg
Mercury	0.076	mg/Kg
Selenium	18.3	mg/Kg
Silver	< 1.0	mg/Kg
TCLP Leachate:		
Arsenic	0.020	mg/L
Barium	0.56	mg/L
Cadmium	0.01	mg/L
Chromium	< 0.01	mg/L
Lead	0.12	mg/L
Mercury	< 0.001	mg/L
Selenium	0.013	mg/L
Silver	< 0.01	mg/L

mg/Kg = milligrams per Kilogram
mg/L = milligrams per Liter
< = Less than

Very truly yours,

DALARE ASSOCIATES, INC.

Paul A. Weber

Paul A. Weber

DAI

Dalare Associates Inc.

217 S. 24th Street / Philadelphia, PA. 19103

Telephone 215 - 567 - 1953 / Facsimile 215 - 567 - 1168

ANALYTICAL AND ENVIRONMENTAL TESTING

October 2, 2002

VFL Technology
Attn.: Rocus Peters
16 Hagerty Blvd.
West Chester, PA 19382

Dear Mr. Peters:

We have examined the samples submitted and would report our findings as follows:

Date Received: 9/27/02 Analytical Report # 910

Hutsonville

	Mix #2	Mix #5
TCLP Leachate:		
Arsenic	< 0.010 PPM	< 0.010 PPM
Barium	0.28 PPM	0.25 PPM
Cadmium	< 0.01 PPM	< 0.01 PPM
Chromium	0.06 PPM	< 0.01 PPM
Lead	< 0.02 PPM	< 0.02 PPM
Mercury	< 0.001 PPM	< 0.001 PPM
Selenium	0.019 PPM	0.010 PPM
Silver	< 0.01 PPM	< 0.01 PPM

PPM = Parts per Million
< = Less than

The TCLP Leachate was analyzed in accordance with the method described in the Federal Register, Volume 55, No.61, 3/29/90, pages 11863-75.

Very truly yours,

DALARE ASSOCIATES, INC.

Paul A. Weber

Paul A. Weber

PAW:jc

DAI
Dalare Associates Inc.
217 S. 24th Street / Philadelphia, PA. 19103
Telephone 215 - 567 - 1953 / Facsimile 215 - 567 - 1168

ANALYTICAL AND ENVIRONMENTAL TESTING

October 2, 2002

VFL Technology
Attn.: Rocus Peters
16 Hagerty Blvd.
West Chester, PA 19382

Dear Mr. Peters:

We have examined the samples submitted and would report our findings as follows:

Date Received: 9/18/02

Analytical Report # 908

Hutsonville

	Mix #9	Mix #14
TCLP Leachate:		
Arsenic	< 0.010 PPM	< 0.010 PPM
Barium	0.14 PPM	0.11 PPM
Cadmium	0.01 PPM	< 0.01 PPM
Chromium	0.05 PPM	< 0.01 PPM
Lead	< 0.02 PPM	< 0.02 PPM
Mercury	< 0.001 PPM	< 0.001 PPM
Selenium	< 0.010 PPM	< 0.010 PPM
Silver	< 0.01 PPM	< 0.01 PPM

PPM = Parts per Million
< = Less than

The TCLP Leachate was analyzed in accordance with the method described in the Federal Register, Volume 55, No.61, 3/29/90, pages 11863-75.

Very truly yours,

DALARE ASSOCIATES, INC.

Paul A. Weber

Paul A. Weber

PAW:jc

Exhibit 12

RULES and REGULATIONS

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 261

(530-Z-93-009; FRL-4689-8)

Final Regulatory Determination on Four Large-Volume Wastes From the Combustion of Coal by Electric Utility Power Plants

Monday, August 9, 1993

***42466** AGENCY: Environmental Protection Agency.

ACTION: Final regulatory determination.

