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A NEPA FOLLOW-UP STUDY OF DOE LOAN GUARANTEE FUEL ETHANOL PLANTS

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April 1989

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MARTIN MARIETTA ENERGY SYSTEMS, INC.
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for the
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ABBREVIATIONS, ACRONYMS, AND INITIALISMS

AFO	Alcohol Fuels Office (U.S. Department of Energy)
AIRCO	carbon dioxide recovery facility located adjacent to the New Energy Company of Indiana fuel ethanol plant
BOD	biochemical oxygen demand
CEQ	President's Council on Environmental Quality
CFR	Code of Federal Regulations
CO	carbon monoxide
CO_2	carbon dioxide
DDG	distillers' dried grains
DDGS	distillers' dried grains with solubles
DOE	U.S. Department of Energy
EA	environmental assessment
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESA	Energy Security Act, Public Law 96-294, June 1980
FONSI	finding of no significant impact
FPPA	Farmland Protection Policy Act of 1981
FR	*Federal Register*
gpd	gallons per day
H_2S	hydrogen sulfide
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
JSTP	Jasper Sewage Treatment Plant (Jasper, Tenn.)
lb/h	pounds per hour
LDEQ	Louisiana Department of Environmental Quality
mgd	million gallons per day
Mg/year	10^6 grams/year
MWWTP	Municipal Wastewater Treatment Plant (South Bend, Ind.)
N	nitrogen
NA	not available
NAAQS	National Ambient Air Quality Standards
NECI	New Energy Company of Indiana
NEPA	National Environmental Policy Act of 1969
NJI&I	New Jersey, Indiana and Illinois Railroad
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NSPS	New Source Performance Standards
O_2	oxygen
OSHA	Occupational Safety and Health Administration
PEA	programmatic environmental assessment
P.L.	Public Law
PSD	prevention of significant deterioration
SBCOC	South Bend Chamber of Commerce (Ind.)
SO_2	sulfur dioxide
TK Nitrogen	total Kjeldahl nitrogen
tpd	tons/day
TSP	total suspended particulates
TSS	total suspended solids
TVA	Tennessee Valley Authority
VOC	volatile organic compounds

EXECUTIVE SUMMARY

The purpose of the study was to characterize the environmental impacts of three fuel ethanol plants constructed under the U.S. Department of Energy's (DOE's) Office of Alcohol Fuels Loan Guarantee Program (established under the Energy Security Act of 1980) and to evaluate these impacts relative to predictions made in environmental assessments (EAs) prepared about 6 years ago for these facilities. The three plants, designed to produce fuel-grade ethanol for blending with gasoline, use a variety of feedstocks, processes, and fuel sources and are located in different environmental settings. The results of this study will provide DOE with a current overview of the site-specific environmental impacts that can occur at fuel ethanol facilities and will also provide a factual basis on which to begin National Environmental Policy Act of 1969 (NEPA) assessments for future fuel ethanol plants. The assessment method used in this study involves three major steps: (1) reviewing background materials for each project to identify predicted impacts; (2) visiting each project site to inspect the facilities, review environmental permits and other germane information, and discuss project characteristics with project personnel; and (3) contacting state, local, and federal agencies to gather information on the projects. The assessment method is based on available data. No monitoring programs, field studies, or laboratory analyses were possible within the scope of this study.

Key findings resulting from the collection and evaluation of project-specific information for the three plants are as follows. First, available data characterizing actual environmental impacts on the temporal and spatial scales of the predictions are scarce, especially concerning ambient impacts (i.e., those beyond the boundaries of the facility). Typically, if any quantitative information on impacts was located, it described air emissions at the point of release to the atmosphere or water effluents at the point of discharge to a water body or publicly owned treatment plant, and the information was usually required by permit or regulation. A second major finding is that the facilities "as built" differed considerably from those that were assessed, with corresponding changes in emissions and effluents. Consequently, actual environmental impacts may have differed from forecasts; however, the differences are not expected to be significant in that for all projects as built, the appropriate operations permits were obtained from environmental agencies and compliance with regulations and standards was demonstrated. Third, most of the mitigation measures that were relied on in the EAs to limit impacts to insignificant levels were implemented and were required by permit condition, law, or regulation. Fourth, impacts generally occurred in the areas for which they were predicted (e.g., air, water, ecology). Major impacts not anticipated by the EAs include odor, effects of wastewater on operations of a municipal treatment plant, possible nuisance classification of treated wastewater from a molasses-based process, and habitat losses from both vegetation removal during construction and the unforeseen construction of barge terminals. In all cases, impacts were judged to be not significant in the final outcome, either because corrective action was taken by plant management (and other involved parties) or because the resources affected in these particular cases were not important.

Principal conclusions from the above findings are as follows. First, follow-up studies would benefit from the availability of ambient monitoring data to more thoroughly characterize actual impacts. Such a proposal would be prohibitively expensive for every predicted impact but perhaps could be limited to key potential impacts for which mitigation is required to reduce the impact magnitude below a significance threshold but which is not required by law, regulation, or permit condition. Second, future NEPA documents for fuel ethanol facilities should address impacts evaluated previously, and consideration should be given to addressing the following issues as well: generation and disposal of solid wastes (none of which were found to be hazardous at the three facilities); preventing and minimizing impacts from spills and other nonroutine releases; interfaces between plant wastewater discharges and municipal treatment plant operation (especially regarding biochemical oxygen demand); potential odor effects from corn-based plants using rotary-kiln driers and sited upwind of populated areas; and changes in emissions and effluents from values given in the conceptual designs. Third, the follow-up study provided a unique opportunity to examine the environmental implications of a complete alternative energy program that began with the Energy Security Act and culminated in the three facilities examined herein, and the study has demonstrated that early consideration of environmental factors can lead to the production of alternative fuels in an environmentally acceptable manner, thereby contributing to NEPA's goal of taking actions that "protect, enhance, and restore" the environment.

ABSTRACT

This study was implemented to examine and characterize the actual environmental impacts of three fuel ethanol plants constructed under the U.S. Department of Energy, Office of Alcohol Fuels Loan Guarantee Program, and to compare actual impacts with those predicted about six years ago in environmental assessments (EAs) prepared for these facilities. The objective of the program, established under the Energy Security Act of 1980, was to conserve petroleum resources by promoting the use of fuel ethanol in motor vehicles. The plants were designed to produce fuel-grade ethanol for blending with gasoline and reflect different feedstocks, processes, fuel sources, and site locations. Although two of the facilities as constructed differed substantially from those assessed previously, actual environmental impacts generally occurred in the areas predicted by the EAs. Major impacts not anticipated include odor from air emissions, effects of wastewater discharge on operation of a municipal sewage treatment plant, possible classification of treated wastewater from a molasses-based process as a nuisance, and habitat losses from both vegetation removal and unforeseen construction of barge terminals. In all cases, impacts were judged to be not significant in the final outcome, either because plant management (or other involved parties) took corrective action or because the resources affected in these particular cases were not important. Mitigation measures relied on in the EAs to limit adverse impacts to insignificant levels were implemented and were required by permit condition, law, or regulation. Future follow-up studies would benefit from the availability of ambient monitoring data to more thoroughly characterize actual impacts.

1. INTRODUCTION

The Energy Security Act (ESA, Public Law 96-294, June 1980) provided for federal loans, loan guarantees, price guarantees, and purchase agreements to promote expansion of the fuel alcohol industry in the United States, with the objective of helping reduce the need for imported petroleum. The Office of Alcohol Fuels (AFO) was established within the U.S. Department of Energy (DOE) to implement the provisions of Public Law (P.L.) 96-294, with the loan guarantee program as a cornerstone. An initial DOE request for proposals generated 57 applications for loan guarantees. On the basis of specific requirements, DOE screened these proposals for potential viability and selected eleven projects in August 1981 for conditional commitments for loan guarantees. The DOE program emphasized compliance with the National Environmental Policy Act (NEPA) [Public Law 91-190, January 1970], which is implemented in accordance with procedural regulations issued by the President's Council on Environmental Quality (CEQ) [U.S. Code of Federal Regulations, Title 40 (40 CFR) Pts. 1500-8].

DOE evaluated the potential environmental impacts of proceeding with the Loan Guarantee Program in a programmatic environmental assessment (PEA) [DOE/EA-0140, November 1981] that resulted in a finding of no significant impact (FONSI) (47 *Federal Register*, No. 34, February 19, 1982, p. 7483). Following the PEA, DOE evaluated the potential environmental impacts of each of the ten proposed fuel ethanol plants (one loan guarantee applicant withdrew before the assessment work began) in a series of site-specific environmental assessments (EAs) in 1982; no significant impacts were predicted in the EAs for the projects.

Three of the ten projects received loan guarantees and were built: the New Energy Company of Indiana (NECI) facility located in South Bend, Indiana; the Tennol Energy Company (Tennol) facility located near Jasper, Tennessee; and the Agrifuels Refining Corporation (Agrifuels) facility located near New Iberia, Louisiana. The first plant to be constructed was NECI, which was completed in October 1984. The plant reached full production in June 1985. The Tennol plant was completed and began operation in December 1985. Tennol's production levels had never exceeded 50% of design capacity, because of technical problems, and in September 1988, the decision was made to place the facility in standby mode because of financial difficulties. The Agrifuels project began start-up operations in the spring of 1987 but was halted in April 1987 because of financial difficulties. The future disposition of the Tennol and Agrifuels plants is uncertain. Table 1 highlights key project characteristics.

Each of these plants converts biomass into fuel ethanol, producing carbon dioxide (CO_2) as a by-product. A brief overview of the ethanol production process is given below; Appendix B presents more detailed process information on each of the three plants examined in this study. Fuel-grade ethanol is grain alcohol that has been denatured to prevent human consumption. In the production process, fermentation is achieved by using microorganisms grown in sugar solutions that produce ethanol and CO_2 as metabolic by-products. Any type of sugar can be used, but the need to keep costs low dictates an inexpensive source of sugar for fuel alcohol production. As

Table 1. Summary descriptions (as planned) of fuel ethanol projects receiving loan guarantees from the U.S. Department of Energy

	New Energy Company of Indiana	Tennol Energy Company	Agrifuels Refining Corp.
Location	South Bend, Ind.	Jasper, Tenn.	New Iberia, La.
Setting	Urban	Rural	Rural
Annual capacity (gal x 10^3)	50,000	25,000	35,000
Feedstock	Corn[a]	Corn[b]	Molasses/syrup
Process heat	Coal	Coal	Bagasse[c] and waste methane
Wastewater disposal	Municipal[d]	Municipal[e]	On-site treatment
Dehydration	Benzene	Diethyl ether	Cyclohexane
By-products sold[f]	DDGS, CO_2	DDGS, CO_2	None

[a]Dry milled.
[b]Wet milled.
[c]Bagasse is the fibrous residue remaining after liquid has been extracted from sugar cane.
[d]Without biochemical oxygen demand (BOD) pretreatment.
[e]Following treatment to reduce BOD.
[f]DDGS = distillers' dried grains with solubles; CO_2 = carbon dioxide.

shown in Table 1, two of the three projects receiving loan guarantees are based on corn, and the third uses molasses as a feedstock. Corn is rich in starch, which must be hydrolyzed to sugar before fermentation. All corn-processing plants use variants of two basic approaches, dry milling or wet milling (Elmore et al. 1982), to expose the starch to hydrolysis by acids or enzymes. Most plants process the solid/liquid mixture remaining after fermentation through the use of centrifuges, evaporators, and dryers for complete recovery of a dry solid, which then can be sold for animal feed as distillers' dried grains (DDG) or distillers' dried grains with solubles (DDGS). Carbon dioxide may be either (1) vented to the atmosphere or (2) compressed, dried, and sold. In a molasses-based plant, the process essentially begins with sugar, so no solid by-products are available for sale. Fermentation results in an alcohol content of 8 to 10%, which is eventually increased to 100% by distillation and dehydration with an organic solvent. The alcohol is then denatured to make it unfit for human consump-

tion (thereby avoiding the beverage alcohol tax); most fuel ethanol producers denature the alcohol by adding 5% gasoline because the alcohol will eventually be blended with gasoline.

Although only three of the ten projects evaluated were actually constructed, these three projects reflect the variety of technologies proposed by companies under the loan guarantee program. Because impacts are closely related to technology (Elmore et al. 1982), the sample of three projects is a representative subset of the program for the purposes of this follow-up study. The AFO Loan Guarantee Program officially terminated on June 30, 1987.

The termination of the AFO loan guarantee program is an appropriate time to follow up on the three projects that were constructed, by examining actual environmental impacts that have occurred, by comparing these with the forecasts made in the EAs, and by verifying the nature and extent of mitigation measures that were implemented. The results of this work should thus provide a comprehensive perspective on environmental concerns for fuel ethanol production to assist in future programmatic planning (including NEPA compliance) and technology transfer. The results of the follow-up study also represent a logical conclusion to the environmental issues evaluated a priori in the loan guarantee program, and they represent a "springboard" for initiating environmental reviews of any future activities. Follow-up studies, in general, help to better achieve the purpose of the NEPA process by providing a factual, rather than predictive, basis for understanding environmental consequences.

Section 2 of this report defines the approach used, Sect. 3 presents the findings, and Sect. 4 evaluates the findings and draws conclusions. Appendix A provides a detailed checklist of predicted vs actual project characteristics and environmental impacts for each of the three plants, and Appendix B describes the plants as found during this study.

2. ASSESSMENT METHOD

Three major steps comprise the approach used in this study: (1) reviewing background materials for each project to identify forecast impacts; (2) visiting each project site to inspect facilities that were constructed, review environmental permits and other information germane to impacts, and discuss project characteristics with plant personnel; and (3) contacting federal, state, and local agencies for information regarding the impacts of a particular project. The basis for gathering information in all of the steps is an assessment checklist (Appendix A) that contains information on predicted project characteristics, predicted impacts, monitoring, and mitigation, and also a provision for unforeseen impacts that occurred.

In the first step, the NEPA documents for the projects were collected for review. Table 2 summarizes the NEPA histories of the projects, which ranged from simple to complex. The EAs and FONSIs were reviewed to identify impact forecasts; the forecasts were then evaluated to rank them in terms of relative importance, and information was sought for the most important perceived impacts. Major resource areas of interest are air quality, water quality (surface and groundwater), water use, ecology, land use, and socioeconomics. Table 3 summarizes this information. Of primary interest are any adverse effects that routinely occur during normal operation. Impacts from nonroutine events are of concern if they result in irreversible harm to the environment.

Table 2. Summary of National Environmental Policy Act histories of loan guarantee fuel ethanol projects

Project	History
1. New Energy Company of Indiana	EA published, April 1982 (DOE/EA-0163) FONSI issued, April 27, 1982
2. Tennol Energy Company	EA published, December 1982 (DOE/EA-0205) FONSI issued, December 22, 1982
3. Agrifuels Refining Corp.	EA published, June 1982 (DOE/EA-0165) FONSI issued, June 16, 1982 Reevaluation of impacts due to change in boiler fuel (from pelletized bagasse combustion to condensed molasses solubles combustion) and other project changes, January 1983. FONSI upheld. EA revised and reissued because of major changes in process (ethanol production, boiler fuel, wastewater treatment, etc.), May 1985. FONSI reissued, June 3, 1985

Table 3. Estimated probability of occurrence and severity of potential impacts from loan guarantee fuel ethanol projects

Impact	Probability of occurrence	Severity of consequences
Air emissions of criteria pollutants	High	Low to moderate[a]
Water use	High	Low to moderate
Groundwater pollution	Low to moderate	Moderate to high
Wastewater discharge[b] (volume, BOD, TSS)	High	Moderate to high
Habitat disturbance; ecosystem alteration	Moderate	Low
Endangered species	Low	Low
Land use	High	Low to moderate
Noise	High	Low to moderate
Conflicts with cultural and archeological values	Low to moderate	Low
Expenditures (wages, salaries, goods, and services)	High	Moderate[c]
Demand on public services	Low	Low
Traffic congestion	Moderate	Low to moderate
Occupational exposure to chemicals	High	Low[d]
Geology/soils	Low	Low

[a]Assumes all permit conditions are met.
[b]BOD = biochemical oxygen demand;
TSS = total suspended solids.
[c]Predicted socioeconomic impacts were largely beneficial.
[d]Assumes all workplace standards are met.

Reviewing the EAs for the projects identified three general types of impact forecasts: (1) quantitative (e.g., ambient air pollutant levels predicted at a given distance from the plant over a specified time period); (2) binary, which may be quantitative but are either right or wrong (e.g., change in land use, absence of cultural resources on-site); and (3) mainly judgmental (qualitative) (e.g., most workers would be hired from within commuting distance, noise levels should not cause problems for nearby residents).* The type of forecast is important because it influences the types of data needed to verify the forecast (e.g., subjective information will be of only minimal value in verifying quantitative forecasts); conversely, the type of data available on actual effects may also limit verification of some impacts. Table 4 summarizes the types of forecasts found in the three EAs. Another important reason for typifying forecasts is that it provides an indication of the importance of an accurately forecast impact (e.g., predicting ambient air pollutant levels that are close to actual monitored levels is a more highly valued match than predicting that no cultural resources will be affected because none are found on the site). A close match with quantitative forecasts provides more useful information to the assessment process (e.g., the adequacy of simulation models and the nature of impacts) than can be obtained from verification of qualitative or binary forecasts.

For the second step, physical site inspections, review of permit files and discussions with plant personnel were used to obtain information on actual impacts of the projects. As was the case with forecasts, actual impacts are characterized by a wide variety of information types ranging from quantitative to qualitative. Typically the only quantitative information that was located for the fuel ethanol plants deals with emissions and effluents measured at the point of release as part of a permit condition. Ambient monitoring is not required by permit or other condition, probably because the technology (fuel ethanol production) is conventional and is not perceived as hazardous to public health and safety [e.g., Culhane, Friesema, and Beecher (1987) found that the projects with the best ambient monitoring of impacts (of the 29 projects they examined) were either DOE nuclear facilities or facilities licensed by the U.S. Nuclear Regulatory Commission]. For the purposes of this study, the quantitative estimates of emissions and effluents in the EA were compared with actual levels established in permits, or measured by emission and effluent monitoring equipment, or both, and the impact on the resource is discussed by inference. In other words, the source terms are used as indicators of ambient impacts.

More than 30 state and local officials were contacted to gather "external" (i.e., from outside DOE or the plant) information on environmental impacts of a particular facility. Most of this information was obtained by telephone interviews with the agencies. In some cases, copies of permits, notices of violation, or other documents were obtained to supplement the interviews.

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*These define a <u>spectrum</u> of possible forecast types rather than discrete <u>classes</u> of impacts.

