

The University of Texas at Austin

RESEARCH NOTE 3

1976



RECLAMATION AT BIG BROWN STEAM ELECTRIC STATION NEAR FAIRFIELD, TEXAS: GEOLOGIC AND HYDROLOGIC SETTING

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GEOLOGIC AND HYDROLOGIC SETTING

Geology

Regional Setting.—Lignite deposits in Texas occur in three Eocene stratigraphic units: the Wilcox Group (lower Eocene), the Yegua Formation (upper Eocene), and the Jackson Group (upper Eocene). They are part of an extremely thick Gulf Coast Tertiary clastic sequence composed of an alternation of fluvial-deltaic and marine units. At the outcrop, the marine units are volumetrically insignificant. All units dip coastward at $1/4$ to 2° (about 20 to 180 ft/mile).

In Texas, the Wilcox Group, the most important lignite-bearing unit, was deposited in fluvial systems and delta systems updip and delta systems downdip in east-central and northeast Texas and in barrier-bar lagoon systems in South Texas (Fisher and McGowen, 1967).

The Wilcox Group in the vicinity of Fairfield has been subdivided into three formations (Barnes, 1970) (figs. 1 and 2). From oldest to youngest, they are the Hooper Formation composed of mud and sand, the Simsboro Formation of sand, and the Calvert Bluff Formation of sand and mud. The Hooper conformably overlies the Midway marine shales. The Simsboro rests conformably and unconformably on

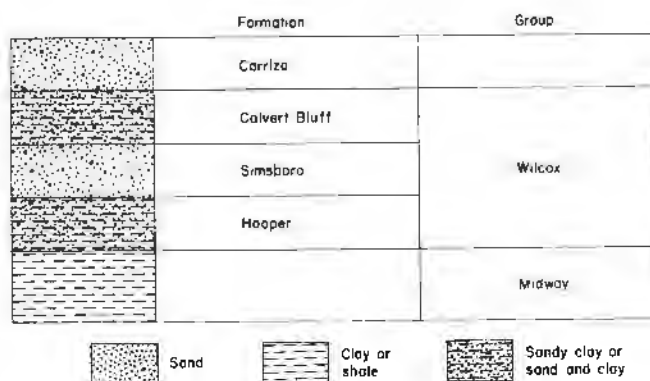


Figure 1. Stratigraphic column of geologic units in vicinity of Big Brown lignite deposit.

the Hooper and has been interpreted as coarse-grained meanderbelt deposit (McGowen and Garner, 1970). The Calvert Bluff conformably overlies the Simsboro. Regional lithofacies mapping of the Calvert Bluff Formation shows that at the outcrop it was deposited as a fluvial system (Kaiser, 1975, unpublished data). Major channel deposits (thick sands) are isolated at the surface, surrounded by extensive interchannel floodbasin deposits of sandy mud or mud and laminated sand and clay.