SUMMARY: Today's action presents the Agency's final regulatory determination required by Section 3001(b)(3)(C) of the Resource Conservation and Recovery Act (RCRA) on four large-volume fossil-fuel combustion (FFC) waste streams--fly ash, bottom ash, boiler slag, and flue gas emission control waste--studied in the Agency's February 1988, Report to Congress: Wastes from the Combustion of Coal by Electric Utility Power Plants (RTC). EPA has concluded that regulation under Subtitle C of RCRA is inappropriate for the four waste streams that were studied because of the limited risks posed by them and the existence of generally adequate State and Federal regulatory programs. The Agency also believes that the potential for damage from these wastes is most often determined by site- or region-specific factors and that the current State approach to regulation is thus appropriate. Therefore, the Agency will continue to exempt these wastes from regulation as hazardous wastes under RCRA Subtitle C. However, EPA believes that industry and the States should continue to review the appropriate management of these wastes. EPA will consider these wastes during the Agency's ongoing assessment of industrial non-hazardous wastes under RCRA Subtitle D.

EPA plans to make a final regulatory determination on the remaining FFC waste streams (beyond the four listed above) subject to Section 3001(b)(3) of RCRA by April 1, 1998.

EFFECTIVE DATE: September 2, 1993.

FOR FURTHER INFORMATION CONTACT: For further information on the regulatory determination, contact the RCRA/Superfund hotline at (800) 424-9346 or (703) 412-9810, or Patti Whiting at (703) 308-8421.

SUPPLEMENTARY INFORMATION:

Table of Contents

I. Background

A. Statutory Authority

Today's notice is issued under the authority of Section 3001(b)(3)(C) of RCRA, which requires that after completion of the Report to Congress mandated by Section

8002(n) of RCRA, the Administrator must determine whether Subtitle C regulation of fossil fuel combustion wastes is warranted.

* * *

IV. Regulatory Determination for Four Large-Volume Coal-Fired Utility Wastes

The following discussion presents EPA's conclusions regarding the regulatory status of large-volume coal-fired utility wastes under RCRA. The determination as to whether regulation of such wastes under Subtitle C is warranted is based upon the February 1988 Report to Congress, comments on the Report to Congress including comments received at the public hearing held in Denver on April 26, 1988, the information collected for the February 12, 1988, Notice, and comments received on the Notice.

Based on all of the available information, EPA has concluded that regulation of the four large-volume fossil-fuel combustion wastes as hazardous waste under RCRA Subtitle C is unwarranted. Below are the Agency's responses to each step of the decision methodology.

Step 1. Does the management of this waste pose human health/environmental problems? Might current practices cause problems in the future? The Agency has determined that the answer to this question is yes.

Substep 1. Has the waste, as currently managed, caused documented human health impacts or environmental damage?

Response: The Agency has determined that the waste has caused documented impacts, but at a very limited number of sites.

In accordance with the methodology described above, EPA first addressed whether the management of this waste currently poses human health/environmental problems and whether current practices could cause problems in the future. In its examination of potential/actual cases in which danger to human health or the environment could be attributed to the management of fossil-fuel combustion wastes, the RTC included information from several studies that documented occasional exceedences of primary and secondary drinking water standards in groundwater underlying fossil-fuel waste management sites. To supplement the RTC data, EPA conducted State file reviews in States selected for their geographical representation and large coal-fired electricity generation capacity. Overall, both efforts indicate that the extent of actual damage cases/environmental harm associated with large volume FFC waste management appears limited.

***42473** EPA used the "test of proof" developed to support the Report to Congress on Mineral Processing Wastes to evaluate the potential damage cases. As described in Chapter 2 of that report, the test of proof requires that a case satisfy at least one of three conditions: scientific investigation concluding that damages occurred, administrative ruling concluding that damages occurred, or court decision or out-of-court settlement concluding that damages occurred. For the six damage cases described below, scientific investigation was the measure of proof satisfied, since the data most supported application of this measure.

In applying the test, EPA first considered whether actual documentation exists that shows that human health or environmental harm occurred (e.g., contaminated groundwater in a water supply well, observed impacts on wildlife). Only a limited number of large-volume FFC waste management sites actually meet this criterion and can be considered proven damage cases. These cases include the two sites identified in the RTC, as well as four additional sites identified during recent data collection efforts. EPA notes that of these six cases, only one case can clearly be attributed to fly ash management alone. The remaining five cases are associated with the co-management of the large-volume wastes with other wastes. Because co-management of large and low-volume wastes is the predominant waste management practice, limited information exists on independently managed large-volume wastes.

