# COMPUTER ENHANCED OVERBURDEN EVALUATION FOR TOPSOIL SUBSTITUTION AT THE OXBOW MINE, LOUISIANA[1]

by

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Abstract. Tremendous amounts of chemical and physical data are collected during pre-mine studies of overburden and native soils. Without computer enhancement, sorting, analyzing, and reporting of the data to meet regulatory requirements for surface mine permitting can be extremely time consuming. Studies to determine if topsoil substitution is a valid option at the Oxbow Mine in Northwest Louisiana are cited to demonstrate how such data management can be accomplished quickly and more effectively. Native soils at the mine are developing in very clayey Holocene alluvium that has severe limitations for crop production. Computerized correlation of the data into lithologic units was completed to show which overburden intervals were more desirable for use as topsoil substitute. Evaluations of the strata showed that material at lower depths is better suited for postmine topsoil. With proper mining procedures, postmine soils will have significantly better chemical and physical characteristics than the native soils at the Oxbow Mine.

Additional Key Words: Surface lignite mine, computer evaluation, overburden, soil management, postmine soils, topsoil substitute, Louisiana.

## Introduction

The Oxbow Mine, a surface lignite mine located about 4 miles west of Coushatta, in Red River Parish, Louisiana, recently completed a 5-year permit renewal for an area that posed some rather unique circumstances. A portion of the permit area lies within the Red River floodplain which, from a historical perspective, contains a significant amount of lands designated prime farm land (PFL). However, the affected area is dominated by a variant of the Moreland soils which fail some of the Louisiana Office of Conservation (LOC) suitability criteria for prime farm land (LOC, 1996). Crop subsidies have artificially provided incentives to farm the area that would otherwise be considered undesirable for crop production.

Essentially all (98%) of the native topsoil in the permit area fails the LOC requirements, exceeding a maximum of 60 percent clay content for topsoil replacement materials. This precludes selective removal and post-mining replacement of the existing native soil even though it is historically designated PFL. Thus, the challenge was to find sufficient quantities of suitable topsoil substitution materials that have the potential for higher crop production than the clayey native soils. Computer enhanced analysis of the overburden and native soils data greatly simplified this task.

## Methodology/Procedures

Nineteen continuous cores for overburden characterization were completed within the permit area. Fifteen of these cores were sampled for native soil horizon analyses. Near surface core samples were recovered using a Shelby Tube sampler and a three-inch inside diameter, Christensen split tube core barrel for the remainder of the samples. Except for several gravel zones, a minimum of 75 percent core recovery was achieved.

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Using the geologist's field description logs and high quality geophysical logs (natural gamma, caliper, gamma-gamma density, and resistivity), sample intervals were selected based on lithologic homogeneity with respect to texture, composition, and color. The intervals were analyzed using test procedures acceptable to the LOC.

An Order 2 soil survey showing the distribution of native soils within the area was completed by the Soil Conservation Service in support of mine permitting activities (USDA, 1980).

## Stratigraphy

Holocene Alluvial deposits, primarily from the Red River, overlie the Dolet Hills Formation of the Wilcox Group (Figures 1 and 2). The alluvium consists of basal sands and gravel, grading upward into finer sands, silts and clays. The basal unit, labeled "Alluvial Sand" (AS) in Figure 2 (see following page), consists of medium- to fine-grained sands and lenses of gravel. Sand content typically exceeds 85 percent in the basal unit, and gravel ranges from "pea" size to as much as 3 inches in diameter (Red River Mining Company, 1996).

| ERA | SYSTEM | SERIES | GROUP | FORMATION |
|---|---|---|---|---|
| CENOZOIC | QUATERNARY | HOLOCENE | | RECENT ALLUVIUM |
| | | PLEISTOCENE | TERRACE DEPOSITS | UNDIFFERENTIATED |
| | TERTIARY | EOCENE | WILCOX | COW BAYOU |
| | | | | DOLET HILLS |
| | | | | CHEMARD LAKE LENTIL (C SEAM) |
| | | | | NABORTON |
| | | PALEOCENE | MIDWAY | PORTERS CREEK |