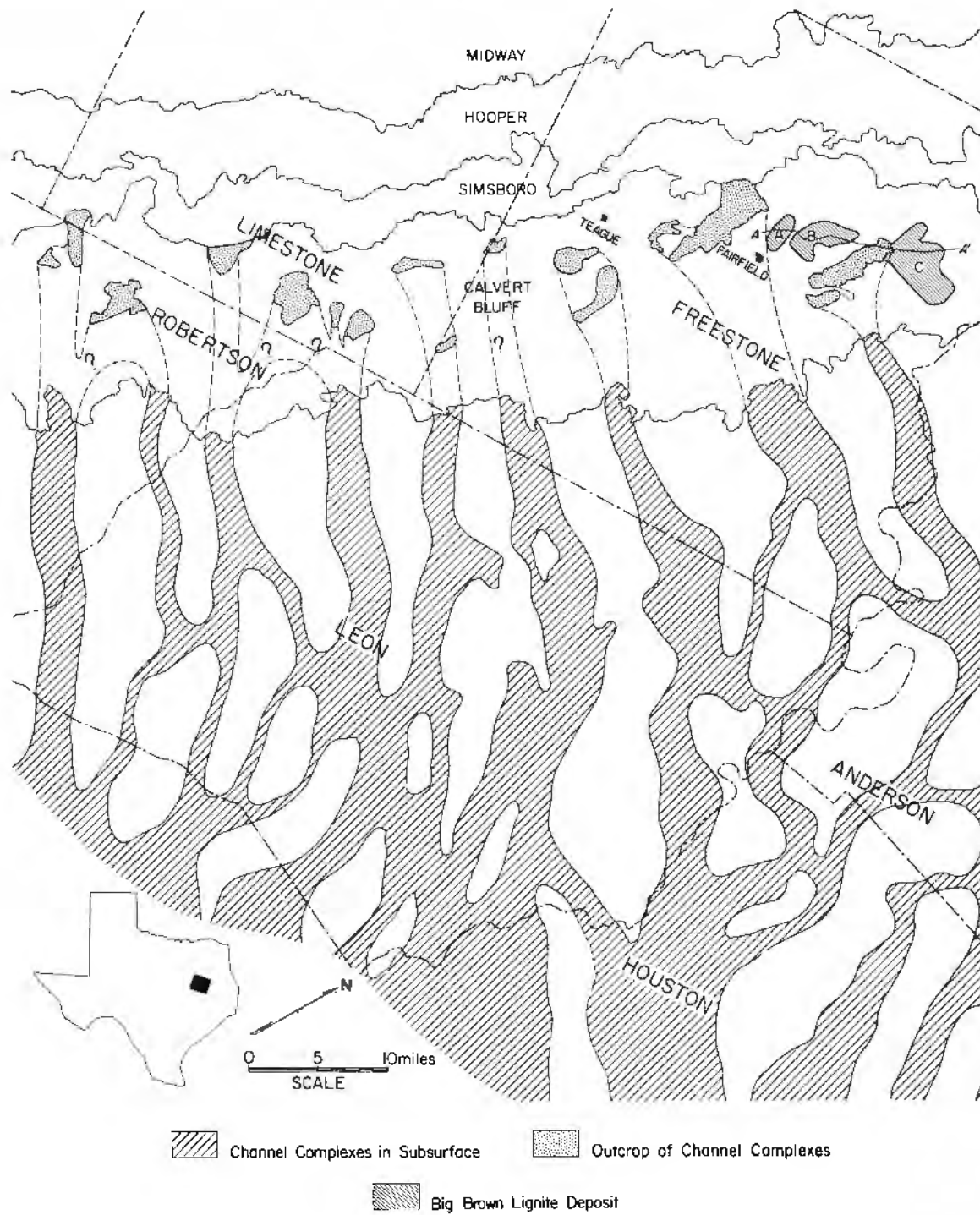


Figure 2. Lithofacies map of Calvert Bluff, Freestone County, and vicinity.

All lignite now mined in Texas comes from the Wilcox Group; that which is mined at the Big Brown strip mine is in the lower Calvert Bluff Formation. Other potentially commercial lignites in the Fairfield area occur at the top of the Calvert Bluff near the contact with the Carrizo Sand and in the upper Hooper Formation. Northeast of Fairfield, the Simsboro dies out as a mappable unit, and the tripartite division of the Wilcox can no longer be made. In this area, lignite deposits occur mainly in the upper and middle Wilcox.

Big Brown Deposit.—The Big Brown lignite deposit extends from U. S. Highway 75, just outside Fairfield, northeast along strike for about 11 miles (fig. 2). Individual seams are 5 to 8 ft thick, tabular, and continuous for up to 7 miles. Texas Utilities Generating Company has informally divided the deposit into three areas, "A," "B," and "C," that include at least four different mineable seams (figs. 2 and 3). Mining started in area "A" in 1971, in area "B" in 1972, and in area "C" in 1975. The lignites from the area designated "A" are now exhausted, and reclamation of the area is presently being completed. Approximately 90 percent of the 275 million tons of estimated initial reserves are in the "C" area.