The RTC described a site that involved a dike failure that caused an accidental release from a fly ash disposal lagoon to a river. This case resulted in substantial damage to river organisms. The other case described in the RTC involved co-management. In this case, a release occurred from a fly ash and petroleum coke waste disposal site that resulted in the contamination of drinking water wells with selenium and vanadium. This site is ranked on the CERCLA (Superfund) National Priority List Site.

EPA's more recent data collection efforts resulted in the identification of four additional sites that are considered proven cases of damage (see the Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste, found in Docket no. F-93-FFCA-FFFFF). Each case involves co-management of wastes at older, unlined waste management units. These incidents involved groundwater contamination and/or vegetative damages due to releases from waste management units.

In summary, there is minimal documentation of impacts on drinking water sources in the vicinity of coal-fired utilities. In addition, it is important to note that the damage case sites were chosen for study because of known releases and cannot necessarily be extrapolated to the general universe. Also, most releases have been from unlined units at older sites that in many States are now subject to more stringent design and operating criteria. [FN7] Furthermore, actual cases of harm to human health or the environment may be limited to a few sites, often with other contributing factors, including additional pollutant sources attributed to the co-management with other FFC and non-FFC wastes. The review of such cases of co-management will be reserved for the "remaining waste" study.

FN7 The percentage of units required to meet more stringent design and operating criteria will increase as older units reach capacity (assuming a typical lifetime fo 15 years) and new units come on-line (and are subject to these more stringent requirements).

The FFC waste damage case/environmental data collected to date indicate, therefore, that although the extent appears limited, damage to the environment has occurred. Although the releases are often confined to the vicinity of the units and have not reached environmental/human receptors, the potential for exposure necessitates further analysis in Substep 2, which examines the potential risks posed by these wastes.

Substep 2. Does EPA's analysis indicate that the waste could pose significant risk to human health or the environment at any sites that generate coal combustion wastes, under either current management practices or plausible mismanagement scenarios?

Responses: Groundwater contamination and surface water contamination through groundwater recharge are possible under some plausible conditions (unlined units). Available information on the environmental conditions of the sites indicates ecological and natural resource damages are of most concern, because potential for human exposure is limited.

The RTC contains considerable information on the four large-volume coal combustion wastes (fly ash, bottom ash, slag, and flue gas desulfurization (FGD) sludge). Information includes waste characteristics and management practices, environmental factors affecting human exposure potential at disposal sites, and evidence of ecological damage at coal combustion sites. In addition, EPA collected supplemental information from various EPA offices and other Federal agencies, State agencies, and the electric utility industry on waste characterization, management, and potential impacts. This supplemental information included groundwater monitoring data for 43 coal combustion waste sites collected from State regulatory agencies and from EPA site visit reports. All data used in this supplemental analysis are available for public inspection in the docket No. F-93-FFCA-FFFFF. A bibliography of the sources used in the risk analysis is found in Appendix A of the Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste, also found in Docket no. F-93-FFCA-FFFFF.

The first step of the methodology was to evaluate constituents of concern (identified by waste characterization data) using a risk screen. A risk screen analysis is a process which applies a conservative and simplified methodology to the constituents and pathways to determine if they are of concern. The risk screen compared waste characterization data with screening-level criteria. The screening criteria were developed to identify wastes, constituents, and pathways requiring further analysis; that is, wastes captured by the screen may or may not be of concern. Criteria for 23 constituents (primarily metals) were developed for groundwater, surface water, ingestion, and inhalation exposure pathways using a methodology similar to that used in the mineral processing regulatory determination. (In the cases where the Agency regulatory levels had changed since the mineral processing RTC, the screening criteria were also updated.)

Groundwater exposure criteria were developed using the MCLs set by the Agency to protect drinking water. If no primary MCL had been established for a particular parameter, then a health-based level (HBL) was calculated using Agency cancer slope factors or non-cancer reference doses (RfDs) from IRIS. [FN8] In instances where the calculated HBL was less than corresponding MCL, both values were considered in the screening.

FN8 U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS). (IRIS, November 1992 update).