Figure 1. Stratigraphic column for the Oxbow Mine area

The middle Alluvial unit, labeled "Alluvial Silt" (AM) in Figure 2, is a transitional unit between the basal unit with high sand content and the upper clay-enriched zone. On a weighted-average basis, sand content is less than 85 percent and clay content is less than 60 percent in the Alluvial silt unit. This unit grades from lenses of reddish-brown, medium- to fine-grained sands upwards into clayey silts.

The upper Alluvial unit , labeled "Alluvial Clay" (AC) in Figure 2, typically consists of clay or silty clay in which the native soils are developing. On a weighted-average basis, clay content within this unit exceeds 60 percent. This material is sticky when wet, hard when dry, and has a high shrink-swell potential.

The geologic cross-section shown in Figure 2 shows the general thickness of the Holocene alluvium. It also depicts the eroded surface of the Wilcox upon which the alluvium has been deposited. In places, the Wilcox has eroded away, and the alluvium rests directly on the C seam. This is illustrated in Figure 3, which shows that Wilcox materials range from 0 to 20 feet in thickness along western and northern parts of the area, and thicken in a southeasterly direction to as much as 80 feet above the C lignite seam, which is scheduled to be mined.

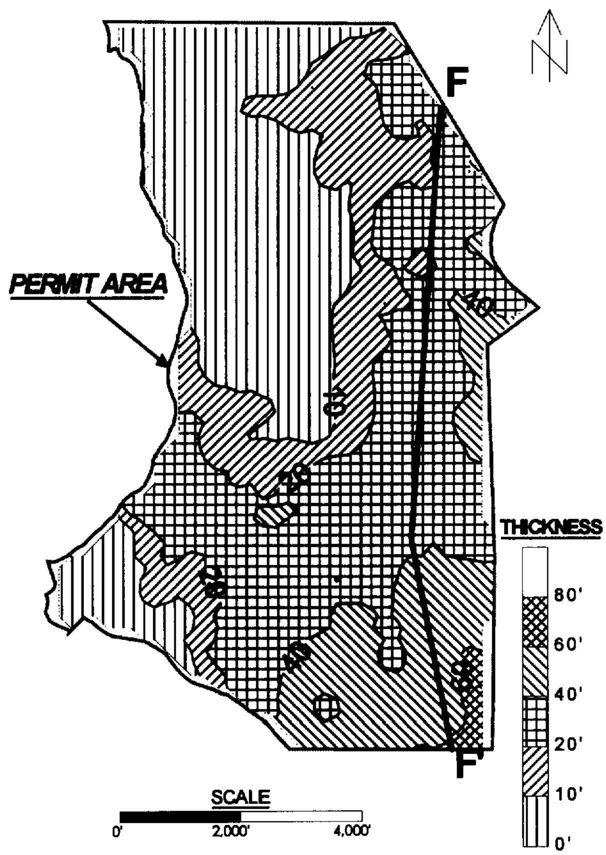


Figure 3. Isopach of Wilcox interval (Dolet Hills Formation) above the C lignite seam.