Table 4. Types of impacts forecast in the environmental assessments for loan guarantee fuel ethanol projects

Project[a]	Predicted Impact	Type of Forecast[b]
NECI	Geology	Qualitative
	Groundwater quality	Qualitative
	Groundwater use	Quantitative
	Surface water quality - spills	Qualitative
	Wastewater discharge	Quantitative
	Air emissions	Quantitative
	Ambient air pollutant levels	Quantitative
	Occupational exposure	Qualitative
	Noise	Qualitative
	Ecology	Binary/qualitative
	Land use	Binary
	Socioeconomics	Quantitative
	Cultural resources	Binary
Tennol	Geology	Qualitative
	Groundwater quality	Qualitative
	Groundwater use	Quantitative
	Surface water quality - spills	Qualitative
	Wastewater discharge	Qualitative
	Floodplain	Qualitative
	Air emissions	Quantitative
	Ambient air pollutant levels	Quantitative-qualitative
	Occupational exposure	Qualitative
	Noise	Qualitative
	Ecology	Qualitative
	Land use	Binary
	Socioeconomics	Quantitative
	Cultural resources	Binary
Agrifuels	Geology	Qualitative
	Groundwater quality	Qualitative
	Groundwater use	Quantitative
	Surface water quality - spills	Qualitative
	Wastewater discharge	Quantitative
	Air emissions	Quantitative
	Ambient air pollutant levels	Quantitative-qualitative
	Occupational exposure	Qualitative
	Noise	Qualitative
	Ecology	Binary/qualitative
	Land use	Binary
	Socioeconomics	Quantitative-qualitative
	Cultural resources	Binary

[a]NECI = New Energy Company of Indiana.
Tennol = Tennol Energy Company.
Agrifuels = Agrifuels Refining Corp.

[b]Quantitative forecasts involve some type of numerical estimate.
Binary forecasts are "right/wrong" estimates (e.g., land use changed or not).
Qualitative forecasts are based to some extent on judgment calls.

The method is based upon the use of available data. No monitoring programs, field studies, or laboratory analyses were possible within the scope of this study. Thus, the evaluation of actual impacts is limited to interviews, visual inspections of sites and facilities, and available data collected for reasons other than for the follow-up study (e.g., to fulfill permit requirements).

The scope of the assessment method involves an evaluation of each project at two different times: one taken during the planning phase and one taken after construction was completed and operation had begun. Consequently, the results of the follow-up study should not be viewed as an exhaustive list of every impact that could occur at a given project, especially those that may occur after long-term (2-5-year) operation. Short-duration impacts that occurred before the follow-up site visit can be only detected and evaluated by reviewing documentation and interviewing personnel who observed construction and operation of the project. Also, impacts not addressed herein may occur after the follow-up study is completed and before the project terminates.

3. FINDINGS

This section compares actual and predicted impacts for the major resource areas of interest to this study (air quality, water quality, water use, ecology, land use, and socioeconomics); other impacts of less interest are briefly discussed. Appendix A presents the data on predicted and actual emissions, effluents, and other project characteristics for each of the three plants; discussions in this section emphasize the changes in actual vs. predicted values.

3.1 AIR QUALITY

Air quality impacts were forecast by using emissions estimates for the facilities as input to a simple air pollution dispersion model to predict ambient concentrations, which were compared to prevention of significant deterioration (PSD)* increments to evaluate the significance of the impact. Adding the predicted ambient concentrations to background levels (existing levels without the facilities) and comparing the total to National Ambient Air Quality Standards (NAAQS) was another measure of the significance of the potential impact. The only data available on actual air quality impacts are emission levels specified in permits or measured by monitoring equipment. No perimeter ambient air quality monitoring data have been nor are required to be collected by the facilities. Monitors operated by regulatory agencies were not optimally located to verify ambient pollutant level forecasts made in the EAs. Table 5 summarizes the difference between forecast and actual air emissions for the three facilities. Using the emission information as an indicator of impacts, this section evaluates actual vs forecast impacts and describes implementation of mitigation discussed in the EAs.

3.1.1 Actual vs Predicted Impacts

New Energy Company of Indiana

Air emissions of criteria pollutants (those pollutants for which NAAQS have been established) and of volatile organic compounds [(VOC), catalysts in the photochemical formation of ozone] were estimated in the EA. The proposed emission levels used in the EA are based on the New Source Performance Standards (NSPS, 40 CFR Pt. 60). NSPS-based levels were incorporated into the air pollution operating permits issued by the St. Joseph County Health Department for the NECI plant and are still in effect. Thus, the air emission levels listed in the EA were excellent estimates of actual circumstances. Actual emissions for plant operations are within the proposed

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*Areas of the United States whose air quality either meets the national ambient air quality standards (NAAQS) or cannot be classified (because of a lack of monitoring data) are designated as PSD areas. Increments are specified maximum ambient pollutant levels that can be added to background air quality in those areas without exceeding the NAAQS. Three general types of PSD classes are used to protect air quality: Class I (pristine areas in which the increments are the smallest); Class II (increments are larger), and Class III (where ambient pollutant levels may increase up to NAAQS).

Table 5. Percent differences in actual air emissions vs forecasts used in preparing environmental assessments[a]

Facility[b]	Pollutant[c] (%)				
	NO_x	TSP	SO_2	VOC	CO
NECI[d]	0	0	0	0	0
Tennol	-24	112	-15	157	80
Agrifuels	5	260	>280[e]	80	105

[a]Values are computed as follows: [(actual-predicted)/predicted] x 100%. Overestimates of actual emissions are shown as negative numbers, underestimates as positive numbers.

[b]NECI = New Energy Company of Indiana
Tennol = Tennol Energy Company
Agrifuels = Agrifuels Refining Corp.

[c]NO_x = nitrogen oxides; TSP = total suspended particulates; SO_2 = sulfur dioxide; VOC = volatile organic compounds; CO = carbon monoxide.

[d]The operations permit for NECI contained the same emissions levels specified in the environmental assessment. Actual levels have been 50% of permit levels for TSP, VOC, and CO and 80% each for SO_2 and NO_x.

[e]Negligible SO_2 emissions were forecast, so the percent change is in excess of 280% (actual emissions are 282 tons/year).

limits, ranging from approximately 80% of the limits for sulfur dioxide and nitrogen oxides (SO_2 and NO_x) to less than 50% for total suspended particulates, carbon monoxide, and volatile organic compounds (TSP, CO, and VOC) (Rarick 1988). The EA mentions that, because potential SO_2 and NO_x emissions were estimated to be more than 100 tons/year, a PSD review could be necessary. A PSD review was performed and an approval to construct was subsequently granted.

After construction was completed, the facility underwent emissions testing and subsequently, federal and local permitting agencies granted permits to operate. The permits demonstrated that the facility would not violate any national ambient air quality standards or PSD increments, in agreement with EA predictions.

Tennol

The Tennol actual plant emissions, based on maximum levels allowed in the air permits, vary from the estimates in the EA. The predictions overestimated emissions of SO_2 and NO_x by 15% and 24%, respectively, while underestimating emissions of TSP and VOC by over 100% and CO by about 80%.

Even though underestimated, actual emissions of the latter three pollutants are relatively small, at levels of less than 100 tons per year, and therefore did not trigger a PSD review. The EA indicated that, because annual emissions of SO_2 and NO_x were expected to exceed 100 tons each, a PSD review would probably be required. Projected SO_2 and NO_x emissions did trigger a PSD review, which was performed and approved before construction of the plant. Furthermore, a second PSD review was requested by the state of Tennessee after construction of the plant was complete because major changes were incorporated into the plant design that were not included in the original PSD permit application (J. Yoder, Tennol Energy Company, Jasper, Tenn., personal communication to R. L. Miller, Oak Ridge National Laboratory, Oak Ridge, Tenn., Aug. 10, 1988). The second PSD permit application (for the plant "as built") was completed in 1987 and approved by the state of Tennessee. The detailed analysis performed as part of this PSD review confirmed that the Tennol ethanol plant was in compliance with all appropriate NAAQS and Class I and Class II PSD increments for all pollutants, as predicted by the EA.

Agrifuels

Expected actual emissions from Agrifuels can be estimated from the modified PSD permit application submitted to the Louisiana Department of Environmental Quality (LDEQ) in November 1986. Large increases in SO_2 emissions expected at the Agrifuels plant from the operation of a newly installed bio-gas burner and control valve located on the bio-gas/natural gas boiler triggered the permit revision. The application and corresponding modified PSD permit issued by the LDEQ in April 1987 reflect the configuration of the plant as actually constructed. The most substantial difference from predicted emissions is the estimate of 282 tons/year of SO_2 emissions as a consequence of hydrogen sulfide (H_2S) in the bio-gas. Negligible SO_2 emissions were predicted on the basis of the previous plant design. Emissions of CO were also extremely underestimated by predictions (a factor of 100), and emissions of TSP and VOC were somewhat underestimated (factors of 2-3) [see Appendix A]. Expected actual NO_x emissions are very similar to predictions. Thus, the design changes for the Agrifuels plant resulted in expected actual emissions that are dramatically different from predicted emissions. All predicted concentrations were less than the applicable ambient air quality standards and PSD increments. Actual concentrations (as based on the modified PSD permit application) are expected to remain below applicable ambient air quality standards and PSD increments, as well.

Unanticipated Impacts

The principal unanticipated air quality impact, considering all three plants, is the plume of odorous substances emitted from the NECI facility.*

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*At the time the EA was prepared, little published information existed that would have identified odor as a potentially significant impact from NECI. The city of South Bend evaluated the potential for odor from NECI, and concluded that odor "will not be a significant problem" (R. O. Parent, Mayor of South Bend, letter to Mr. Barry Direnfeld, NECI, Apr. 9, 1980). More recent data from the U.S. Environmental Protection Agency (EPA) support the earlier impressions that odor, in general, should not be of concern for fuel ethanol facilities (EPA 1986).

Shortly after the NECI plant began operation in 1984, an odor emanating from the plant was detected in the ambient air at distances up to 20 miles downwind of the plant. The odor has been characterized by citizens as a "brewery odor" similar to the smell of "burning sugar." Many local citizens objected to the odor. Although this odor would perhaps be a minor concern in a remote area, it is a potentially important issue at South Bend because of the plant's proximity to and location upwind of the city's population center (in the direction of prevailing winds); thus, the center of South Bend often is downwind of the plant. In 1985, a suit (which is pending) was filed against the plant that would enjoin the plant from producing an odor during operation. A number of odor-masking and neutralizing systems were evaluated initially by NECI but failed to produce the desired improvements. Analysis of air emission samples taken at the plant determined that the most likely cause of the odor was the exhaust stacks from the five rotary-kiln dryers for producing DDGS and the single stack from the evaporator. The emissions appear to be normal by-products of a whole-grain fermentation process and have a wide range of physical and chemical properties. According to the literature, the compounds are odiferous to varying degrees. This mixture is believed to have contributed to a complex odor spectrum in the exhaust gases from the dryers and the evaporator. As suggested by the results of the analysis, a number of odor control technologies were evaluated for potential effectiveness at NECI, and a few were tested on a pilot scale on the NECI DDGS dryer stacks. The evaluation and testing eventually led to the selection and installation of a reaction chamber and a dry-chlorine injection system on the dryer stacks and the evaporator stack. The system has helped to abate the odor and has reduced the distance downwind at which odors are detectable. Overall, the chlorine system was estimated to reduce the odor by about 75%.

Unexpected temporary impacts to air quality occurred during start-up operations at Tennol and Agrifuels. The Tennol facility as built differed substantially from the design authorized under the construction permit (and from that assessed in the EA), causing the state of Tennessee to issue a complaint order to Tennol. The facility (as built) has been repermitted and has been shown to comply with ambient air quality standards and PSD increments. Also, faulty design and construction of the baghouse on the coal boiler stack led to violations of opacity levels specified in the permit. The baghouse was modified and opacity levels now are well within standards. At Agrifuels, a number of design changes occurred that resulted in changes in actual air emissions from those anticipated in the approved state construction permit (and the EA). The state of Louisiana fined the company for installing a burner before the permit was granted, and resolution of the issue is on hold until the plant restarts. No significant ambient air quality impacts are expected because of these changes, however, because EPA has already issued the federal PSD permit for the facility as constructed. Emissions from the facility are expected to comply with all applicable ambient air quality standards and PSD increments. Also at Agrifuels, a temporary odor emanating from the flare for the wastewater treatment facility was encountered during preliminary start-up operations (B. Potier, Louisiana Department of Environmental Quality, personal communication with R. L. Miller, Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 22, 1988). The odor is believed to have been caused when quantities of H_2S from the large digesters in the treatment facility exceeded the capacity of the flare because the bio-gas/natural gas boiler (which burns the bio-gas, including

H_2S) was not operating (the plant process was not in operation, thereby greatly reducing the need for steam). Although the boiler normally would be operating, a modification to increase the capacity of the flare would probably prevent the odor, even on occasions when the boiler is off-line.

3.1.2 Mitigation

The NECI EA described several measures to mitigate potential problems related to air quality. Dust control in the DDGS dryers would be achieved by expansion chambers and wet scrubbers at the dryer exhaust. The actual equipment uses modified wet Venturi rod scrubbers with a cyclone system. Organic vapors from the distillation process that could not condense would be sent to the boiler for combustion. An alternative system of vent condensers was installed because it was more economical. Low-sulfur coal (maximum sulfur content of 0.75%) is used to limit SO_2 emissions as predicted; similarly, as expected, a baghouse is employed to limit particulate emissions from the powerhouse. Soil wetting during construction reduced dust emissions, as recommended by the EPA in their review of the EA (B. T. Backley, Chief, Environmental Review Branch, Planning and Management Division, U.S. EPA Region V, Chicago, Ill., letter to W. A. Vaughan, Assistant Secretary, Environmental Protection Safety and Emergency Preparedness, U.S. DOE, Washington, D.C., July 28, 1982).

The several measures described in the Tennol EA to mitigate potential air quality impacts have been implemented. Low-sulfur coal (maximum sulfur content of 0.75%) limits SO_2 emissions; likewise, a baghouse limits particulate emissions from the powerhouse. Coal dust is controlled by both a wet suppression system to remove dust upon entry of the coal to the conveyor belt and a fabric filter system at the top of the conveyor. Dust control at the grain-handling area includes a baghouse and a shaker/aspirator system for suppression of particulates along the conveyor between the corn silo and the process area. Soil wetting was used during construction to reduce dust emissions.

The Agrifuels EA described several mitigation measures that have been implemented. Soil wetting reduced dust emissions during construction. Following construction, the roads within the facility were paved to reduce fugitive dust emissions. To reduce VOC emissions, vent condensers were installed on the distillation and fermentation units, and floating roofs are used on the ethanol storage tanks. A Venturi scrubber was installed on the bagasse/wood boiler to reduce TSP emissions. A product-recovery column was installed to reduce the potential for impacts from odor during fermentation and distillation (D. Meyer, Production Manager, Agrifuels Joint Venture Operations, personal communication to R. L. Miller, Oak Ridge National Laboratory, Oak Ridge Tenn., Sept. 19, 1988). In addition to measures identified in the EA, a caustic scrubber was installed on the bagasse/wood boiler to reduce SO_2 emissions.

3.2 WATER RESOURCES

As was the case with air quality impacts, the only quantitative information obtained on water resource impacts was wastewater characteristics at the point of release and water intake rates at the point of withdrawal.

Table 6 summarizes the changes in water-related source terms for the three facilities. Discussions of the data for each facility are provided below.

Table 6. Percent differences in actual water use and discharge vs predicted values used in preparing environmental assessments[a] (All values are percentages.)

Facility[b]	Water use	Wastewater flow	Wastewater BOD[c]	Wastewater TSS[c]
NECI	100	170	450	120
Tennol	-7	-10	d	d
Agrifuels	-20	-20	-60[e]	-50[e]

[a]Values are computed as follows: [(actual-predicted)/predicted] x 100%. Overestimates of actual data are shown as negative numbers, underestimates as positive numbers.
[b]NECI = New Energy Company of Indiana.
Tennol = Tennol Energy Company.
Agrifuels = Agrifuels Refining Corp.
[c]BOD = biochemical oxygen demand; TSS = total suspended solids.
[d]No available quantitative forecast.
[e]Reflects difference between permitted levels and forecast values. Actual levels in treated effluent during start-up exceeded forecast values by a factor of 20 for average BOD and a factor of 30 for average TSS.

3.2.1 Actual vs Predicted Impacts

New Energy Company of Indiana (NECI)

The major water resource issues considered in the EA were (1) groundwater consumption and (2) effects of wastewater discharges, runoff, and spills on surface and groundwater resources. All plant water requirements are met with groundwater. A relatively small amount of city-supplied water is used to satisfy on-site drinking water needs, while a much larger amount is obtained from the plant's well field for process water. No surface waters are on or immediately adjacent to the NECI plant site. The plant discharges wastewaters to the South Bend municipal wastewater treatment plant (MWWTP), which in turn discharges the treated effluent to the St. Joseph River. NECI discharges also noncontact cooling tower blowdown and runoff from nonprocess areas to the city stormwater retention basin (constructed by the city of South Bend under an Urban Development Action Grant). From there, water flows via the Dixon West Place Ditch to the Kankakee River.

NECI's process water is supplied from its own well field; the city supplies drinking water. The EA predicted that water withdrawn by the plant would probably not adversely affect water supplies for other users.

According to the Department of Public Works and the Indiana Department of Natural Resources (IDNR), Division of Water, no impacts of NECI withdrawals, whether from the city or from its own well field, have been observed, and none are expected because the area's groundwater resource is considered to be abundant (W. Dillon, South Bend Department of Public Works, Office of Water Supply, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 4, 1988; T. Greenawalt, Indiana Department of Natural Resources, Division of Water, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 18, 1988). Hunn and Rosenshein (1969) estimated the groundwater supply potential for St. Joseph County at 278,000 gal/min. NECI's consumption from its own well field, according to time-of-operation meters and pump curves, averaged 4514 gal/min in 1985, 3062 gal/min in 1986, and 3542 gal/min in 1987. These rates of consumption represent from 1.1% to 1.6% of the estimated potential yield for the county. In comparison, municipal withdrawals average about 15,972 gal/min (or 5.8%) of potential yield. The actual average water withdrawal by NECI in 1985 represented 220% of that (2014 gal/min) originally proposed for the plant and used as a source term in the EA. The actual withdrawal rate is 29% lower than that (2847 gal/min) calculated for a plant of this size and type from estimated water requirements reported in the generic environmental assessment (Elmore et al. 1982).

The EA predicted that the NECI plant would have no measurable adverse effects on the quality of major groundwater or surface water in the area, and information available on operations to date supports the prediction. Proposed measures for containment, treatment, and disposal of runoff, spills, and leaks were expected to be adequate to protect both surface water and groundwater from contamination. The municipal wastewater treatment system was considered by city and county officials to be adequate for treatment of all plant process, sanitary, and nonprocess wastewaters. At that time, the municipal wastewater treatment plant was believed to be underutilized, and the additional organic loading and its associated biochemical oxygen demand (BOD) that NECI would provide were considered desirable (M. Vance, South Bend Department of Public Works, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Nov. 12, 1981). NECI estimated a total wastewater discharge volume to MWWTP of 0.483 mgd, containing an average of 280 mg/L BOD and 230 mg/L suspended solids. New Energy reviewed this estimate shortly after the EA was completed in 1981, and, based upon better information, recalculated the BOD and flow estimates to arrive at a value very close to actual levels [which are about 60% of the industry average levels reported by EPA (1986)].