Major channel sands (approximately 4 square miles in outcrop area and greater than 100 ft thick), identified by both surface mapping and subsurface mapping, occur adjacent to the lignite deposits (figs. 2 and 3). One such channel divided the "A" and "B" areas from the "C" area (fig. 3, boreholes 11-15). Not surprisingly, the mud parting or split (probable overbank unit) in boreholes 10 to 12 thickens toward the complex. To the south and west of Fairfield, a major channel complex marks the southwest limit of commercial lignite (fig. 2). Modern stream erosion (Walnut, Pin Oak, and Prairie Creeks) has removed shallow lignite between areas "A" and "B" and in area "C."

At Big Brown, the Calvert Bluff Formation strikes N. 23° E. and dips 0.6° (55 ft/mile) southeast; its average thickness is 700 ft. The lithology is interbedded sand and mud with lignite, interpreted as channel and interchannel deposits. In the interchannel basins, developed between natural levee and meanderbelt deposits of the major river courses, swamps and marshes were the sites of organic accumulation. Channel geometry, as revealed by lithofacies mapping, and the presence of abundant woody material in the lignite (logs as large as 6 by 2 ft and stumps 3 ft in diameter) indicate peat accumulation low on an ancient alluvial plain. The palynology supports dominantly fresh-water swamp conditions.

Lentz (1975, 1976) recognized a cyclic sedimentary sequence composed of coarsening-upward sequences. He called these sequences floodbasin cycles and described two of them in detail. An ideal cycle