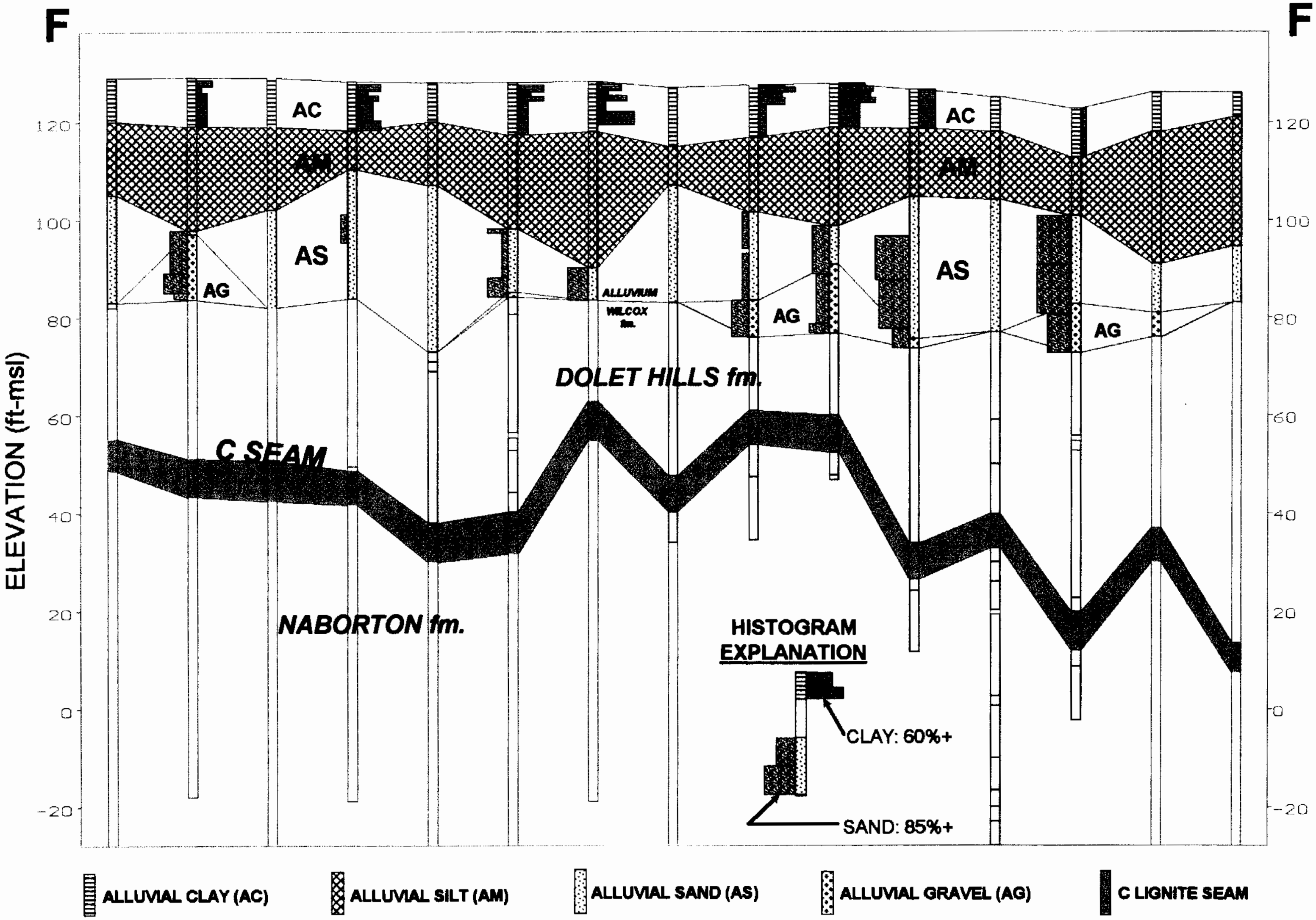


Figure 2. Cross section F-F' with the textural histogram data plotted as an example of the criteria used to help differentiate the Holocene Alluvium units (Red River Mining Company, 1996). Cross section location is plotted on Figure 3.

The Wilcox Group Dolet Hills Formation is made up of interbedded to massive, gray to brownish-gray, very fine- to medium- grained sands containing lenses of silt and silty clay and a few very thin lignite beds. Typically, the lower portion of the Dolet Hills Formation is predominantly sand grading upwards into silts and clays. However, the Dolet Hills section in the Oxbow Mine area generally contains a higher silt percentage.

## Correlation of Analytical Results

With the tremendous amount of laboratory data generated by a study of this magnitude, analysis of the results can be intimidating without the proper tools. A software program called StratiFact® [3] made the job of editing, posting and graphing, correlating zones based on analytical results, and calculating weighted averages much easier.