The actual NECI values for BOD in wastewater were greater than those available at the time the EA was written, as shown in Table 7. At approximately 1.3 mgd, the actual mean wastewater discharge to MWWTP is 2.7 times the original value developed as part of the conceptual design for the loan guarantee application. Furthermore, the actual BOD concentrations exceeded the original predicted value by an average factor of at least 5.4 (1500 - 1800 mg/L) and, on occasion during the first year or two of operation, by as much as a factor of about 11 (3000 mg/L) (J. E. Leszczynski, Director, South Bend Department of Public Works, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 15, 1988). Total BOD loading (flow and concentration) to MWWTP, therefore, has averaged 15 to 17 times the loading expected. A comparison of the original BOD values with

data published in the literature and summarized in Elmore et al. (1982) showed the original values to be reasonable (although toward the low end of the range of values).

Table 7. New Energy Company of Indiana liquid effluent forecasts versus actual operating values

Parameter	1981 value (predicted)	1985-87 value (actual)	Change factor
Avg water use	2014 gal/min	3062-4514 gal/min	1.5 - 2.2
Effluent			
Flow	0.48 mgd	1.3 mgd	2.7
BOD[b]	280 mg/L[c]	1500 -1800 mg/L	5.4 - 6.4
BOD load[d]	0.56 tpd[e]	8.3 - 9.7 tpd	15 - 17
Suspended solids	230 mg/L	500 mg/L	2.2

[a]Calculated from daily values assuming 24 h/d, 60 min/hr operation.
[b]BOD = biochemical oxygen demand.
[c]mg/L = milligrams per liter.
[d]Calculated from effluent flow and BOD concentration.
[e]tpd = tons per day.

The BOD concentration and volume of discharge from the ethanol facility, coupled with the state of repair of MWWTP at the time NECI began operation, initially adversely affected operation of MWWTP and thereby contributed to exceedances of MWWTP's NPDES permit limits for BOD. These upsets and exceedances appear to occur less frequently since corrective measures have been taken by both MWWTP and NECI. In 1986, at a cost of more than $500,000 to the city, MWWTP replaced a fine-bubble diffuser in the secondary aeration tanks and installed a second 60-ft-diam gravity sludge thickener to handle the increased BOD loadings (K. Kopec, Manager, South Bend Municipal Wastewater Treatment Plant, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 4 and Apr. 15, 1988). Some of the funds spent on this upgrading are recovered through a surcharge on BOD concentrations in excess of specified levels. A second compliance survey, after upgrading was complete, found no exceedances of discharge permit limits (S. Boswell, Indiana Department of Environmental Management, Division of Water, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 13, 1988). The MWWTP manager has also indicated that the upgraded treatment plant generally can now handle its organic load, although occasional upsets still occur. For its part, NECI has implemented further water conservation and wastewater spill control measures and has developed procedures for notifying MWWTP when changes in wastewater volume or BOD loading are expected (e.g., from maintenance shutdowns, process start-up). Nevertheless, the Indiana Department of Environmental Management (IDEM) believes that the wastewater retention time at the ethanol plant is

too brief (S. Boswell, Indiana Department of Environmental Management, Division of Water, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 13, 1988) to be sufficiently effective. The forecast of a beneficial impact of NECI on operation of MWWTP was thus not as expected. Because of subsequent changes in the BOD source term and the state of repair of the MWWTP, initial impacts were adverse and required modifications on the part of both parties to achieve an acceptable operations interface.

All discharges to the city's stormwater retention pond (noncontact cooling water, stormwater runoff, and subsurface drainage) are subject to the limits and sampling requirements specified in an NPDES permit. Discharge from the stormwater retention basin must meet also the requirements of a separate NPDES permit. Thus far, neither the IDEM's Division of Water nor the IDNR's Division of Fish and Wildlife have had any indication of unacceptable impacts on water quality or aquatic life of the Kankakee River as a result of discharges from the ethanol plant by way of the stormwater retention pond.

No groundwater contamination has been observed in samples from five wells and two subsurface drainage locations at the NECI site (K. W. Anderson, New Energy Company of Indiana, Inc., personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., March 3, 1988; P. Trost, St. Joseph County Health Department, Pollution Control Office, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 4, 1988; J. E. Leszczynski, Director, South Bend Department of Public Works, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 15, 1988; and W. Dillon, South Bend Department of Public Works, Office of Water Supply, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 4, 1988). The Groundwater Section of the Office of Environmental Response, IDEM, which normally becomes involved in the event of a spill or discharge to groundwater, has received no reports of groundwater contamination involving the ethanol plant (J. Nowacki, Indiana Department of Environmental Management, Office of Environmental Response, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 14, 1988). Isolated spill incidents at the facility have been properly and promptly contained and cleaned up before they could enter the groundwater, according to the County Health Department (P. Trost, St. Joseph County Health Department, Pollution Control Office, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 4, 1988).

Tennol

The Tennol EA's principal water-related concerns centered on (1) groundwater consumption, (2) development of wells in the floodplain, and (3) water quality during both construction and operation. The EA predicted that impacts related to these three areas of concern would not be significant.

The EA predicted no important impacts on water use in the region. Operation of the plant at full production capacity would require groundwater withdrawals calculated at 280 gal/min. This volume is slightly less than the 300 gal/min predicted by the EA. Withdrawal rates at the highest plant production level actually achieved to date have been estimated to be about

50% of these estimates, which are based primarily on design--not actual monitoring data. Consumption of potable city water at a rate of 3.7 gal/min, on the other hand, is almost twice the two gal/min predicted in the EA. Nevertheless, the city has been able to satisfy this demand without adverse effect on other users. The city is withdrawing an average of about 490 gal/min and is rated for a maximum withdrawal of 1100 gal/min from its spring and the Sequatchie River. Tennol's consumption therefore represents only 0.8% of average city withdrawal and only 0.3% of maximum rated withdrawal. There have been no reports of adverse water quality effects from construction of wells in the floodplain, and none are likely.

According to the EA, the Tennol plant would generate about 300,000 gpd of process wastewater (including cooling tower blowdown) and 3000 gpd of sanitary wastewater. Predictions of water quality were limited to the statement that, after pretreatment by Tennol and final treatment by the Jasper Sewage Treatment Plant (JSTP), effects of the final effluent on surface and groundwater quality would be negligible. To date, Tennol has produced up to 271,000 gpd of process wastewater, the limit established by the city of Jasper. Sanitary wastewater is limited by permit to 5000 gpd. Recent discharges of process wastewater (June 1988) have averaged 79,000 gpd. Tennol management has applied for an increase in the permitted rate of discharge to 310,000 gpd during dry weather and 367,000 gpd during wet weather.

Initial Tennol operations have resulted in several instances of moderate effects on water quality. All of these effects have been associated with episodic events such as plant start-up or temporary operational problems, and effects on water quality have been relatively short-lived and without any reported (or expected) impacts on water quality.

Agrifuels

With respect to water resources, the Agrifuels EA was concerned primarily with the effects on water use, surface water quality, and aquatic ecosystems. Specific concerns for the latter included the effects of additional suspended solids and BOD loading on aquatic life in the Bayou Teche, particularly during periods of low or no river flow. The EA concluded that, although some local degradation of water quality in the Bayou Teche could be expected, planned runoff and wastewater management would prevent substantial impacts on water resources and aquatic life.

The Agrifuels plant supplies its own water from three wells tapping an aquifer approximately 295 feet below grade. Estimated water consumption by the Agrifuels plant, at 1511 gal/min, is less than the EA's projected rate of withdrawal of 1915 gal/min. No adverse effects on availability of groundwater have been reported for this water-rich area (J. Gregg, Louisiana Department of Environmental Quality, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge Tenn., Sept. 19, 1988), where rainfall exceeds evapotranspiration, and recharge of the aquifer from the river would likely occur should withdrawals exceed recharge by other pathways.

Because plant operation has thus far been limited to start-up and maintenance modes, little can be said about wastewater effluents at design

operating conditions. During start-up, or stand-by conditions, or both, however, plant effluents have often exceeded by a considerable amount the state and NPDES permit limits for BOD, total suspended solids (TSS), ammonia as nitrogen, and total Kjeldahl nitrogen concentrations. Table 8 compares concentrations of pollutants in plant effluents during start-up with the permit limits imposed by the state of Louisiana and EPA. Highest BOD levels, for example, occurred during start-up in April of 1987 when BOD in discharge from Outfall 101 (treated process wastewaters and contaminated stormwater runoff) averaged 507 mg/L [51 times the permitted average (10 mg/L)] and peaked at 1290 mg/L [86 times the maximum permitted concentration (15 mg/L)]. During this same period, TSS concentrations averaged 919 mg/L (61 times the permitted average of only 15 mg/L) and peaked at 2051 mg/L (89 times the permitted maximum level of 23 mg/L). Occasional excursions from permit limits for dissolved oxygen and for oil and grease have also occurred. Plant officials have attributed these excursions from permit limitations to inadequately established biological treatment processes used in the wastewater treatment facility during start-up (Hamilton 1987). Given the extent to which plant effluents have exceeded permitted BOD, TSS, ammonia, and total Kjeldahl nitrogen concentrations during start-up, however, it is not clear that the plant as currently designed will be able to satisfy state and EPA effluent limitations for these pollutants under normal operating conditions at full capacity.

Unanticipated Impacts

Unexpected water quality impacts occurred at Tennol and Agrifuels. Tennol impacts are primarily concerned with episodic events such as accidental releases of BOD-containing substances to surface waters. Measured impacts from these events emphasized aquatic ecology and thus are discussed in more detail in Section 3.3.

The Agrifuels EA assumed that no significant water quality impacts would result if the plant complied with permit conditions. However, potential problems were identified by nearby residents during start-up that could possibly persist under normal operating conditions in accordance with permit conditions. These problems concern the odor and dark color of the final (treated) effluent. Even if the effluent were to meet the permit conditions, the color is likely to persist (partly because of the dark color of the molasses feedstock). If the state classifies the odor, or color, or both as public nuisances under its water pollution control regulations, then the plant may have to initiate retrofitting of additional equipment (e.g., activated carbon filtration) or other measures (e.g., rerouting the effluent line to the Bayou Teche in the vicinity of the barge terminal rather than through the approximately 4 mi through agricultural and residential areas) to eliminate the problems.

3.2.2 Mitigation

Most of the water resource mitigation measures proposed for the projects dealt with erosion control, effluent treatment, and spill containment, and in general, they were implemented (most were also required by law, regulation, or permit condition). One important measure described in the Agrifuels EA as part of the plant design for mitigating the effects of spills and leaks was

Table 8. Agrifuels National Pollutant Discharge Elimination System effluent permit limits vs measured concentrations of selected pollutants during start-up[a], April 1987 [Units are mg/L except for flow (mgd).]

Parameter[b]	Minimum	Average	Maximum
Flow			
Measured	NA[c]	0.17	0.22
Predicted	NA	1.6	—
BOD			
Measured	NA	507	1290
Limit	NA	10	15
TSS			
Measured	NA	919	2051
Limit	NA	15	23
Ammonia (as N)			
Measured	NA	39.1	145
Limit	NA	5	7.5
TK nitrogen			
Measured	NA	109	327
Limit	NA	8	12
Oil and grease			
Measured	NA	3.2	12
Limit	NA	5	10
Dissolved O_2			
Measured	1.3	3.3	5.5
Lower limit	5	NA	NA

[a]All measurements except dissolved oxygen (Outfall 001) taken at Outfall 101 [treated process wastewaters and contaminated stormwater runoff (Hamilton, P., Agrifuels Refining Corporation. July 9, 1987. Quarterly Discharge Monitoring Report.)]. mg/L = milligrams per liter; mgd = millions of gallons per day.

[b]BOD = biochemical oxygen demand.
TSS = total suspended solids.
N = nitrogen.
TK nitrogen = total Kjeldal nitrogen.
O_2 = oxygen.

[c]NA = not available

never implemented, that is, the approximately 7-ft-high dike that was to surround the entire plant. Instead, a ditch that conducts runoff (and any spills outside secondary containment structures) from the plant to the Bayou Teche now surrounds the plant. The containment provided by the ditch is not as complete as that provided by the dike system as originally planned. Also, spill containment was not installed at the barge terminal.

3.3. ECOLOGY

3.3.1 Actual vs Predicted Impacts

New Energy Company of Indiana

The EA predicted that NECI would have no significant adverse effects on aquatic ecosystems of the area. Discussions with local and state (Indiana and Michigan) officials generally confirm the assessment, despite the initial problems experienced by MWWTP with the ethanol plant's BOD loading and total wastewater flow (J. E. Leszczynski, Director, South Bend Department of Public Works, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 15, 1988; K. Kopec, Manager, South Bend Municipal Wastewater Treatment Plant, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 4 and Apr. 15, 1988; T. Lauer, Indiana Department of Natural Resources, Division of Fish and Wildlife, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 12, 1988; J. Bantjes, Michigan Department of Natural Resources, Division of Surface Water Quality, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 13, 1988; J. Duffy, Michigan Department of Natural Resources, Fisheries Division, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 12, 1988; G. Seketa, Kankakee River Basin Commission, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 15, 1988). No fish kills in the St. Joseph River in the vicinity of South Bend have been reported in the past 10 years (J. E. Leszczynski, Director, South Bend Department of Public Works, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 15, 1988). The St. Joseph River is and has long been regarded an excellent smallmouth bass stream (J. Duffy, Michigan Department of Natural Resources, Fisheries Division, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 12, 1988; T. Lauer, Indiana Department of Natural Resources, Division of Fish and Wildlife, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 12, 1988). Officially classified as a warmwater stream in the past, the river was reclassified in 1984 as a trout migration stream as far upstream as Mishawaka, several stream miles upstream of MWWTP's outfall (T. Lauer, Indiana Department of Natural Resources, Division of Fish and Wildlife, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 12, 1988). Both Michigan and Indiana now stock and manage the river for trout and salmon (J. Duffy, Michigan Department of Natural Resources, Fisheries Division, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 12, 1988; T. Lauer, Indiana Department of Natural Resources, Division of Fish and Wildlife, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 12, 1988). Because

salmonids generally require better water quality than warmwater fish, the river may actually have improved in water quality during the last few years.

The EA predicted that there would be no significant impacts to terrestrial ecology, including endangered species, chiefly because of the already-disturbed agricultural/industrial nature of the site. This prediction has indeed proved true. In fact, some unplanned enhancement to terrestrial ecological resources has occurred as a consequence of (1) construction of the storm water retention basin at the west end of the site and (2) disposal of excavation materials to the south of the site. Area 1 has become a resting place for waterfowl, while area 2 has become a grassy hill providing habitat for small mammals.

Tennol

The EA predicted that the Tennol plant would have no significant effects on aquatic ecosystems in the area, particularly because no permanent aquatic habitat existed on the industrial part of the site and because the proposal to build a barge terminal on the Tennessee River was dropped. In most respects, that assessment has proven to be correct, but no monitoring or sampling studies that would supply supporting data have been conducted. Certainly nothing significant enough to garner official or public attention has occurred.

The EA predicted that there would be no significant impacts to terrestrial ecology, including endangered species, chiefly because of the already-disturbed nature of the upper part of the site. Portions of the upper site were cleared and graded before the project was undertaken, and the remainder was in an old-field successional state. The prediction of the EA has proved true for the upper (developed) portion of the site: about 27 acres of previously disturbed terrestrial habitat is now occupied by the facility, with minimal impacts to terrestrial biota.

Agrifuels

According to the Agrifuels EA, impacts of plant construction and operation on aquatic biota of the Bayou Teche would be minimal even though plant effluents may occasionally cause decreased oxygen concentrations. At the time of the EA (ca. 1982), the Bayou Teche often experienced episodes of low flow and low dissolved oxygen; it was therefore believed that organisms unable to cope with such conditions would be unlikely to inhabit the bayou in its natural state. Further, motile organisms would be able to avoid any localized conditions of oxygen depletion. Since then, the Teche-Vermilion Water Diversion Project was constructed and now diverts water from the Atchafalaya River to the Teche Bayou, thereby presumably improving water quality, including the maintenance of higher dissolved oxygen levels in the bayou. Furthermore, informal reports by sport and commercial fishermen have suggested that the diversity and numbers of desirable fish in the Bayou Teche have improved since the diversion (G. Tilyou, Louisiana Department of Wildlife and Fisheries, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 19, 1988). A better fishery would be expected to follow diversion of Atchafalaya River water to the Bayou Teche. If in fact a more desirable fishery less tolerant of low oxygen conditions has developed, then the consequences of continual discharge of the

effluent may be greater than predicted by the EA for the more degraded bayou conditions of the past. In any case, no adverse effects of the limited operations to date have been reported to the Louisiana Department of Wildlife and Fisheries, Division of Fish (G. Tilyou, Louisiana Department of Wildlife and Fisheries, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 19, 1988; W. Tucker, Louisiana Department of Environmental Quality, Lafayette Office, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 19, 1988).

The EA predicted that there would be no significant impacts to terrestrial ecology, including endangered species. For the facility features that were evaluated and constructed, actual impacts support the forecast. Some unexpected impacts did occur (see next section) because of project changes.

Unanticipated Impacts

Principal unexpected ecological impacts are concerned with the Tennol and Agrifuels facilities. On October 1 and 2, 1986, land application of waste stillage from Tennol at a farm in Monroe County resulted in a fish kill when the application apparatus was left unattended, and excess stillage entered Fork Creek. The site of the incident is nearly 90 miles from Tennol and allegedly was the fault of the waste disposal operator contracted by Tennol to transport and dispose of the waste in a safe manner. That contractor no longer serves Tennol. According to the Tennessee Division of Water Pollution Control, the incident killed almost 12,000 fish valued at about $5000 (using standard cost-determining procedures) over a reach of 11 stream miles (J. West, Tenn. Department of Health and Environment, Division of Water Pollution Control, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 1, 1988). Among the dead were sunfish, black bass, white suckers, minnows, carp, catfish, sculpin, darters, freshwater drum, and shad.

Construction of a barge terminal on the Tennessee River apparently was included in early plans for Tennol but was dropped before the EA was written. Later, however, the barge terminal was built by another party to deliver corn to the Tennol plant. As a result, one of the potentially more important but indirect impacts of the Tennol project, the potential disturbance of benthic habitat and resident aquatic life in the vicinity of the barge terminal, did not receive formal NEPA review. In earlier informal consultations reproduced in the EA, the U.S. Fish and Wildlife Service had raised the possibility of impacts on five endangered species of mussels that may reside in the area but then dismissed this concern as an issue because plans for a barge terminal had been dropped. Since then, the range of the federally listed (threatened) snail darter has been found to be considerably greater than formerly believed and may also occur in the vicinity of the barge terminal (J. Jenkinson, Tennessee Valley Authority, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 1, 1988). The Tennessee Valley Authority (TVA 1985; S. A. Ahlstedt, Tennessee Valley Authority, personal communication to G. K. Eddlemon, Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 2, 1988) conducted a brief assessment of barge terminal impacts on mussels in the area. A brief survey by divers was included in the assessment; no endangered species of mussels were found. Their report made no mention of fish species, including the threatened snail darter, in the

area. TVA concluded that dredging for the proposed terminal would "destroy a large number of mussel specimens" but would "not have any effect on any endangered mussel species."