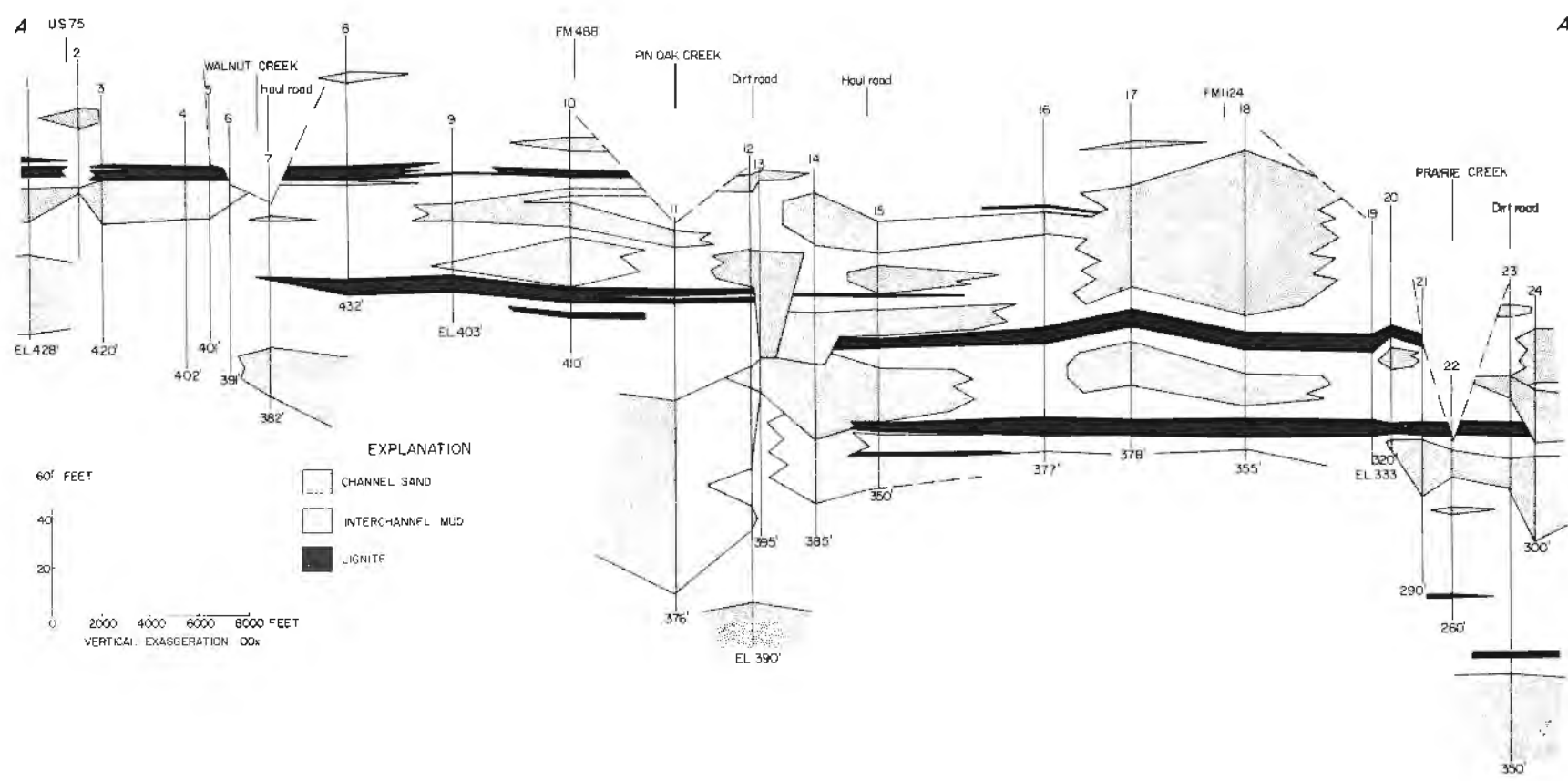


Figure 3. Strike section across the Big Brown lignite deposit.

is 10 to 15 m thick and begins with lignite then passes into clay, mud, interlaminated very fine-grained sand and mud, and finally flat-bedded fine sand. At Big Brown, these sequences were fed by extended crevasse distributaries, initiated by overbank flooding and crevassing on major streams to the northeast and south. As crevasse splays advanced into the lowest part of the interchannel basin or floodbasin, upward-coarsening sediment sequences were deposited. Infilling was accomplished by the continued progradation of crevasse splays and lacustrine deltas basinward. Upon the joining of advancing splays and their subsequent abandonment, swamps and marshes were again reestablished. Reinitiation of crevassing repeats the cycle. A modern analogue of the Big Brown interchannel basin is the Atchafalaya basin of the Mississippi delta complex (Lentz, 1975). Depending on the mining activity at Big Brown, the following ancient subenvironments are exposed in the pits and ramps: swamp, crevasse splay, lacustrine, crevasse-distributary channel, and fluvial channel.

Hydrology

One of the most critical problems of lignite mining will be its potential effect on the quality and availability of ground water. Wilcox and Carrizo sands, which are contiguous to economic lignite deposits, are major sources of ground water throughout East Texas. These sands have the potential to supply much greater volumes of ground water than are used presently. Mining which intersects these sands will undoubtedly lead to the introduction of some mine drainage.

The lithology and geometry of the Wilcox Group and Carrizo Sand are as critical to their hydrology as they are to the location of lignite. In the Fairfield area, the Wilcox-Carrizo aquifer can be divided into three distinct parts: the multilateral Simsboro sands, the multilateral Carrizo sands, and the multistory channel sands in the Calvert Bluff Formation. All three are hydraulically connected.

Rainfall on the sand outcrops or streams flowing across the outcrop recharge the sands. As many of the sands are saturated to land surface, much potential recharge is rejected. Rejected recharge runs off or seeps out as springs to enter the surface-water flow. Ground-water movement is mostly downdip to the southeast with some flow towards the Trinity River. The natural rate of ground-water movement ranges from 10 to 100 ft/year (Guyton and Associates, 1972).

All present mining in the Fairfield area is in the Calvert Bluff Formation, hence sand geometry and permeability and transmissivity of the sands in that formation are most important to mining. The highly

permeable, water-bearing parts of the formation are the channel sand complexes (fig. 2). Connected to the major channel sands are slightly less permeable minor sands deposited by tributaries and crevasse distributaries. The different sands in the Calvert Bluff can be viewed as a network of interconnected pipes tilted coastward running through the relatively impermeable interchannel muds.

Surface runoff or ground-water infiltration related to mining in the future could enter the Simsboro or Carrizo sands. Unlike the Calvert Bluff, sand deposits are far more extensive and the sands are continuous along outcrop for many tens of miles. Most large wells, including municipal wells, are in Simsboro or Carrizo sands; fewer occur in Calvert Bluff channel sands. These sands provide the greatest quantities of high-quality water. Smaller domestic wells simply derive ground water from the shallowest suitable source probably including many of the minor sands. The best locations for wells should be determined from a more thorough understanding of the geometry of the thicker, more permeable channel sands such as is provided by figure 2.