The impressive power of StratiFact® is its graphical interface with the database manager. In the graphics mode, cross sections are selected. Individual analytical parameters can be posted as histograms simultaneously along with the stratigraphic information. The geological correlations can then be easily adjusted by a click of the mouse on the zone table to match the analytical data. The database is automatically updated by these on-screen edits.

Figure 2 is an example of one of these cross sections. Histograms for clay content exceeding 60 percent and sand content exceeding 85 percent (both LOC unsuitable thresholds) are posted to demonstrate how the suitable Alluvial silt zone was selected. The geophysical logs for non-core holes were compared to those from the core holes to aid with correlation "picks" for all holes within the study area.

The basal unit (AS) of the alluvium is high in sand, with gravel (AG) that ranges from "pea" size to as much as 3 inches in diameter. The middle section (AM) is predominantly silty material, while the upper section (AC) is high in clay. In this illustration, the Wilcox is undifferentiated because it does not exhibit the consistency in textural differences that the alluvium exhibits.

Once the stratigraphic zones were correlated to reflect the analytical data, data reports were generated for each zone of interest. StratiFact's® filtering capabilities simplified this task. Information including depths, thickness, and desired analytical parameters for each zone were exported as Lotus® spreadsheets. This greatly facilitated the calculation of weighted averages to aid in comparing pre-mining environment to predicted post-mining conditions.

## Native Soils

Approximately 98 percent of native soils within the permit area have been mapped by the Soil Conservation Service (USDA, 1980) as the Moreland series, classified in the fine, mixed, thermic family of Vertic (USDA, 1975). These are very deep, somewhat poorly drained, very slowly permeable soils that are developing in clayey sediments of the Red River floodplain. Due to wetness during some part of most years and to poor tillage characteristics, Moreland soils have severe limitations for many crops common to the area. The problem is even more limiting because laboratory data show that the weighted average clay content of these soils within the permit area in greater than 60 percent. This places them in a very-fine family which makes them a clayey variant of the Moreland series.

LOC surface mining regulations allow the use of substitute material in post-mine soils provided such materials are equal to or better than native soil materials for crops common to the area. The LOC (1996) has also established a policy in that downgrades the quality of soils with clay content greater than 60 percent unless used for rice production. Because the Moreland Variant soils within the permit area have not been used for rice, they are recognized as having inferior quality to most other alluvium soils in the area.

Figure 4 is a schematic diagram illustrating the relationship of overburden strata shown in Figure 1 to native soils in the vicinity of the Oxbow Mine. The illustration extends from the western boundary of the permit area eastward to the Red River, a distance

[3] GRG Corporation, Inc.; Wheat Ridge, CO; (303) 423-0221

slightly more than two miles. The clayey alluvial sediments (AC in Figure 2) in which the Moreland variant soils are developing extend through the permit area to within about one-half mile of the Red River. At this point, the Coushatta soils (fine-silty, mixed,

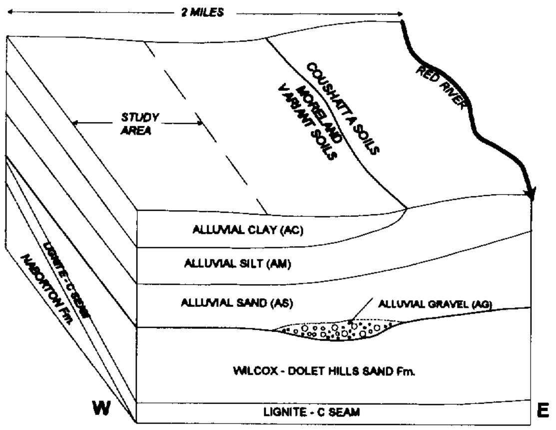


Figure 4. Schematic diagram of soils and overburden outcrops in Oxbow Mine area.

thermic family of fluventic eutrochrepts) are developing on silty outcrops (AM sediments) at slightly higher elevations. These are very deep, well-drained, moderately permeable soils that are loamy throughout. They are among the most productive soils in the area, and are adapted to a wide range of crops. Outcrops of Units AS and AG are very minor and mostly located within flooded areas behind levees to the Red River. Due to excessive sand and gravel content, they are not rated as suitable for post-mine soils use. Wilcox materials do not crop out within the floodplain.