In terms of terrestrial ecology, unexpected impacts at Tennol resulted from construction of a transmission line and the barge terminal. Construction of a transmission spur to connect the main TVA electrical power line to serve the plant required clearing and maintaining a right-of-way. Other electrical transmission line issues that may arise include displacement of other land uses, physical and electrical interference with agricultural operations, human health effects, and bird collisions. These impacts are usually considered to be minor or can be mitigated. The construction of the power line and the analyses of attendant potential environmental impacts were conducted by TVA. The Tennol barge terminal (including associated roadway improvements) constructed along the river bank on the lower part of the site has entailed minor unexpected impacts to riverine (possibly wetland) vegetation along the bank and existing roadway, and in a floodplain. Because this terminal was not part of the project as evaluated, neither the EA nor the floodplain assessment addressed attendant potential terrestrial ecology impacts.

At Agrifuels, the principal unexpected ecology impacts were terrestrial in nature, and resulted from construction of a barge terminal (including associated roadway and pipelines) along the bayou across the highway from the site. Construction involved clearing and graveling of about 1.5 acres of terrestrial habitat (including pipeline and access road), some (<0.5 acre) of which was riparian woodland along the banks of the bayou. Riparian habitat is generally of limited occurrence and supports a greater diversity of plants and animals than does surrounding agricultural land. Although this impact was unexpected, the area involved is small and thus represents a minor impact to terrestrial biota.

3.3.2 Mitigation

The principal terrestrial ecology mitigation measure discussed in the three EAs was the maintenance of a line of large black willow trees along the southern boundary of the NECI site. This recommendation was based on a site visit by and letter consultation with the U.S. Fish and Wildlife Service, which recommended that the trees be left intact to provide habitat for birds and other wildlife. The trees were removed, probably during construction of a fence and improvement of the road, site security, and visibility along the boundary. Loss of the habitat is not a significant adverse effect, but it does represent an unanticipated impact resulting from not implementing planned mitigation. Aquatic ecology mitigation measures are closely tied to those discussed previously for water quality (e.g., spill containment, meeting pollutant discharge limits specified in permits) and are not addressed further in this section.

3.4 SOCIOECONOMICS

Socioeconomic impacts were generally predicted to be beneficial for the three plants through payment of wages and salaries and the purchase of materials, goods, and services. Potential adverse effects from increased

demand on public services through influx of workers were expected to be minimized by supplying the bulk of the work force with workers living within commuting distance. Table 9 summarizes forecast and actual values for socioeconomic parameters for the three facilities.

Table 9. Percent differences in actual socioeconomic parameters vs forecasts used in preparing environmental assessments[a] (All values are precentages.)

Facility[b]	Estimated cost	Construction workers	Operations personnel	Construction wages and salaries
NECI	24	-3 to 44	-51 to -22	c
Tennol	d	336	2 to 23	d
Agrifuels	36	50	49	100

[a]Values are computed as follows: [(actual-predicted)/predicted] x 100%. Overestimates of actual data are shown as negative numbers, underestimates as positive numbers.
[b]NECI = New Energy Company of Indiana.
Tennol = Tennol Energy Company.
Agrifuels = Agrifuels Refining Corp.
[c]Actual data not available.
[d]Forecast not available.

3.4.1 Actual vs Predicted Impacts

New Energy Company of Indiana

Principal socioeconomic impacts of interest are the demand on public services from an influx of workers, expenditures, and traffic levels from plant construction and operation. Construction of the NECI facility required about 900 workers (maximum), and 150 permanent jobs at NECI were created. Of the permanent jobs, 60% were filled with residents of the South Bend/Mishawaka area (SBCOC 1985). An estimated additional 128 permanent jobs have been created in industries related to the NECI plant (E. Leonard, City of South Bend, Economic Development, personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., May 5, 1988). The EA predicted that a total of 625-930 (temporary) workers would be required for the peak construction work force and that a total of 360-570 permanent jobs (NECI and other industries) would be created as a result of the NECI plant. The range of workers estimated for plant construction was reflected by the actual value, but the forecast range of permanent jobs created was an overestimate of at least 30%, according to available data on jobs created. Actual impacts of the workers (construction and operation) on housing and public services should be only slightly greater (because of larger work forces) than the levels predicted in the EA, which were expected to be minor even under the assumed extreme case that 850 workers move to the site (estimated population increase of 2% in the EA). No significant impacts

on public services surfaced during construction, nor are they apparent now (E. Leonard, City of South Bend, Economic Development, personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., May 5, 1988).

The NECI plant has had a beneficial impact on the economy of South Bend and vicinity during construction through the payment of salaries and the purchase of materials, equipment, and services and during operation through the purchase of corn and local goods and services. Limited data are available to verify the EA forecasts of socioeconomic impacts from construction. The total cost of the facility (as built) was $186 million, about 24% higher than the predicted $150 million cost. Actual beneficial economic impacts during construction were likely to have been greater than predicted.

The annualized economic impact of NECI plant operation in the South Bend area* is estimated at $27 million, which includes $7.5 million for rail and truck transportation businesses; $5.5 million for utilities; $4.7 million for raw materials, plant supplies, and equipment lease businesses; and $400,000 for professional service firms (SBCOC 1985). The 150 permanent jobs result in payment of about $5.5 million in direct wages. The EA predicted an economic impact in the South Bend area of about $27 million annually, with about $16.3 million from income generation, which produces about $10.5 million in annual retail trade and about $350,000 in state sales tax benefits. Although actual and predicted impacts agree when available data are used, the estimates may be based on different assumptions and thus may not reflect the same factors contributing to the impact.

The EA predicted a significant but temporary adverse impact on Calvert Street traffic during plant construction. According to conversations with the Traffic Engineering Department of the city of South Bend (G. Ladewski, City of South Bend, Traffic Engineering Dept., personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 28, 1988) and with plant personnel (M. Craig, New Energy Company of Ind., personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Mar. 3, 1988), these temporary traffic problems did arise during the morning and afternoon commute times at peak construction. No significant impacts have been observed by the city of South Bend since the plant went into operation in October 1984 (G. Ladewski, City of South Bend, Traffic Engineering Dept., personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 28, 1988), mainly because the mitigation discussed in the EA was implemented.

Tennol

Socioeconomic impacts forecast in the Tennol EA are the creation of jobs (with minimal demands on public services), an increased demand for local goods and services, an increased tax base for the county, and minor effects on county transportation systems.

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*Outside the South Bend area, corn purchases (about 22 million bu/year) from Indiana farmers and grain elevators add about $48 million annually to the total expenditures, which in turn generates additional activity at farm supply businesses.

Actual impacts verify the forecast that additional jobs would be created by Tennol. Construction required about 872 workers at peak (during October 1985), and the plant was completed about 18 months after construction began in August 1984. Approximately 97% of the construction work force came from within commuting distance of the Tennol facility (Walker 1988). When the Tennol facility is operating at peak capacity, about 123 permanent workers are required. Approximately 95% of the Tennol operations work force came from within commuting distance of the plant, so only about six of the permanent employees moved to the area because of the facility. The EA predicted that a peak work force of about 200 would be employed during an 18-month construction period and that about 100-120 new permanent positions would be created at the plant during operation. A majority of the construction and operations work force was predicted to be supplied by workers living within commuting distance of the plant, and thus, few new families would be moving to the area. The actual peak construction work force was about a factor of four times greater than predicted, but because of the high percentage of local workers, adverse impacts on public services were minimal (C. Woodsin, Marion County Chamber of Commerce, personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 26, 1988). The operations work force estimated in the EA was accurate. Again, because of the high percentage of local workers, impacts on public services have been minimal (C. Woodsin, Marion County Chamber of Commerce, personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 26, 1988).

The Tennol facility has also increased the local demand for goods and services, as forecast in the EA. The payment of salaries and purchase of equipment, materials, and services during construction provided an economic influx to the Jasper area of about $150 million, of which at least 15-20% was spent in the Jasper area. During operation, an estimated $40 million is spent annually for salaries and wages, capital equipment and materials, and services. Of the total, all but about $20 million (or about 50%) is for corn purchases, the only nonlocal component (most of the corn comes from Indiana, Iowa, and Illinois).

As predicted in the EA, Tennol also benefits the local area through tax payments; current annual tax payments are estimated to be about $285,000 (about 95% to the county and the remainder to Jasper), and tax payments are anticipated to increase to about $550,000 annually. The Tennol facility more than doubled the tax base for Marion county (Walker 1988). Tennol also pays a monthly fee of about $5000 to the city of Jasper for wastewater treatment.

The EA's forecast of minor impacts to transportation systems was also accurate. Transportation activity levels forecast in the EA were 18-20 railcars/d and 15-20 truck trips/d for transportation of all raw materials, plant products, by-products, and fuel coal. Operation of the Tennol plant at full capacity was estimated to require about 30 truck trips per day and 12 railcar loads per day for transportation of all raw materials, plant products, by-products, and fuel coal. The estimates of actual transportation loadings are thus about 33% lower than those predicted for railcars and about 50% higher than predicted for trucks. One reason for the decrease in rail transportation may be the use of barges for corn delivery, which reduces the number of railcars originally anticipated. The increase in truck traffic

over predicted levels may be due to the use of trucks for DDGS shipment, as opposed to railcars as originally planned. Completion of the interchange to Interstate 24 (which was under construction at the time of the EA) has greatly reduced the potential for impacts from truck traffic. The truck route to the plant does not pass near or through any residential areas, nor does it encounter any areas of traffic congestion.

Agrifuels

Principal socioeconomic forecasts in the Agrifuels EA are economic effects from expenditures for plant construction ($12 million in wages; $66 million in capital equipment, materials, and services), a small influx of new workers during construction and operation (and associated minimal demands on housing supply and public services), impacts on traffic loads (were not quantified but were predicted to be high enough to warrant considering implementation of a traffic management plan), stimulation of new economic activity (manufacturing and agriculture) within a 20-mile radius of the plant, and tax payments of about $4000/year (with no new revenue-generating mechanisms needed by the parish for additional public services required by the facility).

Construction of the Agrifuels plant required about 750 workers at peak (a period of about two months). The 17-month construction phase of the project began about December 1985. About 20% of the construction work force had permanent residence outside Louisiana, and the remainder came from within the state. Operation of the Agrifuels facility at full capacity would require about 125 workers. During plant start-up, which required approximately the full operations work force, about 120 people were permanent residents of the state, and the remaining five relocated to the area. The EA predicted that about 500 workers would be required for peak construction, that 25% would move to the area for work, and that construction would require about 21 months. The EA also predicted an operations work force of 84, 30% of which would move to the area. The size of the actual peak construction work force was thus about 50% greater than predicted, but the actual construction period was about 25% shorter than predicted. The actual operations work force (during start-up) was about 50% greater than expected. For the construction work force, the predicted percentage of in-state workers was accurate; for operation, the EA overestimated the percentage of out-of-state workers by a factor of five. An unexpected issue that may have resulted in greater-than-expected use of in-state workers is the high unemployment levels experienced in Iberia Parish due in part to the downturn in the oil industry; unemployment rates for Iberia Parish during the construction period were 13.9% in 1985, 20.2% in 1986, and 19.8% in 1987 (P. Lopez, Louisiana Department of Labor, Research and Statistics, personal communication to L. W. Rickert, Oak Ridge National Laboratory, Oak Ridge, Tenn., Oct. 4, 1988).

The Agrifuels facility has had a beneficial effect on the economy of the New Iberia area during construction. The payment of salaries and the purchase of equipment, materials, and services during construction provided an economic influx to the New Iberia area of about $80 million, of which about $24 million was for wages and salaries and $56 million for capital equipment, materials, and services. Locations for the sources of materials, services, and capital equipment are not readily available; at least some of the capital equipment (boilers and distillation towers) was imported, and

thus did not represent an economic influx to the New Iberia area. The EA predicted a total facility cost of $78 million, with construction wages of about $12 million and about $66 million in capital equipment, materials, and services. Actual expenditures were thus estimated to be about 100% higher than predicted for wages and about 33% less for capital equipment, materials, and services.

Agrifuels also has the potential to benefit the local economy during operation, which supports forecasts made in the EA. The materials and services to be purchased during operation were expected to come primarily from Louisiana, except for some molasses to be purchased outside the United States. The plant's demand for blackstrap molasses would represent about 250% of the total state production (M. Tillman, State of Louisiana, Department of Agriculture, personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 21, 1988); consequently, if the plant were to purchase the entire state crop, it could result in a rapid price increase with corresponding benefits to producers and sellers and adverse effects on other consumers of blackstrap molasses (M. Tillman, State of Louisiana, Department of Agriculture, personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 21, 1988). Of the $54 million estimated annual operating costs, about $3 million would be spent on payroll, $2 million for miscellaneous repairs and maintenance, $44 million for raw materials, and about $5 million for utilities, taxes, and insurance.

Current property tax payments are based on the value of only the land (10% of market value) and total about $3900 per year (E. Barras, Iberia Parish Tax Assessor, personal communication, D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 21, 1988). The Agrifuels facility applied for a 10-year phased exemption of property taxes (a program implemented by the parish to help attract new business development). If this exemption were not granted or (at the end of the 10-year period) the property taxes would be increased to 15% of the market value of the land and buildings, taxes would be much higher than current tax levels (E. Barras, Iberia Parish Tax Assessor, personal communication, D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 21, 1988). The EA predicted annual tax payments of $6000, about 50% higher than actual current levels and substantially less than anticipated full tax payments.

The EA identified potential adverse impacts to traffic loadings on the two-lane road leading to the site (Parish Road 344) and on the connecting State Highway 86. Operation of the Agrifuels facility would generate about 50 truck trips/day for shipment of alcohol product (16 trucks/day), and receipt of boiler fuel (wood chips, 7 trucks/day), gasoline (1 truck/day), and blackstrap molasses (26 trucks/day if all from Louisiana). During the 3-month cane-grinding season in the fall, about 150 trucks/day serve the Cajun Sugar Cooperative, which would mean that the total traffic load would exceed 8 trucks/h with 24 h/day operations. Additional traffic on Parish Road 344 includes employee commuters for both Agrifuels (125 employees) and the Cajun Sugar Cooperative. Actual traffic levels during construction, which also occurred in part during the grinding season, created no significant problems (E. Jordan, Assistant Director of Public Works, Iberia Parish, Louisiana, personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 21, 1988). Consequently, traffic levels

from the much smaller operations work force and associated trucking activities should present no problems (E. Jordan, Assistant Director of Public Works, Iberia Parish, Louisiana, personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 21, 1988).

3.4.2 Mitigation

The principal socioeconomic impact for which mitigation was proposed in the EAs was traffic and transportation, principally at NECI and Agrifuels. Principal socioeconomic mitigation measures proposed in the NECI EA dealt with widening of Calvert Street, construction of an access road to the NECI plant from Highway 23, and installation of traffic signals. Calvert Street has been widened, and the new access road for truck traffic was constructed before the plant became operational. The city of South Bend elected not to install traffic signals at Calvert and Olive Streets, because of the lack of significant traffic problems during plant operation (G. Ladewski, City of South Bend, Traffic Engineering Dept., personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Apr. 28, 1988).

At Agrifuels, a traffic management plan was to have been implemented if traffic congestion resulted from employee commutes, truck shipments, and traffic associated with the Cajun Sugar Cooperative adjacent to the Agrifuels site. Conversations with the Public Works Department of Iberia Parish suggested that implementation of the plan was not required during construction of the Agrifuels facility and is not likely to be needed during full operation (E. Jordan, Assistant Director of Public Works, Iberia Parish, Louisiana, personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., Sept. 21, 1988).

3.5 LAND USE

For this study, land use impacts consist of the change in land use at the plant site, land use associated with solid waste disposal, and potential conflicts with archeological or historical resources (i.e., prior land use).

3.5.1 Plant Site

At each of the plant sites, project development resulted in the conversion of agricultural land to industrial use: 50 acres at NECI, 27 acres at Tennol, and 28 acres at Agrifuels, all of which are in agreement with forecasts of land use changes made in the EAs. At Tennol, the site at the time of the EA was industrially zoned disturbed land that nonetheless was classified as prime farmland by the Soil Conservation Service because of the types of soil. The Agrifuels site is also located on designated prime farmland. In some cases, conversion of parcels of prime farmland of these sizes could be considered a significant land use impact to be avoided if possible. Since the EAs were prepared, the Soil Conservation Service has issued a rule [49 FR 27724] for complying with the Farmland Protection Policy Act of 1981 (FPPA) as amended by the Food Security Act of 1985, particularly with reference to prime and unique farmlands (Steiner, Dunford, and Dosdall 1987). The rule considers not only the amount of prime farmland to be converted to another use but also such factors as the degree of agricultural

use and development in surrounding areas. Had the rule been implemented at the time of the EAs, the conclusions of no significant effects would have been substantiated because prime farmland that a state or local government has designated (e.g., through zoning) for commercial, industrial, or residential use is excluded from the provisions of the FPPA. Environmental assessments of future fuel ethanol plants sited on prime farmland may encounter additional review requirements to comply with the new regulations.

Unexpected changes in land use occurred at the three projects. At NECI and Tennol, other industries constructed CO_2-recovery plants adjacent to the ethanol plants. At the time the EAs for these projects were prepared, no one had expressed firm interest in CO_2; consequently, the scope of the EAs did not include impacts from constructing and operating a CO_2 recovery plant. Inspection of the two facilities at NECI and Tennol indicates that impacts from construction and operation of a "typical" CO_2 recovery plant should not be significant when considered by themselves or when combined with impacts from a fuel ethanol plant. Table 10 gives details of the two CO_2-recovery facilities. Principal construction effects were temporary dust, noise, vehicle emissions, and traffic, and principal operational effects were vehicle emissions and traffic. At Agrifuels, an unexpected impact is the planned use of a 22-acre parcel adjacent to the plant site for land farming of sludge from the facility's wastewater treatment plant. The practice was approved by the Louisiana Department of Environmental Quality and should result in only minor (if any) other environmental effects (e.g., water quality, biota).

3.5.2 Solid Waste Disposal

Production and disposal of solid waste was not explicitly discussed in the EAs for the three projects. Elmore et al. (1982) discussed solid waste but did not consider it a potentially significant impact. Similarly, the programmatic EA (DOE 1981) discussed stillage as a solid waste. At the NECI and Tennol plants, as at most ethanol plants, however, stillage is sold as a by-product material (because of the nature of its process, Agrifuels produces no marketable stillage).

Solid waste is produced at the NECI plant and consists primarily of ash from the boiler (about 30 tons/d). The ash is analyzed yearly for NECI by a contracting laboratory to determine levels of possible hazardous substances. As a result of the analyses, the ash is classified as a nonhazardous solid waste that can be disposed of at any state-approved sanitary landfill (G. Oliver, State Board of Health, letter to K. Anderson, New Energy Company of Indiana, September 19, 1985). In addition to the ash about one 20-yd^3 container of poor-quality DDG and small quantities of miscellaneous trash, tank material, and other waste material are accumulated each week. The company is exploring ways of using land application of waste DDG in place of landfill disposal. Currently, however, all solid waste is sent to the county landfill. Minor quantities of sludge from cleanup operations are also produced and disposed of at the county landfill.