Screening criteria based on primary MCLs were derived by multiplying the MCL by a factor of 10 to simulate scenarios where only limited dilution of waste leachate occurs prior to exposure. HBLs were derived from IRIS[9] drinking ***42474** water or oral cancer slope factors (CSFs) representing a 110^{-5} lifetime cancer risk, or RfDs. Calculation of the HBLs relied on the following conservative assumptions: the maximally exposed 70 kg individual drinking 2 liters of water per day, 365 days per year, for a lifetime duration of 70 years. (The 70-year exposure duration was chosen to maintain comparability with the MCLs; this approach is consistent with that taken in the mineral processing regulatory determination.) These assumptions yield the following general equations:

HBLCSF (mg/l) = (110^{-5})(70 y)(70 kg)/{(CSF $(mg/kg/d)^{-1}$)(2 l/d)(70 y)}

HBRfD (mg/l) = (RfD mg/kg/day)(70 kg)/(2 l/day)

As with the MCL-based criteria, the HBLs were multiplied by a factor of 10 to simulate a scenario where only limited dilution of waste leachate occurs prior to exposure. Groundwater exposure criteria were compared with waste EP Toxicity and TCLP analysis results for each of the four waste steams.

FN9 Ibid.

The surface water exposure criteria were selected to represent potential harm to aquatic organisms exposed to surface water releases of wastes or waste leachate. The criteria were derived by multiplying the freshwater chronic Ambient Water Quality Criteria (AWQC) for non-human effects by a factor of 100 to simulate a scenario where only limited dilution occurs. Surface water exposure criteria were compared with waste EP Toxicity and TCLP analysis results for the four waste streams.

The ingestion screening criteria were derived from IRIS oral RfDs and oral CSFs, assuming incidental ingestion of solid waste materials. Exposure assumptions are an ingestion rate of 200 mg/day from ages 1 to 6, and 100 mg/day from ages 7 to 31 (resulting in an average of 0.114 g soil/day), an adult receptor weight of 70 kg and an exposure of 350 days/year for 30 years. For CSF-derived values, a life-time averaging 70 years was assumed. These assumptions were then used to calculate the concentration of a constituent in a waste that would result in an exposure equivalent to the RfD or the concentration corresponding to a lifetime cancer risk of $1x10^{-5}$. The equations for RfD- and CSF-based criteria are shown below.

CriterionRfD (mg/g) = RfD (mg/kg/d) {(70 kg)(365 d/y)(30 y)}/ {(350 d/y)(30 y)(0.114 g soil/d)}

CriterionCSF (mg/g) = $\{10^{-5}$/CSF $(mg/kg/d)^{-1}\}$(70 kg)(365 d/y) (70 y)}/ { (350 d/y)(30 y)(0.114 g soil/d)}

No dilution factor was employed in deriving the criteria for solid samples. The exposure pathway assumes exposure to particulate whole waste material. Ingestion exposure criteria were compared with waste total constituent analysis results for the four waste steams.

The exposure assumptions used in deriving inhalation exposure criteria include: 50 MUg/m3 airborne dust concentration; [FN10] adult inhalation volume of 20 m^3/d; 70 kg body weight; exposure frequency of 350 days per year; exposure duration of 30 years; and, for CSF-derived values, 70 year lifespan (or averaging time) and $1x10^{-5}$ risk of cancer. Note that 50 MUg/m^3x20 m^3/d results in a soil exposure rate of 1 mg/d. The equations used to derive the criteria from both inhalation RfDs and inhalation CSFs are shown below:

CriteriaRfD (mg/g) = RfD (mg/kg/d) {(70 kg)(365 d/y)(30 y)}/ {(350 d/y)(30 y)(0.001 g soil/d)}

CriteriaCSF (mg/g) = {$1x10^{-5}$/CSF $(mg/kg/d)^{-1}$}{(70 kg)(365 d/y)(70 y)}/ { (350 d/y)(30 y)(0.001 g soil/d)}

Again, no dilution factor was employed in deriving the criteria for solid samples. The exposure pathway assumes exposure to particulate whole waste material. Inhalation exposure criteria were compared with waste total constituent analysis results for the four waste steams.

FN10 50 MUg/m3 is the National Ambient Air Quality Standard for annual exposure to particulates.