This partial sorting of sediments on floodplains during overflow results in a predictable depositional pattern of sandy or loamy natural levees near the stream channel that slope to clayey backswamps (Murray, 1948). Because Figures 2 and 4 demonstrate predictable lithologies, they offer an opportunity to test various strata of the overburden as substitutes for post-mine soils compared to native soils within the permit boundary. Computer correlation and characterization of the various materials allows the development of relevant models to predict the quality of post-mine soils.

## Post-mine Soil Modeling

The main concerns for post-mine soil reclamation are:

(1) to select materials having chemical and physical properties that are least limiting to crop production; and

(2) to select materials free of acid-forming (AFM) and toxic-forming (TFM) materials.

The ideal reclamation plans are those that test overburden materials against native soils to determine if topsoil substitution is a valid option. By classifying both soils and overburden into correlatable units through computer modeling, planners can use sound agronomic knowledge to make this evaluation.

Table 1 compares selected physical and chemical properties of various units within or adjacent to the Oxbow Mine. Its purpose is to test parts of the overburden against native soils to determine which is better for post-mine use. The Wilcox interval below the alluvium (Figures 2 and 4) is included because the data indicates it has good potential as substitute material. The basal alluvial units (AS and AG in Figure 2) are omitted because they are comprised of excessive amounts of sand or gravel. The Coushatta soils are included in the model to determine if substitute materials might change the area from the clayey Moreland variant soils to substantially more desirable soils.

Table 1 indicates that selected overburden including both the suitable alluvium (Unit AM) and/or the Wilcox interval is a viable option for postmine use. Textures would improve from clay to a light clay loam (Unit AM) or to loam in the Wilcox interval. This would improve drainage and tillage characteristics. The pH values are slightly higher but well within suitable ranges adapted to the floodplain. Acid-base account (ABA) values, expressed in tons calcium carbonate equivalent per thousand tons of soil, are lower in the overburden, but are well within acceptable ranges. None of the other chemical features are within ranges of concern. The analytical parameters suggest that substitute material from selected overburden is significantly better than that of the Moreland Variant soils for postmine use, and is somewhat similar to the highly productive Coushatta soils. Organic carbon was not determined but would be expected to be somewhat lower than that of the native soils. Studies (Daniels et al, 1981) have shown that organic matter and structure develop rather quickly in topsoil substitute materials.

TABLE 1. Weighted-averages comparison summary for native soils and proposed topsoil substitute materials

| ANALYTICAL PARAMETER | NATIVE SOILS[1] Moreland Variant (0.4') | NATIVE SOILS[1] Coushatta (0.4') | OVERBURDEN Suitable Alluvium (AM) | OVERBURDEN Wilcox Interval |
|---|---|---|---|---|
| Sand (%) | 1 | 20 | 44 | 44 |
| Silt (%) | 33 | 59 | 26 | 35 |
| Clay (%) | 66 | 21 | 29 | 21 |
| USDA Text | Clay | Silt Loam | Clay Loam | Loam |
| pH (s.u.) | 7.5 | 7.3 | 8.0 | 7.8 |
| ABA (t/kt) | 18.0 | -- [2] | 8.7 | 6.9 |
| EC (mmhos/Km) | 0.5 | -- | 1.4 | 1.0 |
| SAR | 1.9 | -- | 5.1 | 5.7 |
| B (ppm) | 0.5 | -- | 0.2 | 1.0 |
| Cd (ppm) | 0.1 | -- | 0.0 | 0.2 |
| Se (ppm) | 0.3 | -- | 0.1 | 0.5 |

Fails suitability criteria

[1] Data are from published Soil Survey of Red River Parish, Louisiana (USDA, 1980). Remaining data collected for permit application.