The Tennol plant (during full operation) would produce about 900 tons/month of solid waste, of which <1% would be wet dewatered grain, about 10% would be dried sewage treatment plant sludge, about 70% would be coal

Table 10. Profile of carbon dioxide (CO_2) recovery plants constructed adjacent to fuel ethanol plants[a]

Facility	CO_2 product	Principal characteristics
AIRCO (adjacent to NECI)	Liquid	Pipeline connection to NECI Office building Process building (pumps, compressors, and other equipment) Cooling tower Truck garage Water treatment system Six 500-ton CO_2 storage tanks Steam purchased from NECI Truck shipment of CO_2 (20 trucks/d) Eight on-site employees Construction required about 60-80 workers and about 10 months
Cardox (adjacent to Tennol)	Liquid and solid	Pipeline connection to Tennol Office building Process building (compressors, heat exchangers, evaporators) Garage Four 400-ton CO_2 storage tanks All equipment electrically powered Truck shipment of liquid and solid CO_2 (6-8 trucks/d) Four on-site employees Construction required about 30-50 workers over about 11 months

[a]NECI = New Energy Company of Indiana.
Tennol = Tennol Energy Company.

Source: D. Lanugager, AIRCO Industries, South Bend, Ind., personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., May 3, 1988.

T. Kuruck, Cardox, Inc., Jasper, Tenn., personal communication to D. B. Hunsaker, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn., September 2, 1988.

bottom ash from the boiler, and the remainder would be fly ash collected from the baghouse. These wastes would be disposed of at the Marion County landfill. During the initial operating period at the plant, thin stillage (which could not be used by the process to produce a marketable by-product) was disposed of by land application under permit from the Alabama Department of Environmental Management. The company is exploring ways of marketing solid wastes locally for land application by farmers.

At the Agrifuels plant, the types and amounts of solid waste produced during start-up operation include bagasse bottom ash (10 tons/d) and sludge from the waste treatment plant (17 tons/d). Full operation would entail additional quantities of such wastes. The bottom ash was to be disposed of at a landfill by a contractor, and the sludge was to be disposed of by land application on a 22-acre site adjacent to the Agrifuels facility (under an agreement with LDEQ). Although, if operated, the plant would rely heavily on wood chips rather than bagasse as a fuel, no impacts would be expected from the standpoint of the nature or volume of the wastes generated.

Two unexpected impacts associated with solid waste from Tennol operations occurred; both were nonroutine events associated with unique circumstances. In one instance, a large amount of wet cake (distillers' grains) was generated at the plant because of technological problems with the process and was temporarily stored outside. Heavy rains washed some of the material into a ditch that eventually reaches the on-site wetland area located south of the plant; however, Tennol personnel intercepted the washed cake with hay bales to prevent impacts to the wetland area, and properly disposed of the solid waste. In the second instance, a contractor to Tennol for solid waste disposal experienced equipment problems that led to a fish kill; this event is discussed in more detail in Sect. 3.3.

3.5.3 Cultural Resources

The final potential land use impact forecast in the EAs dealt with disturbance to archeological and historical resources. The state historic preservation officers did not identify any sites listed on or eligible for inclusion in the National Register of Historic Places for any of the three project construction sites, so no significant effects in these areas were forecast. Because construction occurred where anticipated in all three cases, the forecasts were indeed valid. Impacts of this type are highly site specific and depend on the presence or absence of the resource in question. Thus, they are of little generic value to ascertaining the environmental effects of fuel ethanol production.

3.6 OTHER

Adequately validating some of the impact forecasts made in the EAs was not possible with available data. For example, noise impacts were generally forecast to be not significant because of the plant location, the presence of other noise sources, and the distance to sensitive receptors. At each of the three plants, noise levels at the boundary and beyond have not been measured (nor were there any requirements for such measurements), and the only information available on "impacts" was a lack of official complaints filed against the facility in question. For these reasons, noise impacts are not

discussed further. Potential impacts of the plants on geological resources were included in the EAs. Fuel ethanol plants have very little potential to affect such resources, and the forecast generally consisted of this statement. Because there is little information available to confirm or deny the forecast, it was not considered further in this report. Each of the EAs briefly discussed the potential impacts on worker health from exposure to chemicals in the workplace and stated that impacts should not be significant if all standards are met. At NECI, a workplace monitoring program has been implemented in accordance with the Occupational Safety and Health Act; monitored levels of chemicals are below appropriate standards for protecting worker health. At the other two facilities, no monitoring data were located to verify this forecast.

4. SUMMARY AND CONCLUSIONS

One of the principal findings of this study is that data on actual environmental impacts needed to verify impact forecasts for the three plants are scarce, especially with regard to ambient impacts (e.g., predicted ambient air pollutant levels, ecological assessments). The ideal scenario in conducting a NEPA follow-up study would be to compare quantitative forecasts, expressed in clearly defined units for specified locations and time periods, with quantitative measurements of actual impacts in the same units, at the same locations, and over the same time periods. Monitoring actual ambient impacts to correlate with predictions can represent an extensive (and expensive) amount of work. Consequently, it is not surprising that many follow-up studies have found a general lack of data on actual environmental effects. As summarized by Culhane, Friesema, and Beecher (1987), people engaged in follow-up studies find "their central problem is that good data on project impacts are quite rare." Furthermore, data on actual impacts need to be at least as quantitative as the forecast to be of value to the follow-up study. Making this match on a consistent basis can hinder follow-up studies (Culhane, Friesema, and Beecher 1987).

In general, available data on actual impacts support the conclusions of the EAs for the impacts that were forecast. Table 11 summarizes the key findings from this study and qualitatively highlights the evaluations of actual and predicted environmental impacts. Major impacts not anticipated by the project EAs are: the odor at NECI, the BOD wastewater interface between NECI and the municipal treatment plant, possible nuisance classification of treated wastewater from Agrifuels, and habitat losses due to vegetation removal (NECI) and dock construction (Tennol and Agrifuels). To put these impacts in the proper perspective, however, none of those related to emissions and effluents from continuous operations resulted in irreversible harm to the human environment. The environmental protection programs enforced by federal, state, and local regulators for specific media (e.g., air pollution, water quality) coupled with the sensitivity of the management of the three facilities to compliance with environmental regulations and standards resulted in actions being taken to prevent or minimize these effects.

Issues such as habitat losses from site clearing or construction of project components not addressed in the EAs primarily stem from a "disconnect" between the NEPA documents and implementation of projects by the private sector, which is not required to comply with NEPA for its actions. In all of the cases examined herein, however, impacts were thought to be negligible, according to site inspections and conversations with staff members of federal, state and local environmental agencies.

Other important impacts occurred from nonroutine events at the three facilities, such as the fish kill from improper stillage disposal by a contractor, violations of air quality regulations due to construction and operation of facilities that differed from designs receiving preconstruction approvals, and air emissions that occurred because of faulty design and construction of pollution control equipment. These latter situations reflect perturbations in plant operations during start-up and are not viewed as causing continuous impacts of irreversible harm to the human environment.

Table 11. Summary of key findings from follow-up study

Impact area	Finding[a]
Air quality	Actual emissions varied from predicted values, in some cases considerably. The larger variations tended to be when actual levels exceeded predicted. All plants received operating permits, which demonstrated compliance with ambient standards. Emission of odorous substances from the NECI driers was the principal unexpected impact.
Water quality	Actual levels of BOD and suspended solids in wastewater varied from predicted values, in some cases considerably. Usually the BOD levels were greater than expected. Discharge without BOD pretreatment to a municipal treatment plant could require a period of adjustment; otherwise, no significant adverse effects are expected. Discharge with pretreatment to a municipal treatment plant should not produce significant adverse effects under normal operation. Treated wastewater from molasses-based processes may be classified as a nuisance because of odor, or color, or both.
Ecology	Unexpected habitat losses due to site clearing (NECI) and construction of barge docks occurred, but a lack of data prevents quantifying impacts. A fish kill from improper disposal of waste stillage by contractor (fish valued at about $5000) occurred.
Land Use	Conversion of agricultural land or prime farmland occurred as predicted. Construction and operation of CO_2-recovery facilities were not expected, but impacts were not found to be significant. Solid waste is usually disposed of at permitted facilities. Some states allowed land application of sewage sludge and waste stillage. No significant adverse effects on cultural or historical resources were found.
Socioeconomics	The predicted influx of construction workers to a community was usually overestimated, as was the influx of operational workers. The actual operations work force was usually in the range of forecasts, as was the construction work force. The facilities cost more than predicted, which meant greater-than-expected beneficial economic effects. No adverse effects on public services or traffic were identified (in one case, mitigation identified in EA was implemented to greatly reduce potential traffic impacts).

[a]BOD = biochemical oxygen demand.
CO_2 = carbon dioxide.
EA = environmental assessment.
NECI = New Energy Company of Indiana.

For this particular technology, compliance with pollution control laws eventually will limit these impacts to acceptable levels during normal operation. In addition, the loan guarantee arrangements considered herein are structured to ensure compliance with all applicable environmental standards, regulations, and permit conditions.

Results are also of interest in terms of the types of forecasts (as discussed in Sect. 2, Table 4). The binary and qualitative forecasts tended to be the most accurate of those that could be verified, which is what would be expected (e.g., forecasts of conversion of land use, disturbance to cultural resources, were accurate). Verifying quantitative forecasts for the three projects was extremely limited because of a general lack of monitoring data; this limitation was especially true for predicted ambient air quality impacts. A lack of monitoring data prevented also verification of qualitative forecasts in the areas of noise impacts, surface water quality, and aquatic and terrestrial ecology. It was also difficult at times to match actual data with forecasts to allow verification. For example, socioeconomic impacts for some projects were forecast in detail, but only broad information on actual impacts could be located; conversely, detailed socioeconomic data were located, in some instances, for projects for which only general forecasts were made. Either situation hinders impact verification.

Actual environmental impacts may differ from predicted effects because of changes in the project source terms, changes in the sensitivity of the environment, or changes in the contributions of other sources to cumulative impacts (in addition to inaccuracies in assessment tools and models). In actuality, all factors undoubtedly operate to some degree. The review of the three fuel ethanol plants identified occurrences of each of the first three factors. Changes in source terms was by far the most prevalent and occurred at all three plants, as discussed elsewhere in this report. Changes in the sensitivity of the environment were exemplified in a number of instances, such as at Agrifuels, where the improvement in water quality and fish population of the Bayou Teche, brought on by construction of a new diversion canal, meant that aquatic ecological resources could be more sensitive to BOD discharges from the plant. Changes in contributions of other sources to cumulative impacts were exemplified by the construction and operation of CO_2-recovery facilities at NECI and Tennol, which had a minor effect on overall construction and operational impacts.

The extent of agreement between forecasts and actual values for each of the three plants reflects the maturity of the technology planned for each facility. The NECI plant is the most conventional of the three, which may be one reason why the emissions and effluents were reasonably well characterized* at the EA stage. Tennol uses a technology known in Western Europe but not yet attempted on the scale of Tennol, and Agrifuels uses an innovative process for ethanol production. Emissions and effluents for these two facilities were less quantified at the EA stage, and consequently, large variations were observed when forecasts were compared with actual values.

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*As discussed in Sect. 3.2, the actual wastewater effluent source terms differed significantly from the values used in the EA. However, after the EA was published and before construction began, the values were revised and more closely resembled actual levels.

The above findings must be considered in light of three caveats. First, the search for actual impacts was not exhaustive, in that it was based solely on available data; and the results of field sampling and analysis may have detected other effects or increased the magnitudes of known effects. Second, the findings are based on a very limited operating history: three plants were examined, one of which operated at only reduced capacity for several months and one of which never achieved continuous operation. As more operating data become available, the frequency and magnitude of departures from forecasts may increase. Third, many impacts resulted from site-specific characteristics and may not be relevant for the same technology in other locations.

Although it is difficult to generalize the findings to fuel ethanol production and associated NEPA documentation, a few conclusions can be drawn regarding preparation of future EAs for this technology:

- Solid wastes are generated by these facilities, they are suitable for landfills (i.e., nonhazardous), and disposal of some of the wastes can be achieved through land application as an alternative to a permitted landfill.

- Spills and other nonroutine releases occasionally happen, and spill prevention and response is needed to reduce the chances of accidents and their impacts.

- The potential impacts of BOD and TSS levels in wastewater should be examined in detail, regardless of the type of process and whether wastewater is pretreated and sent to a municipal treatment plant or is treated and discharged.

- The potential for secondary industrial development to recover CO_2 should be considered for evaluation in examining effects from a particular proposed project.

- Potential odor impacts and associated mitigation should be examined for corn-based plants with rotary-kiln driers located upwind of populated areas.

- Compliance with air and water pollution control laws, regulations, and permit conditons can be relied on as key mitigation to reduce the magnitudes of potential adverse effects.

- The EA process should attempt to incorporate changing project characteristics as facilities move from conceptual design to final design, construction, and operation.

Regarding the last point listed above, it was apparent that many project changes occurred between preparation of the EA and construction and operation of the facilities. These changes were caused by a number of factors (e.g., economic considerations, energy supply and pricing, changing environmental review laws and regulations) that were difficult to anticipate during EA preparation. Two recommendations can be made to address project changes in the NEPA process. First, at the EA preparation stage, the analyses could be

based upon ranges in source terms rather than a single value provided by the loan guarantee applicant. In the case of the AFO loan guarantee program, a generic environmental assessment (Elmore et al. 1982) was prepared for this purpose, and the results were used in several of the EAs. This recommendation presumes the availability of technological information, which may not be true for innovative or state-of-the-art technologies. Second, the NEPA documents, once prepared, could be given greater visibility in the project development process. Project personnel associated with the three projects examined in this study were not aware of the EAs being "used" for anything in designing, constructing, or operating the facilities, and many were unaware that the EAs even existed.* One possible mechanism for bringing about greater use of the documents would be to provide a copy to the project environmental coordinator and to encourage the loan guarantee recipient to appoint such a coordinator as early on in project implementation as possible. When project changes occur, the coordinator could assess the significance of associated potential impacts and informally report the findings to the DOE loan guarantee monitor.

Conducting this study provided a unique opportunity to examine the environmental implications of a complete alternative energy program that began with the Energy Security Act and culminated in the three plants examined herein. The evolution of the AFO Loan Guarantee Program in accordance with NEPA demonstrates the usefulness of early consideration of environmental factors in federal decision making--the programmatic EA, the generic environmental assessment, and the project-specific EA's all contributed to the production of a renewable energy source in an environmentally acceptable manner, thereby contributing to an important goal of the NEPA process: helping public officials take actions that protect, restore, and enhance the environment.

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*These responses may in part reflect limited corporate memory resulting from staff turnover (i.e., persons on-site during the follow-up visits were not affiliated with the project during design and construction).

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Appendix A

CHECKLISTS USED IN FOLLOW-UP STUDY

ABBREVIATIONS, ACRONYMS, AND INITIALISMS

BOD	biochemical oxygen demand
Btu	British thermal unit
CO	carbon monoxide
CO_2	carbon dioxide
d	day
DDGS	distillers' dried grains with solubles
DEQ	Department of Environmental Quality (Louisiana)
DO	dissolved oxygen
EA	environmental assessment
ft	feet
gal	gallon
h	hour
H_2S	hydrogen sulfide
km	kilometer
L	liter
lb	pound
m	meter
m^3	cubic meters
max	maximum
mg	milligram
μg	microgram
min	minute
NECI	New Energy Company of Indiana
NO_x	nitrogen oxides
OSHA	Occupational Safety and Health Administration
PSD	prevention of significant deterioration
SO_2	sulfur dioxide
TSP	total suspended particulates
TSS	total suspended solids
TVA	Tennessee Valley Authority
VOC	volatile organic compound

NEPA Follow-Up
DOE Loan Guarantee Fuel Ethanol Projects

I. Background information

New Energy Company of Indiana Project Name	DOE/EA-0163 (April 1982) EA Number (Date)
South Bend, Indiana Location	March 3, 1988 Date of Follow-Up

II. Project characteristics

Assessed	Actual
• 50 x 10^6 gal/year design production capacity	Same
• Dry-milled corn process	Same
• Coal-fired boiler	Same
• Distillation with/benzene	Same
• Continuous production runs of 1-4 weeks	Production runs are 2-3 weeks
• Stillage processing using centrifuges and mechanical evaporators	Same
• 2 floating roof ethanol tanks with vapor seals (1.5 x 10^6 gal total storage)	1 tank (0.75 x 10^6 gal); flare for load-out vapors
• One 75,000-gal gasoline storage tank with vapor recovery (vapors sent to boiler)	Floating roof for vapor control (not sent to boiler); vapor recovery for truck loading
• Fuel oil (boiler operation) storage with vapors sent to boiler	Vapors are not sent to boiler; vapor recovery during truck loading
• Benzene stored in above ground pressure vessel and below ground tank (tank vents through vessel, unrecovered benzene remains in ethanol or is sent to boiler)	Benzene is stored in 1 above-ground tank under pressurized nitrogen blanket.
• Pulverized coal boiler (2 package boilers burning natural gas, distillate oil or residual oil will provide backup)	1 pulverized coal boiler; 2 package boilers, natural gas or oil, used for backup
• 107 x 10^3 tons of low-sulfur coal used annually; 90-d supply (27 x 10^3 tons) stored on-site (12,800 Btu/lb, maximum ash of 7.5%, maximum sulfur of 0.75%)	About 94,000 tons of low-sulfur coal used annually; 90-d supply (33,000 tons) stored on-site (13,000 Btu/lb, maximum ash of 10%, maximum sulfur of 0.75%)

• Little or no pretreatment of process wastewaters	Pretreatment/neutralization of process waste; surge pond for flow control; heavy metal removal (needed occasionally) by limestone; wastes are chlorinated
• Annual residual oil use less than 34×10^3 tons	Very little residual oil used since plant began operation (limited use of backup boiler)
• Electricity purchased	Same
• 72-acre site	70-acre site; a 40-acre plant site is maintained
• Construction in eastern 2/3 of site	Same
• By-product used for animal feed	Same

III. Environmental impact

Predicted	Actual
1. Geology	
• Negligible	No significant adverse effects have developed
2. Groundwater	
• Spills - not significant with containment and pretreatment	Spills have been contained and recovered; periodic well water sampling data confirm no significant effects
• Ash and sludge disposal - not significant with approved landfill disposal	Same
• Water use - 2014 gal/min (7% of average overall municipal withdrawals)	3681 gal/min 1985-1987 avg (~22% of average overall municipal withdrawals; ~1.5% of potential yield for county)
3. Surface water	
• Spills - not significant with containment and pretreatment	Spills have been contained and recovered; no significant adverse effects from runoff
• Process wastewater - 0.48 mgd (280 mg/L BOD, 230 mg/L suspended solids) discharge without pretreatment to municipal treatment plant not significant	1.3 mgd flow (1500-1800 mg/L BOD, 500 mg/L suspended solids) discharge without BOD pretreatment to municipal plant has contributed to treatment plant upsets during the first two years of operation
4. Air quality	
• 1804 tons/year SO_2; ambient levels (31 $\mu g/m^3$ annual, 120 $\mu g/m^3$ 24 h, 492 $\mu g/m^3$ 3 h) below standards	Same emission rate specified in permit; ambient monitoring data not available

• 1052 tons/year NO_x • 87 tons/year TSP • 87 tons/year VOC • 62 tons/year CO	Same emission rates specified in permit
• Construction dust not significant	No complaints filed during construction period
5. Occupational exposure	
• No health problems if vapor levels are maintained at or below OSHA limits	Confirmed by workplace monitoring
6. Noise	
• No significant impacts during construction and operation	One or two complaints received during plant start-up. Equipment modifications made to reduce noise levels.
7. Ecology	
• Negligible impacts to terrestrial biota	Habitat recommended for preservation by U.S. Fish and Wildlife Service was removed, but no significant adverse effects anticipated
• No significant aquatic effects with containment, treatment, and disposal as proposed	Observed species changes in river receiving treated effluent suggest water quality improvements
• No endangered species present	Same
8. Land use	
• 50 acres of cropland will be converted to industrial use	40 acres of site maintained
9. Socioeconomics	
• 360-570 permanent jobs created during operation	278 permanent jobs created during operation
• 625-930 temporary workers for construction (peak)	900 workers (peak)
• Total cost of $150 million	$186 million
• Direct construction wages of $20 million, 75% in South Bend area	Not available
• No significant impacts on housing supply	Same
• No significant impacts on public services (e.g., schools, medical services, fire department)	Same
• Average property tax payments of $2.8 million	Not available
• South Bend investment in site of $6.6 million to $3.5 million	~$5 million
• Significant increase in traffic hazards on Calvert Street during construction	Temporary heavy traffic levels during construction

• Traffic impacts during operation reduced by new access road to State Highway 23, installation of traffic signals and widening of streets; unacceptable if not mitigated	Calvert Street widened; new access road constructed; traffic signal not needed
• No effect on cultural resources because no listed properties are in the site vicinity	Same

IV. Unanticipated impacts

1. Air	
• Odor	Odorous emissions from DDGS and evaporator led to installation of dry-chlorine odor-abatement system.
2. Water	
• Wastewater treatment plant	The EA had anticipated a beneficial impact from NECI's effluent on operation of the municipal wastewater treatment plant; initial impacts were adverse (because of changes in the BOD discharge and the state of repair of the treatment plant), and both parties have modified their facilities to achieve an acceptable operations interface.