The screening criteria described above were then compared to EP, TCLP, and total constituent data from the RTC and subsequent data collection efforts. For all waste constituents that exceeded a screening-level criterion at more than 10 percent of the sites sampled, or exceeded the criteria by more than a factor of 10, further analysis was conducted. A summary of screening criteria exceedences, reported by waste type and by exposure pathway, can be found in Appendix C of the Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste.

The results of the risk screening suggest that of the large-volume wastes, fly ash and FGD sludge are of most concern. The risk screen also identified groundwater, surface water, and inhalation as exposure pathways needing further analysis. The constituents needing further analysis included arsenic, cadmium, chromium, lead, mercury, nickel, Ph, selenium, and silver.

The Agency then evaluated the release, transport, and exposure potential of those constituents, wastes, and pathways for which the risk screen indicated that further analysis was necessary. When available, monitoring data were used to determine the potential for human and environmental exposure. In other cases, information on the physical setting of coal combustion waste sites and on the waste management practices was used to evaluate exposure potential. In the case of the inhalation pathway, the potential for human health risk was evaluated using an atmospheric fate and transport model. For the inhalation pathway, the potential for human health risk, when evaluated using an atmospheric fate and transport model, was found to be negligible. For more information on the air pathway analysis, please consult the Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste. Further analyses of the groundwater and surface water pathway are summarized below.

Groundwater monitoring data were used in both the groundwater and surface water exposure pathway analyses. A summary table of the groundwater monitoring sites is in Appendix D of the Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste found in the docket. When interpreting the groundwater monitoring data, the Agency took several factors into account.

First, many of the sites may have co-managed their coal combustion wastes with other wastes, such as boiler cleaning solution or pyrites. The extent to which these other wastes may have contributed to groundwater contamination could not be conclusively determined, because it was difficult to assess in many cases whether co-management had occurred and without this information, it was not possible to separate the effects of the large-volume wastes from the other wastes. However, at least two site operators asserted that they believed that co-managed wastes, and not the large-volume wastes, were the cause of groundwater contamination. The Agency took the presence of co-managed wastes into account when evaluating the risk from the large-volume coal combustion wastes.

Second, some of the sites have other possible sources of contamination nearby. To the extent that they can be determined, these sources are noted in the summary table referenced above. Finally, in the case of some contaminants (e.g., iron), naturally occurring levels may be quite high. Again, to the extent that naturally occurring constituents can be ***42475** determined to be adding to downgradient concentrations, this is noted in the summary table.

With these considerations in mind, the Agency determined that available data from coal combustion waste landfills and surface impoundments demonstrated the existence of potential for human exposure to groundwater contamination, because coal combustion waste constituents identified in the risk screen as needing further study were found to be leaching onsite in excess of the primary MCLs. Subsequent analyses of coal combustion waste sites suggest, however, that potential for actual human exposure is very limited.

For example, nine sites of the forty-nine sites with groundwater monitoring data had contaminants above the MCL that appeared to stem from coal combustion units. (Another ten sites had upgradient concentrations equal to downgradient concentrations, other possible sources of groundwater contamination, or (in two cases) a lack of upgradient information, preventing any conclusions about the effects of the coal combustion units on groundwater contamination.) Constituents with exceedences include arsenic, barium, cadmium, chromium, fluoride, lead, mercury, nickel, and selenium. Of the nine sites, none were completely lined, although one site had a clay-lined disposal unit with an under-drain emptying into a series of unlined ponds. All nine sites have older (pre-1975) units, four consisting of surface impoundments, four consisting of landfills, and one with both types of units. Fly ash was the principal waste disposed of in all units. Four sites of the nine also are known to have accepted co-managed wastes (pyrites, boiler cleaning wastes, demineralizer regenerant, oil ash, etc.), and the others may have as well.

Potential for human exposure to groundwater contaminants from coal combustion wastes is limited because of the location of most coal combustion sites. Based on a random study (found in the RTC) of one hundred sites, only 29 percent of the sites have any population within 1 kilometer, and only 34 percent of the sites have public drinking water systems within 5 kilometers. Although infiltration and transportation of contaminants in groundwater varies with site- or regional-specific factors (such as depth to groundwater, hydraulic conductivity, soil type, and net recharge), exposure to coal combustion waste groundwater contaminants 5 kilometers from the source of contamination is not expected to occur. Of the public drinking water systems within 5 kilometers of coal combustion waste sites, just under half (47 percent) are expected to treat the groundwater for hardness (i.e., these systems have groundwater with over 240 ppm CaCO3), which would tend to remove co-contaminant metals as well.