MINING AND RECLAMATION

Strip Mining and the Environment

Two types of strip mining are used to obtain coal: contour stripping and area stripping. Contour stripping is practiced in hilly or mountainous areas, where the coal is exposed along the hillsides, and on steep slopes. The coal seam is mined along the side of the hill, creating a bench (fig. 4A). The overlying rock is generally dumped down the side of the hill and piled on the bench after the coal is removed. This type of strip mining, prevalent in the Appalachian area, has caused most of the severe land-surface disruption and water pollution that have given surface mining of coal such a bad public image. Reclamation is difficult under these circumstances; the scarred hills and the water pollution resulting from exposing high-sulfur coals to the elements have combined to create a wasteland.

Where coal or lignite seams are flat lying, as in East Texas, where the topography is flat to gently rolling, and where the overburden is less than 50 m thick, area stripping is used to expose and remove the coal or lignite. Draglines and large shovels are used to remove the overburden and pile it in rows of conical piles, covering the area from which the coal or lignite has recently been removed by power shovels (fig. 4B). The resulting terrain consists of parallel rows of spoil, or overburden, filling a depression. This terrain can be worked by bulldozers to mold it into a continuous, gently rolling topography similar to that which

existed before mining was begun. Surface runoff waters can be controlled quite easily and treated, if necessary, before they leave the property. Area stripping is practiced in Texas as well as in the Midwestern and Rocky Mountain area coal fields.

There are two major environmental problems that can arise from area stripping operations. First, the land is severely disrupted. Where reclamation is not practiced, an impenetrable topography is created; the land is of little or no use. Aside from aesthetic considerations, the severity of this problem depends on the suitability of the land for other uses before mining. That is, if the area were rich, productive cropland prior to mining, the consequences of destroying the surface are much more severe than if the land were scrub forest with poor soils. The second problem is that materials formerly buried beneath the surface are brought to the surface and into contact with the atmosphere. If the overburden and coal or lignite are high in sulfur and the climate is humid, sulfuric acid can be produced. The end result is a barren landscape on which nothing will grow and which yields polluting acidic waters to area streams or to ground water. If the overburden is low in sulfur, natural vegetation may slowly reestablish itself on its own or after some fertilization. Reclamation techniques that segregate and save topsoil (where it is worth saving), and that bury sulfurous materials during mining and then replace the topsoil are able to return the land to a productive and aesthetically pleasing state.

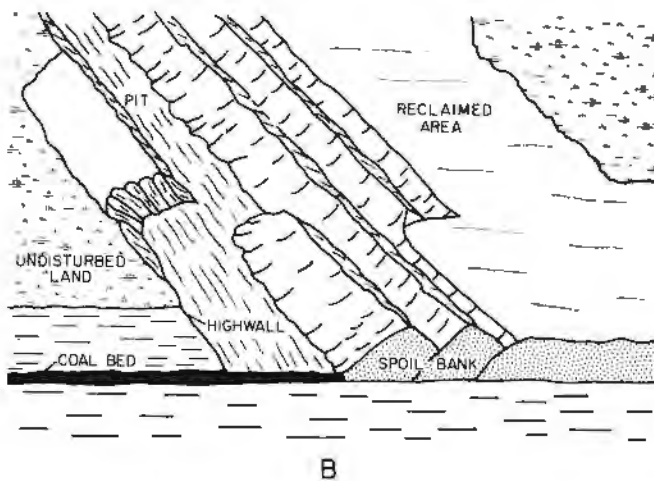
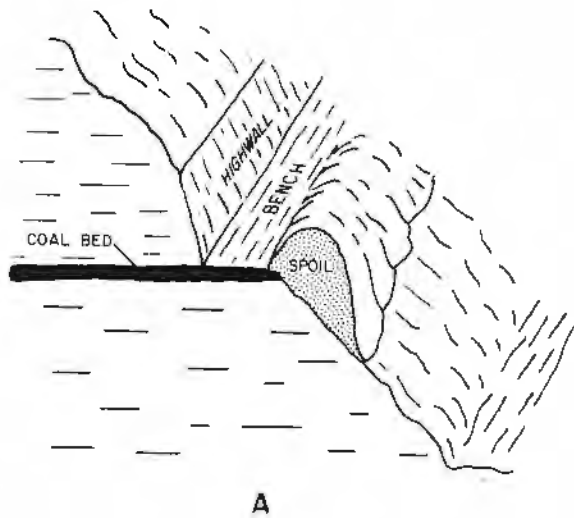


Figure 4. Strip-mining techniques used to mine coal and lignite.