V. Mitigation measures

Proposed	Actual
• Spill containment and pretreatment	Done
• Noncondensable organics sent to boiler	Not done, because of expense
• Dust control in driers by settling chamber and wet scrubber	Venturi cyclone
• Low-sulfur (0.75% max) coal	Same
• Treatment of nonprocess wastewaters	Done
• Fabric-filter dust collection at boiler	Done
• Approved landfill disposal of solid waste	Same
• Vapor levels maintained below OSHA limits	Monitoring data not available to confirm
• Road improvements to reduce traffic impacts during operation	Calvert Street widened; new access road constructed; no traffic signal installed
• Maintenance of willow trees along southern site boundary	Trees were removed during construction

NEPA Follow-Up
DOE Loan Guarantee Fuel Ethanol Projects

I. Background information

Tennol, Inc.	DOE/EA-0205 (December 1982)
Project Name	EA Number (Date)
Marion County, Tennessee	August 10, 1988
Location	Date of Follow-Up

II. Project characteristics*

Assessed	Actual
• 25×10^6 gal/year production capacity	Same
• Wet-milled corn process	Modified wet milling; no separation of corn components before fermentation
• Dehydration by distillation with diethyl ether	Cyclohexane is used
• Pulverized coal-fired boiler	Same
• 48×10^3 tons/year of coal used; 15-d supply stored on-site	~49×10^3 tons/year coal used; same
• Pretreatment of process wastewaters with discharge to Jasper treatment plant	Same
• Electricity purchased	Same
• 128-acre site (27 acres developed for ethanol plant)	Same
• No construction within 0.5 mile of the river	Barge terminal built on river (by another company) to supply Tennol with corn
• Site access by new I-24 interchange and new side track to L&N railroad	Same
• By-products (CO_2, gluten feed, dried germ, gluten meal) sold	By-products are planned to be sold; because of initial technical problems with equipment, solid by-products were not routinely available for sale
• Cooling towers for cooling water	Same

*All values reflect plant operation at full capacity.

III. Environmental impact*

Predicted	Actual
1. Geology/soils	
• Reduction in site erosion	Same
2. Groundwater	
• Spills - not significant with containment and pretreatment	No monitoring data available to verify
• Ash and sludge disposal - not significant with approved landfill disposal	Disposed of under permit by land spreading
• Water use - 300 gal/min well water (3% of total use for county); potable water from Jasper water system (2 gal/min)	250-280 gal/min well water, 3.7 gal/min potable water use from Jasper water system
3. Surface water	
• Spills - not significant with containment and pretreatment	Minor impacts from a few isolated events
• Process wastewater - 0.30 mgd discharged with pretreatment to Jasper treatment plant not significant; same for 3000-gal/d domestic wastewater	0.14 mgd (normal), 0.17 mgd during rainfall, plus a 0.10 mg/d cooling stream to treatment plant in either case
• Minimal impact on floodplain from design, construction, and operation of wells	Same
4. Air quality	
• 827 tons/year SO_2 emissions	704 tons/year
• 485 tons/year NO_x emissions	370 tons/year
• 35 tons/year TSP emissions	75 tons/year
• 23 tons/year VOC emissions	60 tons/year
• 28 tons/year CO emissions	50 tons/year
• Ambient concentrations less than ambient standards (16 $\mu g/m^3$ for annual SO_2, 180 $\mu g/m^3$ for 24 h SO_2, 43 $\mu g/m^3$ for annual TSP, 142 $\mu g/m^3$ for 24-h TSP)	Confirmed by PSD permit (modeling); no monitoring done
• Construction dust not significant	No complaints filed during construction period
• No impact on closest Class I PSD areas	Confirmed by PSD permit (modeling)
5. Occupational exposure	
• No health problems if vapor levels are maintained at or below OSHA limits	No data available

*All values reflect plant operation at full capacity.

6. Noise	
• No significant impacts during construction & operation	No complaints filed
7. Ecology	
• Minor impacts to terrestrial biota	Same
• No significant aquatic effects with containment, treatment and disposal as proposed	Same
• No significant impacts to endangered mussel populations due to lack of activity off-shore	Barge terminal was eventually built; TVA survey of area before construction, using divers, found no endangered mussels
• No disturbance to wetlands and bottomland forest	Minor impacts to wetlands due to barge terminal
8. Land use	
• 27 acres of prime farmland (zoned industrial) will be converted to industrial use	Same
9. Socioeconomics	
• 100-120 new workers during operation	123 permanent employees at full capacity
• 200 workers over 18 months for construction (peak)	872 workers during 1-month peak (October 1985). 18-month construction period
• Majority of jobs (construction and operation) filled by people living within commuting distance	97% of construction workers lived within commuting distance; 95% of operations work force lives within commuting distance
• No significant impacts on housing supply	Same
• No significant impacts on public services (e.g., schools, medical services, fire department)	Same
• No truck traffic through residential areas	Same
• 18-20 railcars/d and 15-20 truck trips/d for transportation of all raw materials, plant products, by-products and fuel coal	~12 railcars/d and 30 truck trips/d
• No historical or archaeological resources identified	Same

IV. Unanticipated impacts

1. Air	Design changes led to air emissions differing from those assessed, but plant is still in compliance with ambient standards and PSD increments. A faulty baghouse, now

	corrected, led to excessive emissions of particulate matter.
2. Water	Construction of a barge terminal resulted in minor water quality impacts
3. Ecology	Barge terminal construction led to minor impacts on aquatic species and on wetland area. Land application of waste stillage by a contractor led to a fish-kill incident.
4. Secondary development	A CO_2-recovery facility (Cardox) was built next to the Tennol plant

V. Mitigation measures

Proposed	Actual
• Spill containment and pretreatment	Done
• Approved landfill disposal of solid waste	Done
• Vapor levels maintained below OSHA limits	Done
• Dust control at grain handling by baghouse	Done
• VOC control in process by chilled water condenser	Done
• VOC control at product storage from floating roof tanks	Done
• Dust control at by-product handling by baghouse	Done
• Fugitive VOCs controlled by improved valves, pumps and fittings, and good maintenance	Done
• Coal-handling dust control by spray bar or telescoping chute	Done
• Site planning and erosion control during and after construction to minimize sediment loads to Tennessee River	Done
• Containment and treatment of coal-pile runoff before discharge to Jasper treatment plant	Done
• Diking of ethanol storage tanks to contain spills	Done
• Low-sulfur coal due to grinding and washing	Done
• Pretreatment of process wastewaters	Done

NEPA Follow-Up
DOE Loan Guarantee Fuel Ethanol Projects

I. Background information

Agrifuels Refining Corporation Project Name	DOE/EA-0165 (June 1982; Revised May 1985) EA Number (Date)
New Iberia, Louisiana Location	August 30, 1988 Date of Follow-Up

II. Project characteristics*

Assessed	Actual
• 35 x 10^6 gal/year production capacity	Same (value is for denatured ethanol)
• Molasses/cane and/or sorghum syrup feedstock	Same
• Methane and bagasse combustion for process heat	Reliable bagasse supply not found. Solid fuel was changed to wood chips. Natural gas added as a fuel source
• Dehydration by distillation with cyclohexane	Same
• 5-d supply of cane syrup (845,000 gal) and 15-d supply of molasses (1,800,000 gal) stored on site	Syrup is stored in two 800,000-gal tanks, and molasses is stored in two 800,000-gal tanks
• Treatment of process wastewaters (anaerobic followed by aerobic) with discharge to Bayou Teche	Wastewater treated and is sent to a ditch that empties into the Bayou Teche about 3 mi through primarily agricultural (although some residential) areas
• Electricity purchased	Same
• 28-acre site	Same
• Modification of existing dock	A new dock was constructed adjacent to the existing dock (which is owned by Cajun Sugar)
• Rail, truck, and barge transportation of raw materials, plant products, by-products, and fuel	Truck and barge transportation. 75% of feedstock (molasses) would be shipped by barge. Barge would be used to ship ethanol product out of state for sale.

*All values reflect plant operation at full capacity.

• CO_2 (by-product) will be sold	CO_2 to be scrubbed and vented. No buyer was found.

III. **Environmental impact***

Predicted	Actual
1. Geology/soils	
• Negligible increase in site erosion	Some possible during construction.
2. Groundwater	
• Spills - not significant with containment and pretreatment	Spill containment not as thorough as originally designed. Hazardous-liquid storage areas are well contained.
• Ash and sludge disposal - not significant with approved landfill disposal	Louisiana DEQ approved land application of sewage sludge on 22-acre site north of plant. Boiler ash sent to landfill by contractor.
• Water use - 1915 gal/min well water (11% of total use for parish)	1511 gpm well water (~9% of total parish use)
3. Surface water	
• Spills - not significant with containment and pretreatment	Spill containment not as thorough as originally designed. The proposed 7-ft-high dike around the plant was not constructed. Instead of the dike, a 3-ft-deep ditch surrounds the plant and conducts runoff to the Bayou Teche. Also, no containment is provided for spills at dock that could affect surface water.
• Process wastewater - 1.5 mgd discharged with treatment to Bayou Teche (25 mg/L BOD, 30 mg/L TSS subsequently revised by state to 10 mg/L BOD, 15 mg/L TSS)	1.2 mgd treated effluent discharged to ditch that drains to Bayou Teche (10 mg/L BOD, 15 mg/L TSS)
• Minimal impact during average flow; some decreased DO levels in vicinity of discharge during low or no flow	Since the EA was prepared, the Teche-Vermilion Water Diversion Project was constructed to divert additional flow into the Bayou Teche, thereby improving water quality (including the maintenance of adequate dissolved oxygen levels).

*All values reflect plant operation at full capacity.

4. Air quality	
• 233 tons/year NO_x emissions	245 tons/year NO_x emissions (PSD permit limit)
• 18 tons/year TSP emissions	64 tons/year TSP emissions (PSD permit limit)
• 44 tons/year VOC emissions	79 tons/year VOC emissions (PSD permit limit)
• 15 tons/year CO emissions	1630 tons/year CO emissions (PSD permit limit)
• Ambient concentrations less than ambient standards (2 $\mu g/m^3$ for TSP, 31 $\mu g/m^3$ for NO_x, 91 $\mu g/m^3$ for VOC, and 32 $\mu g/m^3$ for CO)	Confirmed through modeling in PSD permit applications; no monitoring done
• Construction dust not significant	No complaints filed during construction
• No impacts on closest Class I PSD areas	Confirmed through modeling in PSD permit applications; no monitoring done
5. Occupational exposure	
• No health problems if vapor levels are maintained at or below OSHA limits	Plant not operated. Original plans to use an ether/benzene dehydrant were dropped in favor of cyclohexane, which is less hazardous.
6. Noise	
• No significant impacts during construction and operation	No complaints filed during construction. Plant did not operate, so post-construction noise not evaluated.
7. Ecology	
• Minor impacts to terrestrial biota	Minimal effects on habitat due to prior land use (agriculture)
• No significant aquatic effects with containment, treatment and disposal as proposed	Impacts from spills could be greater than originally anticipated because of both reduced containment at plant and minimal containment at dock.
8. Land use	
• 28 acres of prime farmland (zoned industrial) will be converted to industrial use	Same
9. Socioeconomics	
• 84 new workers during operation (Agrifuels only); 30% moved to area	125 new workers, 4% moved to area
• 500 workers (peak); 21 months for construction; 25% moved to area	750 workers (peak); 17-month construction period; 20% moved to area.

• Majority of jobs (construction and operation) filled by people living within commuting distance	Same
• $12 million in direct construction wages	$24 million in direct construction wages
• $66 million in capital equipment, materials, and services during construction	~$50 million
• $6000/year in property taxes	$3900/year in property taxes current (land only); could eventually reach 15% of market value of land and buildings
• No significant impacts on housing supply	Same
• No significant impacts on public services (e.g., schools, medical services, fire department)	Same
• Potential traffic bottlenecks on two-lane site access roads	Same
• No historical or archaeological resources identified	Same
10. Solid Waste	
• 250,000 lb/d sludge to landfill	State approved land application of sewage sludge on a 22-acre site next to the Agrifuels facility (34,000 lb/d)
• 12,000 lb/d bagasse ash to landfill	20,000 lb/d ash from wood chip combustion to landfill
IV. Unanticipated impacts	
1. Air	SO_2 emissions totaling 282 tons/year due to combustion of H_2S in bio-gas from wastewater treatment; odor during start-up from flare overload (H_2S)
2. Water	Compliance problems with BOD and nitrogen levels in wastewater; also possible nuisance from color and odor of treated effluent
	Impacts from constructing new dock

3. Ecology	Impacts from constructing new dock Potential adverse impacts on aquatic life more likely because of presence of more oxygen-sensitive species caused by increased flow in Bayou Teche from new water-diversion project
4. Land use	Land application of sewage sludge
5. Solid waste	Land application of sewage sludge

V. Mitigation measures

Proposed	Actual
• Spills and runoff will be contained, analyzed and treated if needed before discharge	System is not in place to do this; modifications costing $10,000-$20,000 would be needed to meet these conditions as specified in permit
• Approved landfill disposal of solid waste	Sewage sludge to be applied to land on 22-acre plot adjacent to site with approval by state
• Vapor levels maintained below OSHA limits	Data not available
• VOC control in process by condenser	Done
• VOC control at product storage from floating roof tanks	Done
• Diking of ethanol storage tanks to contain spills	Done
• Treatment of process wastewaters (anaerobic and aerobic)	Done
• Diking of entire plant perimeter to contain runoff and spills	Not done. A ~3-ft-deep ditch surrounds the plant. Adequate containment for hazardous liquids. Little or no containment for spills of liquids at dock.
• Road paving to reduce fugitive dust	Done

Appendix B

DESCRIPTIONS OF THE THREE LOAN GUARANTEE PROJECTS (AS BUILT)

ABBREVIATIONS, ACRONYMS, AND INITIALISMS

AIRCO	carbon dioxide recovery facility located adjacent to the New Energy Company of Indiana fuel ethanol plant
CO_2	carbon dioxide
CSX	formerly the Louisville and Nashville and Seaboard railroads
d	day
DDG	distillers' dried grains
DDGS	distillers' dried grains with solubles
DOE	Department of Energy
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
ft^3	cubic feet
gal	gallon
h	hour
kV	kilovolt
lb	pound
min	minute
MWWTP	Municipal Wastewater Treatment Plant (South Bend, Ind.)
NECI	New Energy Company of Indiana
NJI&I	New Jersey, Indiana, and Illinois railroad
psi	pounds per square inch
TVA	Tennessee Valley Authority

APPENDIX B. DESCRIPTIONS OF THE THREE LOAN GUARENTEE PROJECTS

This appendix presents narrative descriptions of the three fuel ethanol plants constructed under the DOE Loan Guarantee Program. The descriptions reflect the plants as they were found during the site visits for this study (New Energy Company of Indiana, March 1988; Tennol, August 1988; Agrifuels, August 1988). Descriptions of the facilities "as assessed" can be found in the environmental assessments (EAs) for the projects. Appendix A presents a detailed comparison of anticipated vs actual project characteristics.

B.1 NEW ENERGY COMPANY OF INDIANA

The New Energy Company of Indiana (NECI) facility is located in the southwest corner of the city of South Bend, Indiana, as shown in Fig. B-1. The $186 million plant was built with a $141 million loan, 90% of which is guaranteed by the U.S. Department of Energy. The NECI facility is a corn-based, dry-milling fuel ethanol plant with an annual anhydrous ethanol production design capacity rated at 50 million gal. As shown in Figure B-2, the facility consists of a variety of structures for converting corn to ethanol, in addition to process steam generation and environmental control equipment.

Approximately 60-70% of the corn is delivered to the NECI plant by truck and the remainder by rail. Corn is stored in silos after delivery and then passes through scalping screens and magnets to remove foreign objects before milling. Dust is generated during unloading, storing, handling, and milling the corn, but virtually all dust is collected by a system of fabric filters.

Process description

Ground corn is mixed with enzyme, lime, water, and steam, and standard techniques are used to liquefy and saccharify the corn starch. Excess heat is removed from the fermenting mash and transferred to air by way of heat exchanger coils connected to the cooling tower or to ground by way of wells, depending on ambient air temperature. The carbon dioxide (CO_2) from fermentation is passed through a packed tower scrubber before being sent to the adjacent AIRCO plant, via pipeline, for commercial use. The scrubber water is returned to the process for reuse.