Coal combustion units also tend to be near surface water bodies. The same RTC study revealed that 58 percent of the sites are within 500 meters of a surface water body. The volume and flow rate of surface water would tend to dilute and divert the contaminant plume.

In addition, groundwater contamination appears to be attributable to past management practices. As the Agency's groundwater monitoring data outlines above, all of the nine sites with a clear indication of groundwater contamination are older (pre-1975), unlined units. (In contrast, of the 13 lined sites, only one had exceedences of an MCL, and that site had equal concentrations upgradient and downgradient.)

Finally, some of the groundwater contamination may be attributable to co-management with other wastes, such as pyrites, boiler cleaning waste, and demineralizer regenerant. Because of the prevalence of co-management (several public comments on the RTC reported that the predominant industry practice is to co-dispose of low-volume wastes in ash or flue gas emission control waste ponds), the large-volume waste may not be the sole contributor to the groundwater contamination. Two of the nine sites report that co-management is the cause of the contamination.

In conclusion, hazardous constituents in coal combustion waste (particularly in fly ash and flue gas emission control waste) have the potential to leach into groundwater under certain conditions. Contaminants of concern include arsenic, cadmium, chromium, lead, mercury, and selenium. Available data suggest, however, that contamination stems from older, unlined units representing past practices, and that the units are not typically located near populations and drinking water systems. In addition, the sites within 5 kilometers of public drinking water systems, about half have groundwater with over 240 ppm CaCo3 and are therefore expected to treat the water for hardness, thus removing co-contaminant metals as well. Furthermore, at least some of the groundwater contamination is attributable to other wastes managed with the large-volume coal combustion wastes. Thus, potential for human exposure solely from the large-volume coal combustion waste from current management practices is limited.

An examination of the surface water pathway reveals that, although direct discharge of untreated coal combustion waste to surface water is not likely because of Clean Water Act controls, a few of the coal combustion waste constituents have the potential in some instances, to affect nearby vegetation and aquatic organisms by migration through shallow groundwater to nearby surface waters. This was observed at one site where migration of boron to a nearby wetland was determined by the State to be the cause of vegetative damage. In many cases, natural attenuation processes are expected to dilute the contaminants below levels of concern. For example, if contaminants reach surface waters, the volume of surface water and its high flow rate could dilute the contaminants. For those sites whose nearby water bodies may have a low flow rate (e.g., lakes, swamps, or marshes), however, coal combustion waste may cause local environmental damages, as was observed at the above site.

Even when contaminated groundwater does not affect human health and the environment, it may be considered to have caused impacts that limit future use of that groundwater. In particular, available data suggest that the groundwater at a number of coal combustion waste sites is contaminated above secondary MCLs (SMCLs) by such secondary parameters as iron, manganese, sulfate, and total dissolved solids, although these effects may be localized through dilution and attenuation. The SMCLs are guidelines generally set to be protective of such aesthetic considerations as taste, odor, potential to stain laundry, and human cosmetic effects such as tooth and skin staining.

In addition to being disposed of in landfills and surface impoundments, coal combustion ash is often beneficially used both onsite and offsite. EPA continues to encourage the beneficial use of coal combustion wastes. Because most offsite applications tend to immobilize the coal combustion waste (e.g., fly ash used to make concrete), adverse impacts appear to be unlikely. However, if fly ash is applied directly to agricultural soil, there is some concern with metals uptake by food crops and cattle feed. In addition, boron in the coal ash is readily mobilized and has a phytotoxic effect on plants. Although coal ash is not frequently used in agriculture, any ***42476** agricultural use of coal combustion waste should be carefully evaluated. [FN11]

FN11 Characterization of Coal Creek Station Fly Ash for Utilization Potential, Energy and Environmental Research Center, February 1993 (see Docket No. F-93-FFCA-FFFFF).

Substep 3: Does the waste exhibit any of the characteristics of hazardous waste?

Response: The Agency has determined that these wastes exhibit the characteristics of hazardous waste infrequently, from 0 to 7 percent of the samples depending on waste type.