[2] A "dash" ( -- ) indicates absence of data.

Table 2 compares features important to use and management. Capability Subclass "1" has no hazards to use and management (USDA, 1980); Subclass "2" has moderate hazards; and Subclass "3" has severe hazards. The letter 'W' means the hazard is due to *wetness*. Thus, Table 2 shows that the Moreland Variant is severely limited (3w) due to wetness, attributed to the high clay content. Coushatta soils have no limitations, and none are predicted if Wilcox materials are used as a postmine substitute; the suitable alluvium (AM) is predicted to have moderate limitations.

TABLE 2. Comparison of capability and drainage classes*, Oxbow Mine

| MATERIALS | CAPABILITY SUBCLASS | DRAINAGE CLASS |
|---|---|---|
| A. NATIVE SOILS | | |
| Coushatta | 1 | Well |
| Moreland Variant | 3W | S. Poorly |
| B. POSTMINE SELECTED OVERBURDEN | | |
| Suitable Alluvium (AM) | 2W | Mod. Well |
| Wilcox Interval | 1 | Well |

*Source: USDA, 1980, for native soils and estimates for overburden based on similar materials.

Table 3 compares predicted yields of native soils and potential sources of substitute materials. Yields for native soils are derived from the published soil survey of Red River Parish (USDA, 1980). Those selected for overburden materials are based on known yields of soils with similar properties. TABLE 3 shows that the Moreland Variant soils have the lowest predicted yields of any of the materials considered. This stands to reason when the high clay content and associated features are considered.

TABLE 3. Comparison of predicted yields*, Oxbow Mine

| MATERIALS | COTTON (lb) | CORN (bu) | SOYBEANS (lb) | COMMON BERMUDA (AUM) |
|---|---|---|---|---|
| A. NATIVE SOILS | | | | |
| Coushatta | 875 | 90 | 40 | 7.5 |
| Moreland Variant | 625 | -- | 40 | 6.0 |
| B. POSTMINE SELECTED OVERBURDEN | | | | |
| Suitable Alluvium (AM) | 725 | 80 | 35 | 7.0 |
| Wilcox Interval | 725 | 90 | 40 | 7.0 |

*Source: USDA, 1980, for native soils and estimates for overburden based on similar materials.

These tests on predictive models are examples of how native soils can be compared to proposed substitute materials. Other features that affect use and management, such as engineering and woodland practices can be developed. The key to the procedure is the use of data through computer enhancement to develop realistic classes for comparison.

## Summary and Conclusions

Using computer enhanced data of native soils and overburden, correlated classes of materials were developed at the Oxbow Mine for possible use in postmine soils. Using agronomic performance standards, the classes were compared to determine which materials were most suitable. Clayey alluvium in which the dominant major soil is developing were declared unsuitable due to excessive clay content. Basal units of the alluvium, high in sand and/or gravel, were also determined to be unsuitable. The silty middle strata of the alluvium as well as the Wilcox Interval above the first mineable lignite seam compare favorably with the clayey native soils (Moreland Variant) for postmine soil substitution. Postmine soil properties and crop adaptation are predicted to be considerably improved with the substitution of selected overburden strata. A new geological volumetric model was completed using the revised StratiFact® database to confirm that there were sufficient quantities of the suitable alluvium and Wilcox materials for such use. Furthermore, engineering studies were also performed to ensure that an feasible operational plan could be developed to selectively recover these topsoil substitute materials .

While computer editing and modeling is the key to class recognition and correlation, a knowledge of basic geology, soils, and agronomic practices are also essential to interpretations. Computers are used to correlate and manipulate the data into appropriate classes. A knowledge of earth sciences interprets the classes for reclamation planning.

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