The plant uses a two-column distillation process, with a recovery column (to recover the ethanol and allied organics) and a dehydration column. Ethanol of about 94% (by weight) purity condenses near the top of the recovery column, where it is drawn off with some of the light heads. Fusel oil separates out near the middle of this column and is blended into the product ethanol. Azeotropic distillation is used with benzene to dehydrate ethanol (>99.5% by weight). The benzene from the dehydration column is recovered. The gases left in the recovery column, mainly CO_2 and ethanol, are cycled through a separate condenser, where additional ethanol is removed and sent to the dehydration column. Carbon dioxide from the beer feed is removed in the degasser and sent to the CO_2 scrubber, while the other vapors from distillation are controlled by condensers. The distillation column and

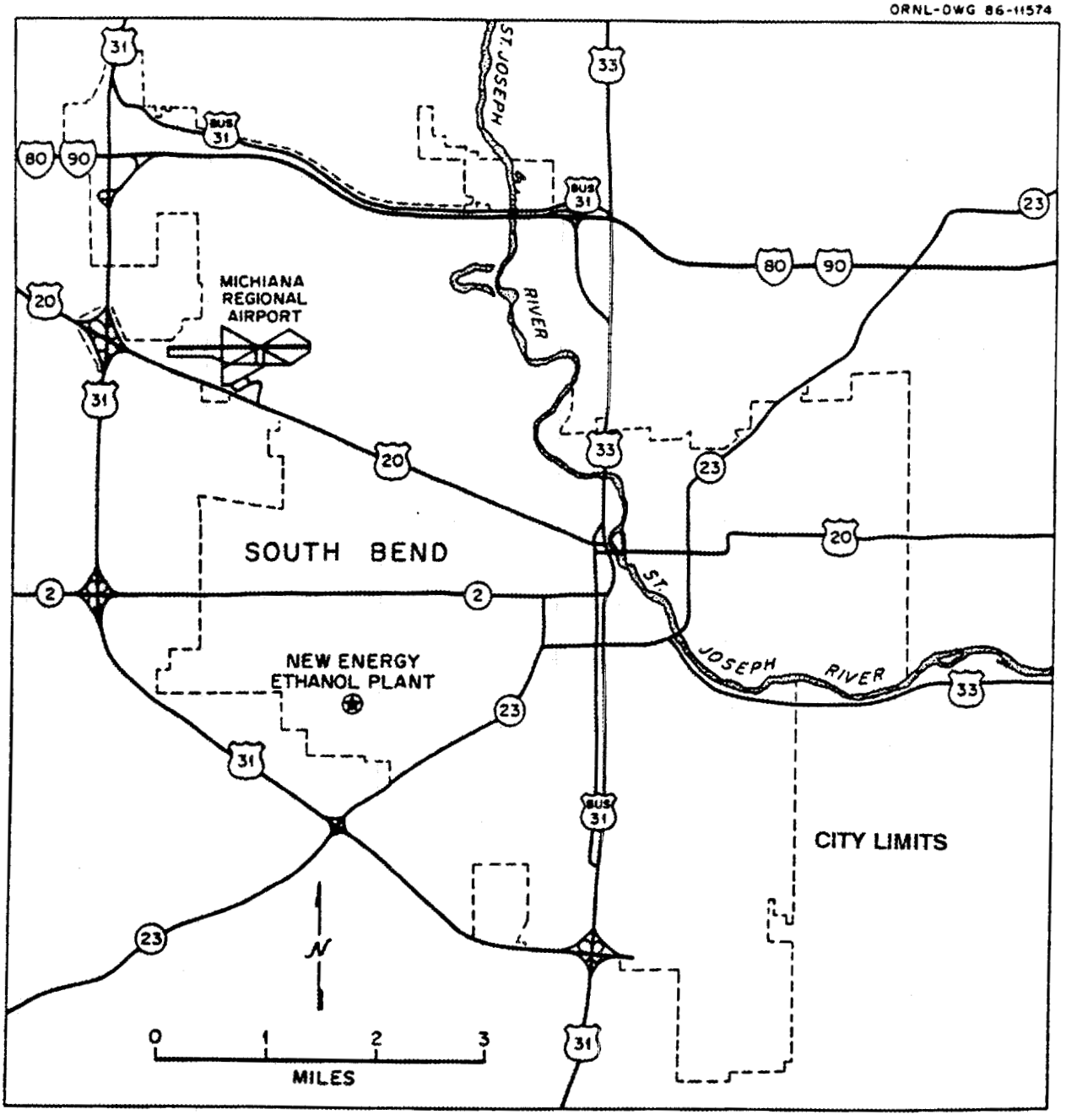

Fig. B-1. Location of the New Energy Company of Indiana fuel ethanol plant in South Bend, Indiana.

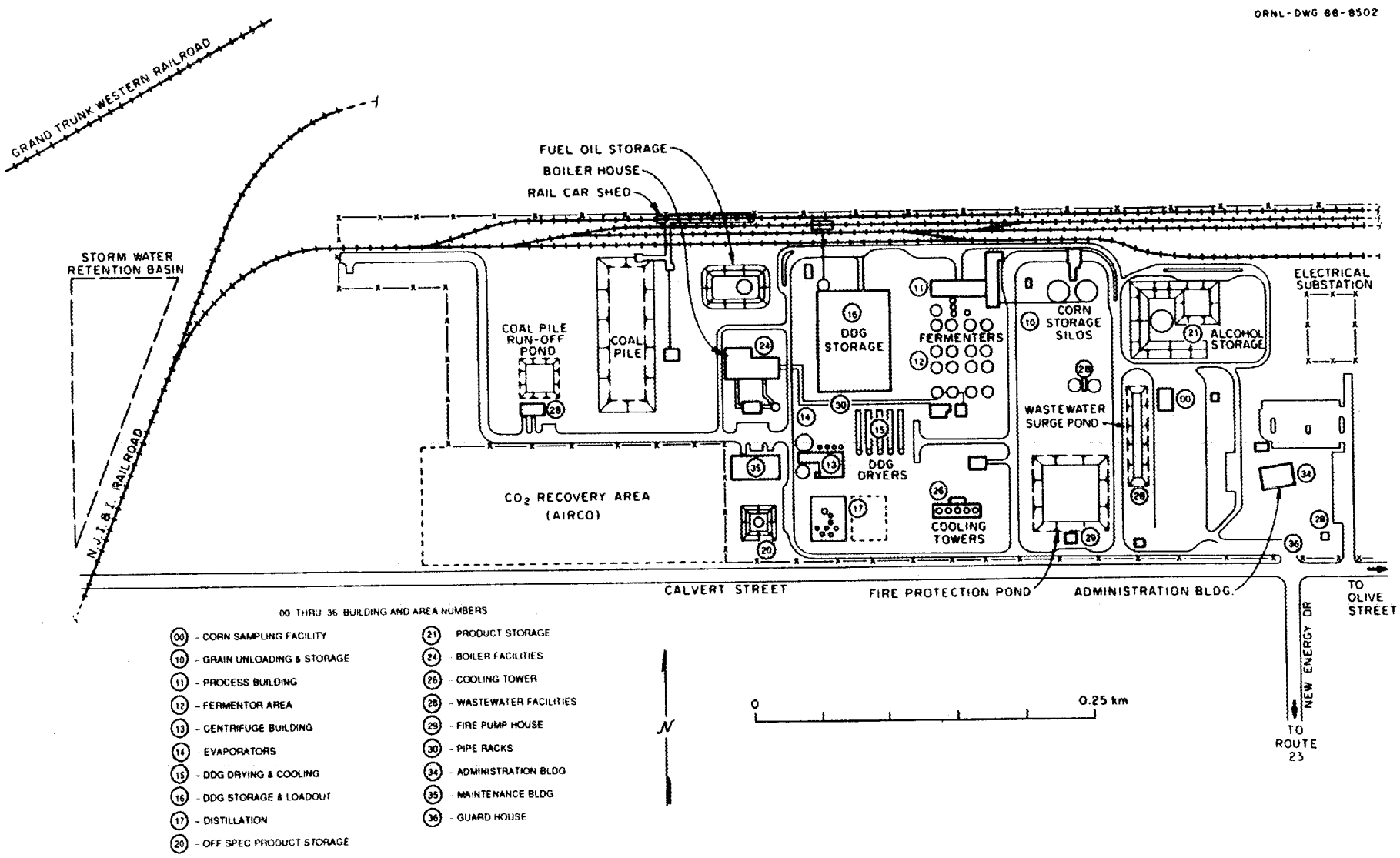

Fig. B-2. New Energy Company of Indiana site plan.

ancillary equipment are designed for continuous runs, with occasional cleaning to remove the buildup of residual corn solids.

The stillage leaving the distillation column is processed with centrifuges and mechanical recompression evaporators. One-third of the thin stillage is used in mash preparation, while the remainder is processed through the evaporator. Noncondensed gases from the evaporation process vent through a stack to the atmosphere. A chlorine-based odor abatement system was added to the evaporator stack in 1987. The evaporator concentrate is mixed with wet cake from the centrifuge and recycled distillers' dried grains (DDG) for feed into the rotary steam-heated (tube) dryers. DDG leaving the dryers contains approximately 10% moisture (by weight). Dust control in the dryers consists of wet cyclone scrubbers at the dryer exhausts.

Two floating-roof ethanol tanks with vapor seals are used to store ethanol. Denaturant (gasoline) is stored in a single tank. The denaturant storage tank uses a floating roof with dual seals to control vapors; vapors generated during loading are recycled back to the truck. Benzene is stored in an aboveground pressure vessel with a nitrogen blanket to control vapors. Displaced vapors generated by alcohol loadout operations are destroyed by thermal oxidation at the loadout flare.

The NECI plant uses process wastewater recycling and by-product recovery to minimize the volume and waste burden of plant effluents. Most of the actual effluents receive minimal waste treatment (primarily neutralization, as necessary) before discharge to the municipal sewer system and final treatment in the municipal wastewater treatment plant (MWWTP). Coal-pile runoff is collected and treated, as described below.

Spill prevention and control is achieved through a system of containment dikes and pads; skimmer pits for oil/water separation; a surge pond; level indicators, controls, and alarms; limestone pits; spill-recovery equipment and procedures; and plant security. Bags of urea are stored on-site in the event of a spill that threatens to overload the MWWTP. The urea would boost the unusually low levels of nitrogen in the plant's wastewaters, thereby promoting bacterial decomposition of the wastes when they enter the MWWTP. A Spill Prevention and Countermeasure Plan has been developed specifically for NECI.

Fuel source

Process steam is supplied primarily by a pulverized-coal boiler generating superheated high-pressure steam. Two backup package boilers are available, which burn natural gas, distillate oil, or residual oil. In an effort to reduce operational energy demand and emissions, an extensive system of heat recovery is included in the many steps when heat must be removed from the process.

About 107 x 10^3 tons of low-sulfur coal are used annually, with a 90-day supply stored on-site. The coal is stored on a limestone bed to elevate the pH of the runoff to acceptable levels. The coal requirements specify a minimum heat value of 12,800 Btu/lb, a maximum ash content of 10%, and a maximum sulfur content of 0.75%. Electricity is purchased. Coal-pile runoff collects in a pond constructed specifically for that purpose. From

there, the runoff flows to a small on-site treatment plant where it is monitored and, if metals are detected, treated in a flocculation tank. Otherwise, the runoff is released to the municipal wastewater treatment plant.

Site description

The site covers about 70 acres located in the southwest sector of South Bend, Indiana (Fig. B-1). It is located west of Olive Street, northeast of the U.S. 31 bypass, and at the west end of Calvert Street. The site is divided by the New Jersey, Indiana, and Illinois (NJI&I) railroad into a small, 8-acre western wedge and a large, 62-acre eastern portion. An access road was built connecting Highway 23 with the eastern end of the plot, and a transmission line crossing the eastern portion was rerouted off- site. A spur was built eastward along the northern plot boundary from the curve of the NJI&I railroad to provide the rail needs of the facility.

B.2 TENNOL

The $91 million Tennol Energy Company fuel ethanol plant was built with a $72 million loan, 90% of which is guaranteed by the U.S. Department of Energy. The facility has a nominal annual production capacity of 25 x 10^6 gal and is located on a site near Jasper, Tennessee (Fig. B-3). The Tennol plant uses a type of corn wet-milling process* to produce fuel ethanol, CO_2, and by-products. Maximum production achieved to date is about 50% of capacity; during the site visit in August 1988, the plant was on standby for process modifications. The plant is designed for continuous operation (24 h/d, 330 d/year). Figure B-4 presents the site plan for the facility.

Raw feedstock corn is shipped by rail or truck, or it is trucked from an on-site barge terminal. Rail shipment is used for about 7 months of the year, and barge shipment is used for the remainder. The barge terminal consists of mooring dolphins and a vacuum unloading system that removes corn from the barge to an elevated silo from which it is dumped to trucks for the one-half mile trip to the plant. At the plant, the corn is unloaded directly from railcars or trucks into an underground, covered receiving hopper, from which it is transported underground to an elevator that empties into four concrete storage silos. All chemicals are transported by truck on existing roads and an interstate highway interchange located about 0.5 mile from the site. Distillers' dried grains with solubles (DDGS) is shipped by truck or rail and can be shipped by barge.

Process water is obtained from two on-site wells with a capacity of about 2000 gal/min and is not treated before use at the plant. Potable water is obtained from the Jasper city water system. Electricity is obtained from TVA through a 161-kV line from a transmission line about 2 miles to the east.

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*The project as originally proposed was classified as a wet-milling facility. The project as built uses a process substantially different from traditional wet milling (e.g., it produces a mash almost identical to that produced by dry milling).

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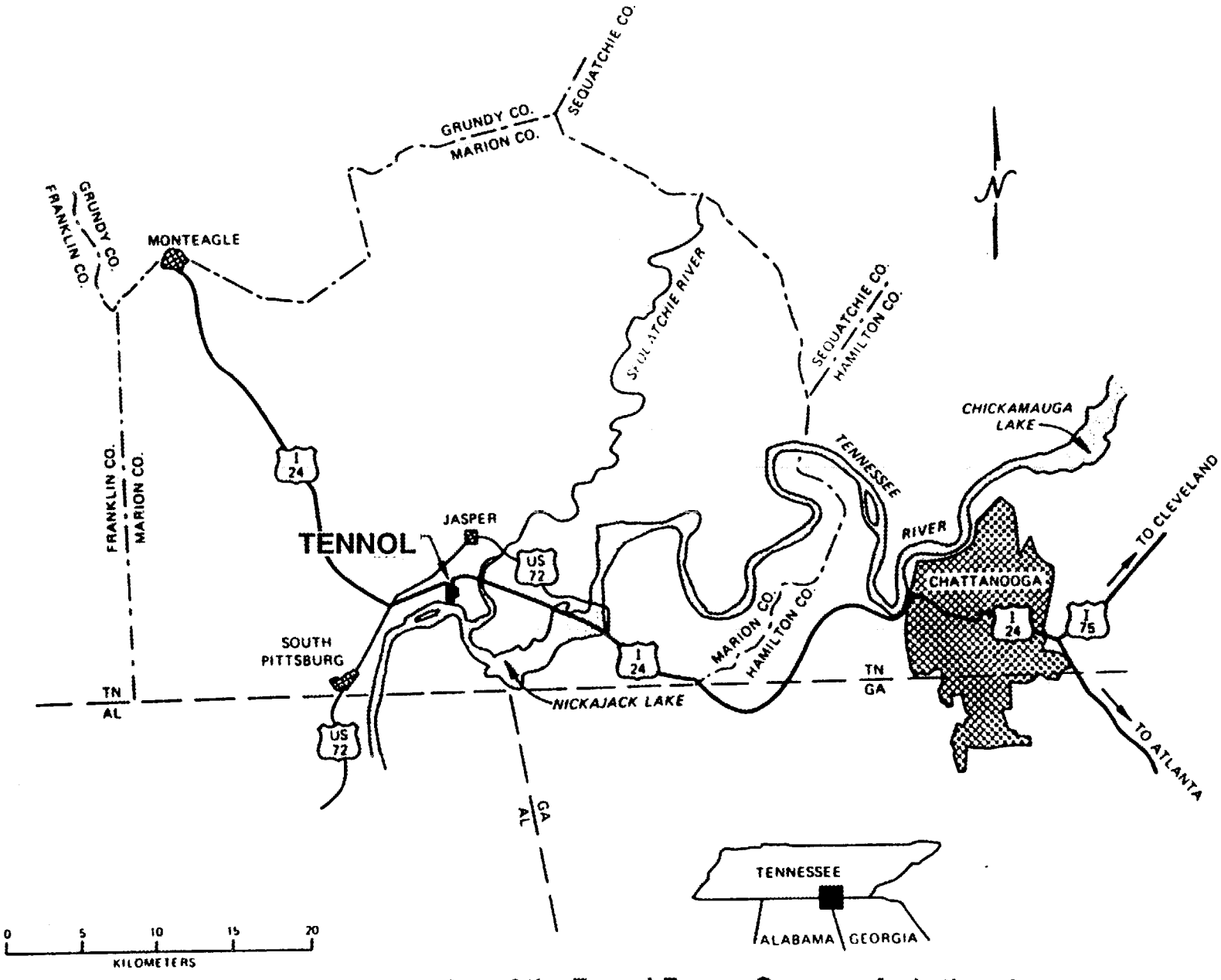

Fig. B-3. Location of the Tennol Energy Company fuel ethanol plant in Marion County, Tennessee.

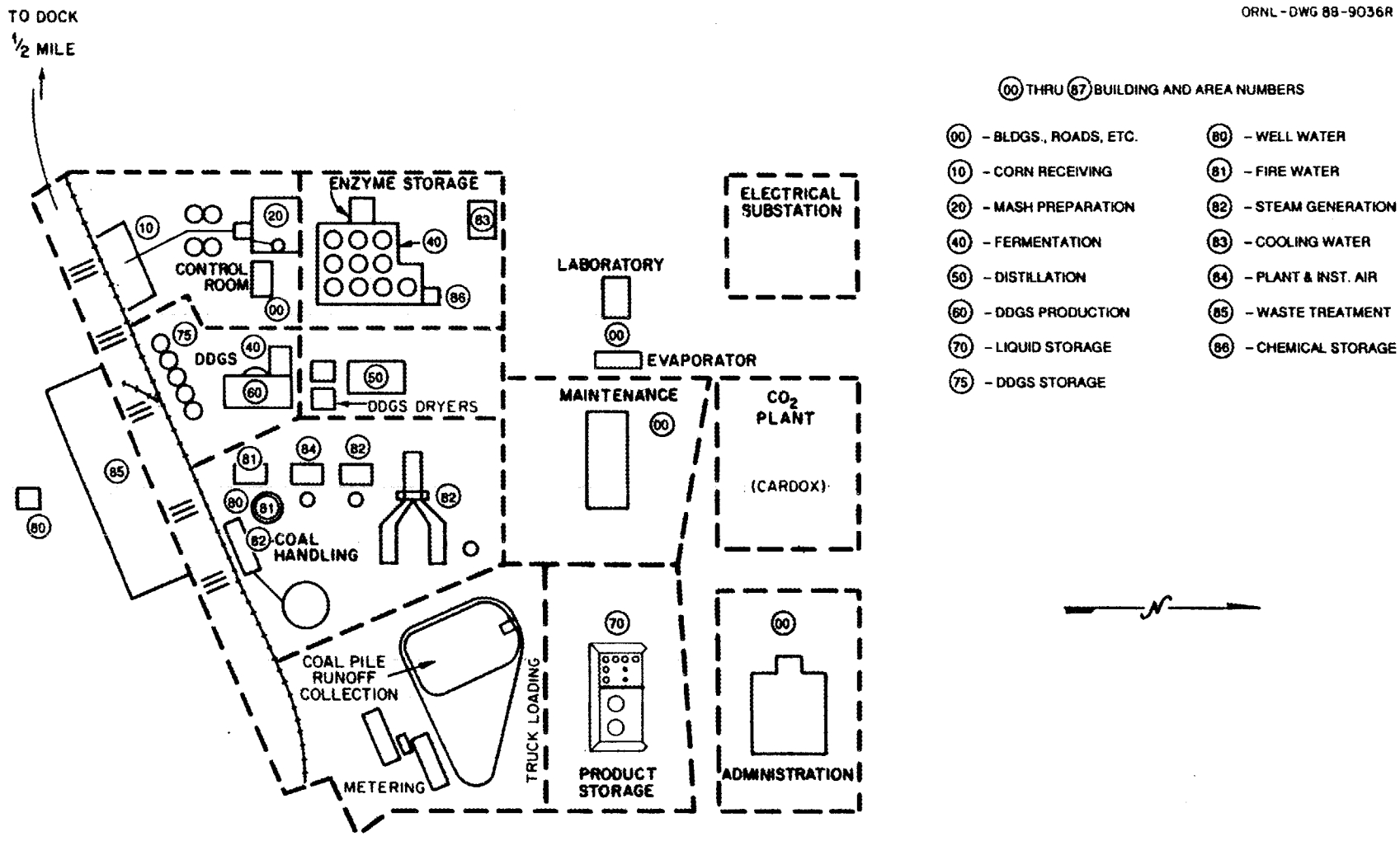

Fig. B-4. Tennol Energy Company site plan.