The RTC concludes that although coal combustion waste may leach contaminants (arsenic, cadmium, chromium, lead, and mercury) above toxicity characteristic regulatory levels, such exceedences are infrequent and the average concentrations of constituents are below characteristically toxic levels. A full bibliography of the sources of EP and TCLP data and a summary of the results are given in Appendices A and B of the Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste.

The results of Step 1 of the analysis indicate that the wastes rarely exhibit any characteristics of hazardous waste and the waste pose very limited risk to human health or the environment under certain scenarios, such as unlined units sited over shallow groundwater with nearby drinking water wells. Furthermore, since most releases have occurred at unlined older sites, EPA recognized that a review of current waste management practices and regulatory control governing these practices was appropriate as outlined in Step 2 of the methodology, which assesses the need for more stringent regulation.

Step 2: Is more stringent regulation necessary or desirable? The Agency has determined that the answer is no. EPA regulation is not necessary or desirable.

In evaluating the need for more stringent controls to address the potential risks associated with the management of these wastes, EPA first evaluated the adequacy of current industry waste management practices in limiting contaminant release and associated risk. The Agency then viewed the adequacy of current State and Federal regulatory controls addressing these wastes. For the purposes of this analysis, EPA supplemented the data supplied in the RTC with site visits, a 1992 EPA study under which the Agency obtained and reviewed State regulations applicable to FFC waste management, the Department of Energy's 1991 report entitled Coal Combustion Waste Disposal: Update of State Regulations and Cost Data, dialogue with industry and State representatives, the Electric Power Research Institute's Facility Design and Installation Manual (1991), State file searches, and literature reviews.

Substep 1. Are current practices adequate to limit contaminant release and associated risk?

Response: The Agency has determined that industry practices are moving toward increased use of control measures (liners, covers, etc.) and groundwater monitoring.

The Agency's data on current practices indicate that industry is moving toward an increased use of control measures (e.g., liners, covers) and groundwater monitoring. For example, the RTC noted that before 1975, less than 20 percent of units (surface impoundments and landfills) in the United States for which data were available had installed some form of liner. More recent data (EEI's Power Statistics Database, 1989) suggest that 13 to 29 percent of surface impoundments for which data are available, have some form of liner and that 41 to 43 percent of landfills have some form of liner. As the damage case and groundwater monitoring information suggests, most of the releases have occurred at older, unlined units. EPA has observed during site visits that newer units are generally lined. Furthermore, most newer utility waste management facilities have groundwater monitoring systems, and many also have leachate collection systems. Despite the positive trends in management of FFC wastes, some of these units may be sited with inadequate controls. Therefore, in addition to viewing industry management practices, EPA collected and evaluated information on the extent of current State and Federal regulation of coal-fired utility waste management.

Substep 2. Are current Federal and State regulatory controls adequate to address the management of the waste?

Response: Effluent limitations in the Clean Water Act regulations for steam electric power plants under 40 CFR part 423 require no discharge from new fly ash ponds. State programs are generally adequate and are improving, with most States now requiring permits and minimum design and operating criteria that would address likely risks. Additionally, Federal authorities exist to address site-specific problems posing threats to human health and the environment under RCRA Section 7003 and CERCLA Sections 104 and 106.

The RTC included information on coal-fired electric utility waste regulation in all 50 States. In updating this information, EPA conducted a review of States that were selected according to the high levels of ash generated in those States. This approach resulted in a study universe of 17 States that generate approximately 70 percent of all coal ash in the United States.

The data show that States have generally implemented more stringent regulations for FFC waste since 1983 (when the State regulation review was conducted for the RTC). Under developing State industrial solid waste management programs, coal-fired utilities are more frequently being required to meet waste testing standards, and waste management units often must comply with design and operating requirements (e.g., liners and groundwater monitoring standards).