Big Brown Operation

Texas lignite, in the areas now being mined, is moderately low in sulfur, and the topography is amenable to area stripping. The overburden material generally is suitable for the establishment of vegetation. These factors combine to make successful reclamation possible at the Big Brown site; similar reclamation programs have been imitated at the Monticello mine opened in 1974 and are planned for Martin Lake, scheduled to open in 1977. The reclamation and environmental programs maintained by Texas Utilities Generating Company started several years prior to the Texas law regulating surface mining. The company had found it worthwhile to be thorough and innovative in its utilization of related property. Of course it is not possible now to assess the long-term productivity of the reclaimed land.

The details of the reclamation and environmental programs at Big Brown will be explained by Texas Utilities staff members. Briefly, two electric draglines with 70-cubic-yard buckets are used to strip 40 to 120 ft of overburden from the lignite. The lignite is loaded into 180-cubic-yard trucks by a 16-cubic-yard electric power shovel and transported to the powerplant along haulage roads that are within the company property. Initially, topsoil was segregated, but research at Big Brown indicated that the topsoil was only slightly more fertile than reworked overburden. Following grading of the spoil by bulldozers, the area is sprigged with coastal Bermuda or seeded with clover and fertilized.

Surface waters are kept on the property and monitored in holding ponds before being allowed to drain into area streams. With the lignite having an average sulfur content of approximately 1 percent and overburden that is low in sulfur, maintaining surface waters at a suitably high pH has not been a problem to date. However, some waters have shown high sulfate concentrations (Lentz, 1975). Another problem that has been encountered is a drop in average pH in surface spoil in an agricultural test plot from an initial 6.6 to 5.3 (Askenasy and others, 1976). This drop in pH may indicate a need for special handling of sulfurous materials during mining or special treatment of surface spoil such as liming to avoid future problems with mine drainage.

Texas Utilities Generating Company maintains a modern, well-equipped environmental research laboratory on the shore of its cooling lake; part of the property bordering on the south end of the lake has been donated to the State for use as a park. The laboratory is used by the company's environmental staff and by graduate students from nearby universities who are conducting research in several aspects of the mining and powerplant operations. These projects, selected by an advisory group of faculty members from

several Texas universities, are funded by the company. Recent work and work in progress includes studies of trace-element content of stack emissions, thermal effects on fish in the cooling lake, soil research related to reclamation planning, and quality of surface waters draining from the mine.

Texas Surface Mining and Reclamation Act

On June 21, 1975 the Texas Legislature passed The Texas Surface Mining and Reclamation Act, which charges the Railroad Commission with devising regulations based on the bill, administering the bill, and monitoring reclamation programs. All new lignite mining operations and all established operations continuing past June 21, 1975 are required to meet the standards of mining and reclamation set forth in the bill. Sections of the bill require that mining companies identify the natural capability of the land prior to mining, control erosion and sedimentation into surface water, avoid chemical pollution of ground and surface water, and minimize the disturbance to the prevailing hydrologic balance. In addition, certain areas may be deemed unsuitable for surface mining including (1) areas in which reclamation is unfeasible, (2) areas of frequent flooding or unstable geology, (3) aquifers and aquifer-recharge areas, or (4) areas of important natural systems that would be damaged significantly by mining operations. In general, reclamation must restore the land to the same or a "substantially beneficial condition." Specifically, the land must be regraded to the approximate original contour, topsoil either preserved and restored or a suitable substitute found, and vegetation reestablished successfully for 4 years.

At this time the Railroad Commission has completed a set of regulations and a permit application; a permit will be issued to each individual mine. All three will contain specific requirements for mining and reclamation for the mine operator.

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