Of the 17 States for which EPA updated the RTC data, 14 regulate coal-fired utility wastes as solid wastes, explicitly exempting them from hazardous waste regulation; [FN12] 16 States require offsite FFC waste management units to have some type of operating permit, with design and operating criteria varying by State; 12 have mandatory liner requirements, while three States provide for discretionary authority to impose liner requirements on a site-specific basis; 12 impose mandatory groundwater monitoring requirements on FFC waste disposal sites; and 16 impose final cover requirements. In addition, some States have been working to reduce the threat of groundwater and surface water contamination, by discouraging the use of wet management in ponds as a disposal practice (through permitting requirements and location restrictions). On the Federal level, National Pollutant Discharge Elimination System permits under the Clean Water Act regulate all direct discharges to surface water. Effluent limitations under 40 CFR part 423 govern steam electric power generating point sources and require no (zero) discharge to surface waters from new source fly ash transport waters (40 CFR 423.15(g)).

FN12 Of the remaining three States, two States establish requirements based on waste characteristics and one exempts these wastes from their solid and hazardous waste management program.

Considering industry's trend toward more protective waste management practices, the fact that State regulatory programs are generally adequate, and because Federal authorities exist that can address these wastes, EPA has concluded that current management practices and regulatory controls are adequate for managing the four large-volume FFC wastes.

***42477** Substep 3. Would Subtitle C effectively address the problems associated with the waste without imposing significant unnecessary controls?

Response: The Agency has determined that it is unlikely that Subtitle C would effectively address the problems associated with the four large-volume fossil-fuel combustion wastes without imposing unnecessary controls.

After reviewing industry practices and current State and Federal regulation, EPA reviewed the alternative scenario of regulating the four large-volume FFC wastes under Subtitle C. First, it was recognized that coal combustion wastes rarely exceed the RCRA characteristics for hazardous waste, and therefore, that most coal combustion wastes would not be subject to Subtitle C controls unless they were listed as hazardous wastes. Furthermore, it was noted that even if these wastes were listed as hazardous, and therefore, regulated under Subtitle C, such an approach would be inappropriate for these wastes. A Subtitle C system would require coal combustion units to obtain a Subtitle C permit (which would unnecessarily duplicate existing State requirements) and would establish a series of waste unit design and operating requirements for these wastes, which would generally be in excess of requirements to protect human health and the environment. For example, if such wastes were placed in the Subtitle C universe, all ash disposal units would be required to meet specific liner and monitoring requirements. Since FFC sites vary widely in terms of topographical, geological, climatological, and hydrological characteristics (e.g., depth to groundwater, annual rainfall, distance to drinking water sources, soil type) and the wastes' potential to leach into the groundwater and travel to exposure points is linked to such factors, it is more appropriate for individual States to have the flexibility necessary to tailor specific controls to the site or region specific risks posed by these wastes.

EPA also reviewed the comments received in response to the 1988 RTC and the Notice. Comments received on the RTC showed unanimous support for EPA's initial recommendation that large-volume combustion wastes do not warrant regulation under RCRA Subtitle C. Specifically, the commenters felt that current Subtitle D criteria, together with existing State regulations, have proved adequate to protect human health and the environment. Furthermore, of the respondents to the Notice who addressed the recommendation that large-volume combustion wastes do not warrant regulation under Subtitle C, all agreed that the supplemental data support this recommendation.

For these reasons, EPA concludes that Subtitle C is inappropriate to address the problems associated with these wastes and that the site or region specific State approach is appropriate for addressing the limited human health and environmental risks involved with the disposal of FFC wastes. The Agency encourages States to continue to develop and implement site-specific approaches to these wastes. EPA believes that industry and the States should continue to review the appropriate management of these wastes. EPA will also consider these wastes during the Agency's ongoing assessment of industrial non-hazardous wastes under RCRA Subtitle D. Should the characteristics of the waste streams change as a result of implementation of any provisions of the Clean Air Act as amended in 1990, the Agency may choose to reexamine the exemption.

Step 3. What would be the operational and economic consequences of a decision to regulate a special waste under Subtitle C?

Although the analysis never reached this point, EPA's preliminary examination of potential costs under Subtitle C indicates that annual costs of full Subtitle C controls would range between $100 and $500 million per year. This assumes that these wastes would be listed as hazardous in RCRA part 261, subpart D. However, if these wastes were not listed, the wastes would often not be subject to Subtitle C, since they rarely test characteristically hazardous pursuant to part 261, subpart C. Subtitle C controls include groundwater monitoring, liners, leachate collection, closure/covers, dust control, financial assurance, location restrictions, and corrective action.

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