All process areas of the plant are drained to sumps and all process waste streams also go to sumps. From the sumps, the process wastes go to an anaerobic digester and thickener-aerator-clarifier system. Sanitary wastes are sent directly to the Jasper sewage treatment plant adjacent to the Tennol plant. The waste treatment system produces methane (which is flared), sludge (which is trucked to the Marion County landfill), and a clear liquid (which is sent to the Jasper treatment plant). The Jasper plant discharges to the Tennessee River.

Process description

In the first step of the process, shelled corn is received from the silos and cleaned. Dust and screenings from cleaning are collected and sold to local farmers for feed mixing. The cleaned corn is then passed through steepers, where the whole kernels are mixed with recycled thin stillage and makeup water. The steepers are large horizontal vessels with a slowly turning screw (auger) that moves the corn through the steeper in about 45 minutes, producing corn the consistency of cooked canned corn. Steam is injected to maintain a temperature of about 194°F.

The softened corn is dewatered and milled and then mixed with steep water and liquefying and saccharifying enzymes to form a mash (approximately 25% solids). Next, the mash goes to fermentation, where yeast is added to produce alcohol and CO_2. The fermentation area consists of nine 350,000- gal batch fermenters and one beer well of the same size used as a surge tank to allow continuous feed to distillation. The fermenters are made of carbon steel and were originally without agitators, which were added when proven necessary to keep the mash solids in suspension. The CO_2 produced from fermentation is sold to the adjacent Cardox plant, where it is cleaned and compressed to a liquid. From Cardox, the CO_2 is used either in beverages, dry ice production, or other industrial applications.

The distillation area is essentially an energy-efficient conventional design with three main columns (a mash-distilling column, a rectifying column, and a dehydration column) and a solvent-recovery column that recovers the cyclohexane entrainer used in dehydration. The mash-distilling column produces a 55% ethanol in water solution and "whole stillage," a mush of solids and dissolved unfermentables. The rectifying column produces 96% ethanol, and the dehydration column produces 99.9% ethanol that is subsequently denatured with 5% unleaded gasoline. Fusel oils and aldehydes (respectively high- and low-molecular weight products of fermentation) are recombined with the denatured ethanol. The only streams produced by the distillation area are whole stillage and ethanol.

Several changes have been made on the original design for stillage processing. As originally conceived, the whole stillage was to be centrifuged to produce a 30% solids cake and thin stillage. The cake was then to be processed in a screw press to increase the solids to 45% and dried in two dryer trains, each consisting of two dryers in series. The dryers consist of vertical columns, each with a rising spiral chamber heated inside and outside by steam. Each dryer has a residence time of about ten seconds and was intended to produce DDGS of high enough quality to be suitable for human consumption. The DDGS was sent to five elevated storage silos with provisions for direct unloading to trucks. Air emissions from DDGS transport

and storage (dust) are controlled with cyclones. The thin stillage extracted in the centrifuges and screw presses, which was expected to contain about 7% dissolved and suspended solids, was to be returned to mash preparation for reuse.

Because of design problems, Tennol has been able to operate at only about 50% of capacity from start-up in 1985 until early 1988, when the plant was shut down for modifications. Many of the features of the plant as built were changed (or were in the process of being changed during the August 1988 site visit) to respond to these design problems, and are summarized below.

Equipment in the mash preparation area (e.g., the original corn cleaner and pumps, corn steeper, liquefaction tanks) was modified or replaced. The original centrifuges were replaced to improve liquid/solid separation. As now designed, whole stillage from the bottom of the mash column is pumped through the new high-efficiency centrifugal decanters that produce a semisolid phase (about 30% solids) that is sent to the DDGS dryers and a thin liquid phase (about 1% solids) that is recycled back to the mash preparation area. An evaporator (under construction) will process thin stillage to produce a condensate (relatively free of solids) that can be recycled to the process and a concentrated syrup that can be dried in the DDGS dryers. The evaporator will be electrically driven and will produce a minor wastewater stream (that will be mixed with other process wastewaters and treated before discharge to the Jasper wastewater treatment plant) and an atmospheric emission of volatile organic compounds from the condensate collection tank. New natural gas-fired, two-stage "flash" DDGS dryers (i.e., short residence time) have been installed to dry the semisolid phase from the centrifuges to a product of about 10% moisture. Drying the DDGS will produce dust emissions that will be controlled with cyclonic dust collectors. In addition, natural gas combustion will emit nitrogen oxides and particulate matter that will be governed by the air emissions permit for Tennol Energy Company.

Ethanol, fusel oils, aldehydes, and gasoline are stored in tanks in a diked storage area. The product alcohol is stored in two 380,000-gal tanks. The denaturant is added during the transfer to tank trucks. Fusel oil is also blended with the fuel alcohol. Three 40,000-gal shift tanks and one 40,000-gal off-specification ethanol tank are also present. Fusel oils are stored in a 5000-gal tank, and aldehydes (used as an auxiliary fuel in the steam boilers) are stored in a 10,000-gal tank. Unleaded gasoline is stored in a 40,000-gal tank. All tanks are carbon steel, with floating heads with seals to reduce vapor emissions.

Fuel source

Process steam is generated on-site by combustion of local coal delivered to the plant by truck. It is dumped into an underground unloading hopper and conveyed to a concrete coal silo, which can store approximately a 15-d supply. Emissions from coal unloading are controlled by a baghouse. Coal ash is disposed of in the nearby Marion County landfill.

The boiler is a stoker-fired, traveling-grate, steam design rated at 120,000 lb/h of steam at 150 psi. A small boiler fed with No. 2 fuel oil is the backup. Normal operations have less than 2% opacity. The permits allow

up to 20% opacity for upset conditions or boiler tube blowdown for any one 6-min period each hour. A baghouse is used to control fly ash emissions. Sulfur dioxide, nitrogen dioxide, and opacity are continuously monitored with a continuous stack-gas analyzer as part of the air quality permits.

A number of process changes (including the new dryers) have increased steam requirements by an estimated 6000 lb/h. New permits have been issued for construction and operation of the new dryers. These dryers still need to be operated and tested under U.S. Environmental Protection Agency (EPA) Method #5 in accordance with the new permit requirements.

Site description

The site for the Tennol, Inc., fuel ethanol facility is located in southeast Tennessee, in Marion County, about 20 miles west of Chattanooga near the town of Jasper (Fig. B-3). The region surrounding the site is primarily rural, but the area just northeast of the site is being developed as an industrial complex. The Tennol property consists of 128 acres, bounded by Interstate 24 on the north, the Tennessee River on the south, agricultural lands on the east, and the Jasper wastewater treatment plant and agricultural lands on the west. In addition to I-24, the interstate between Chattanooga and Nashville, it is on a branch line of CSX (formerly the Louisville and Nashville and Seaboard railroads) and has a barge docking facility on the river. Most of the site (about 2/3) is a swampy former floodplain (the river no longer floods, being part of the TVA reservoir system). The plant site, adjacent to the interstate, is higher and is typical valley bottom land.

The site is located in the Tennessee River valley where it is joined by the Sequatchie Valley, a major Appalachian valley extending northward into central Tennessee. The Sequatchie River enters the Tennessee River about a mile upstream from the plant site. All surface drainage on the site is to the south, through a series of lowlands and swamps toward the river to the natural levee, then westward for about a mile to Glover Branch and into the Tennessee.

B.3 AGRIFUELS

The $106 million Agrifuels Refining Corporation fuel alcohol plant was designed and constructed with an $87.8 million loan, 90% of which is guaranteed by the U.S. Department of Energy. The plant is designed to produce anhydrous fuel-grade ethanol by yeast fermentation of a mixture of 70% high-test molasses or cane and/or sweet sorghum syrup and 30% blackstrap molasses. Once the plant is operational, fuel ethanol will be shipped from the plant to the intracoastal waterway via barge and truck at an annual rate of about 35 x 10^6 gal. Plant feedstock (syrup and molasses) will be purchased from domestic and foreign sugar cane processors and shipped to the plant by barge or truck. The plant is located in southern Louisiana in western Iberia Parish (Fig. B-5).

Process description

The major steps in the process are storage, dilution, fermentation, distillation, denaturing, and alcohol storage and loading. A site plan highlighting locations of the major steps is shown in Fig. B-6. In the first

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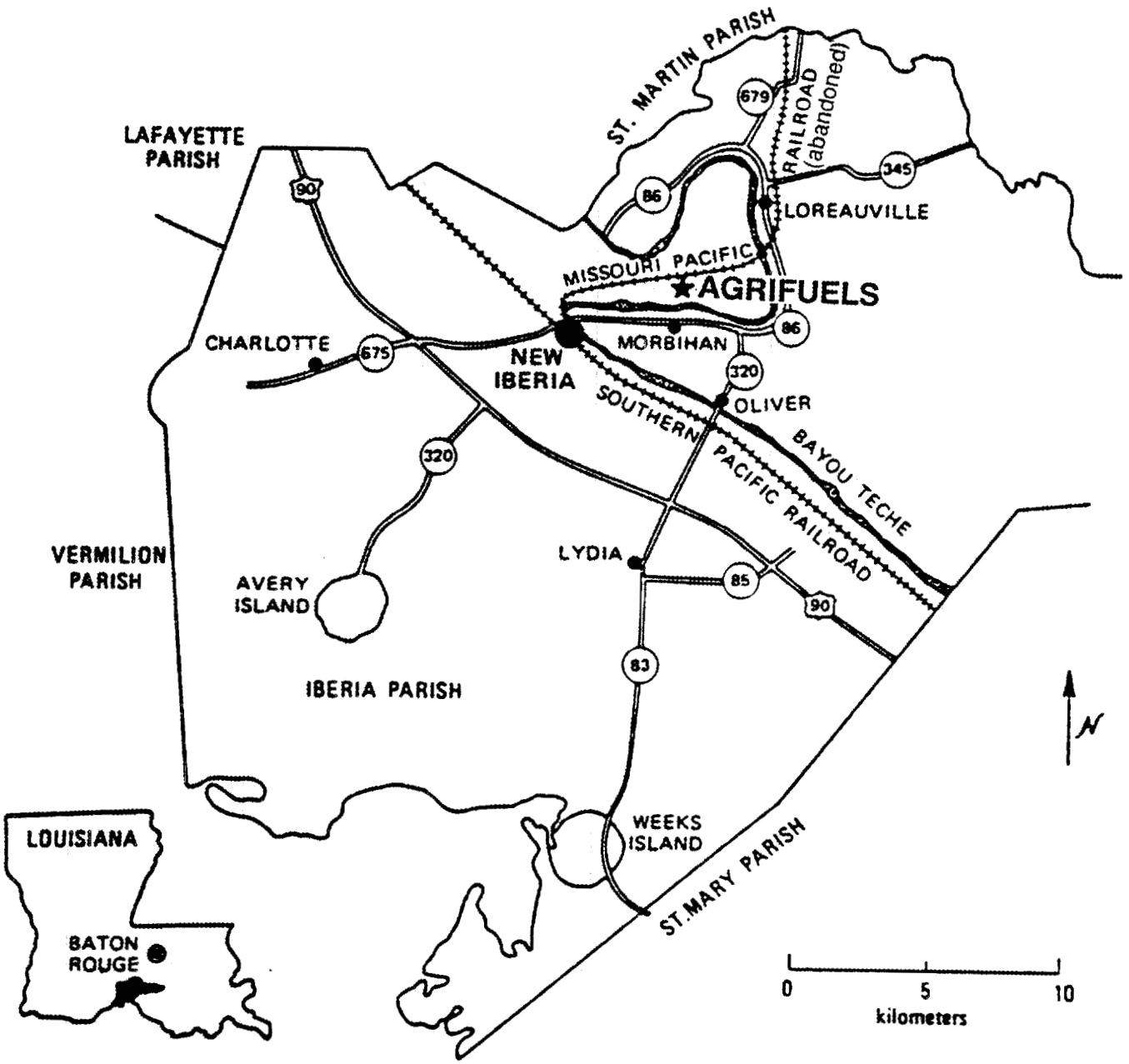

Fig. B-5. Location of the Agrifuels Refining Corporation fuel ethanol plant in Iberia Parish, Louisiana.

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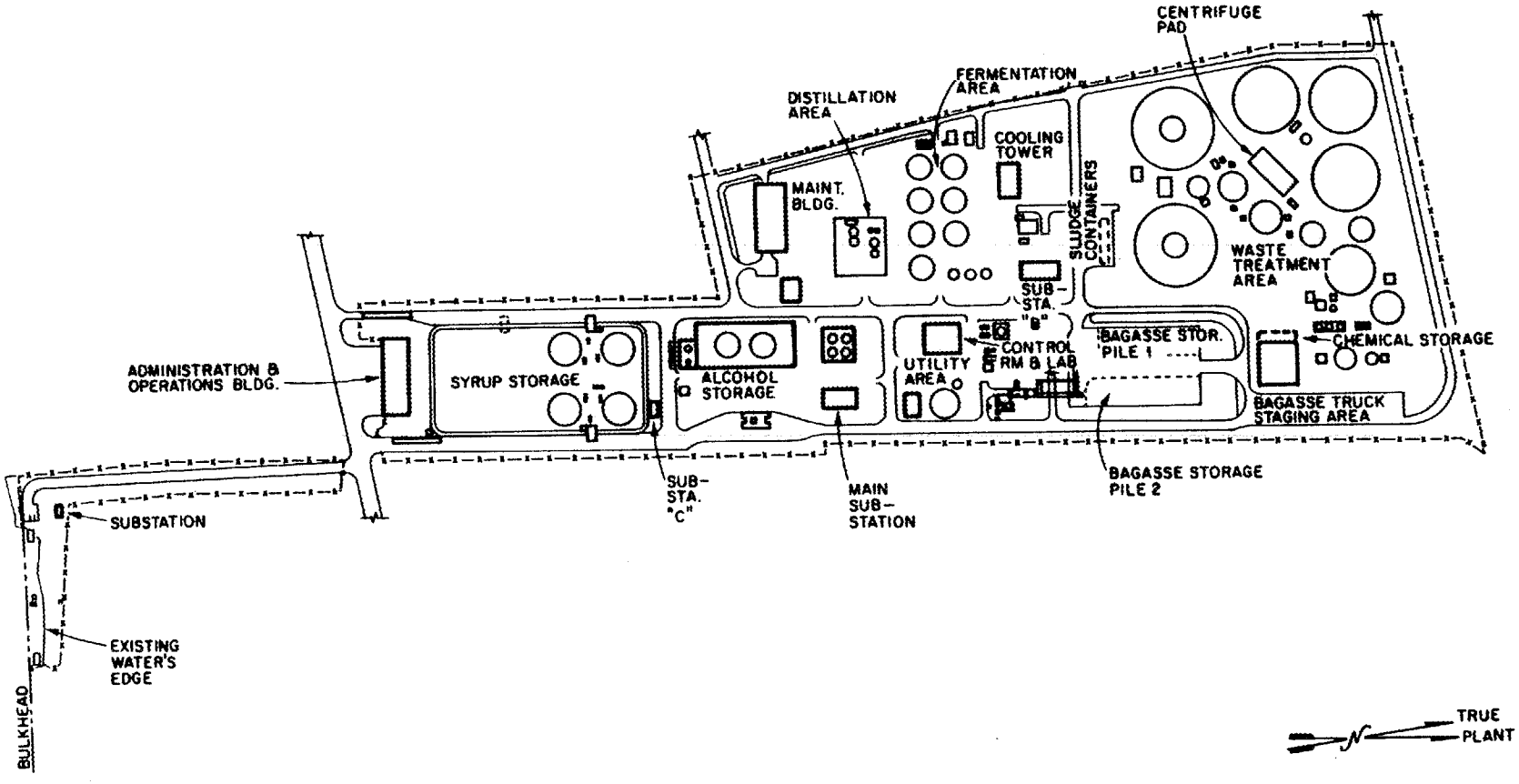

Fig. B-6. Agrifuels Refining Corporation site plan.

step, the delivered cane/sorghum syrup and molasses are placed in storage (four 800,000-gal tanks) and diluted with water to prepare for fermentation. In the fermentation step, the diluted syrup/molasses is treated with yeast organisms in the absence of air to convert the sugar in the molasses to alcohol. A mixture called "beer" is formed and CO_2 gas and ethanol are produced. The CO_2 could be recovered and sold for use, but no potential buyers have expressed interest at this time. CO_2 vented to the atmosphere will first be scrubbed of residual alcohol vapors.

The remaining solution of ethanol and water is then sent to distillation, which consists of four columns: mash, rectifying, dehydration, and solvent recovery. The beer is sent first to the mash column to separate the ethanol and higher molecular-weight organic compounds from the remaining stillage. The bottoms (solids) from the mash column are sent to the anaerobic digester area (wastewater treatment). The ethanol recovered during the distillation is sent to the rectifying column to concentrate the alcohol mixture to 95% alcohol and 5% water. In the dehydration column, the alcohol is dehydrated via azeotropic distillation with cyclohexane. The remaining mixture of cyclohexane, alcohol, and water is sent to the solvent recovery column where cyclohexane is recovered for reuse.

In the fifth step, the anhydrous ethanol is sent to one of two 500,000-gal storage tanks. It is then denatured with gasoline before storage in the final product tank. Denatured ethanol would be shipped by barge or truck. The Agrifuels barge dock will accommodate alcohol barges of up to 350,000-gal capacity, as limited by draft requirements on the Bayou Teche.

Fuel source

Fuel is provided from four potential sources: gas produced in the wastewater treatment plant, natural gas (purchased and supplied by pipeline), bagasse,* wood chips, and electricity (purchased from the local utility).

The waste treatment plant produces 3.8 million ft^3/d of a gas (bio-gas) containing methane, carbon dioxide, and hydrogen sulfide. The heating value of this gas is approximately one-half that of natural gas--the total gas produced is equivalent to 2.0 million ft^3/d of natural gas. This gas supplies two-thirds of the plant fuel requirement.

Natural gas is purchased under contract with a gas company (Entex) for a maximum of 3 million ft^3/d, which is the total plant requirement. The gas is from local south Louisiana gas fields, and the gas is treated for sulfur removal prior to entering the pipeline.

The original design basis for the plant (as assessed in the EA) was to use bagasse as fuel for the solid-fuel boiler. About 175 tons/d of bagasse would be needed to furnish one-third of the plant's fuel requirement, and the source of the bagasse was to be the seven or eight mills that process sugar cane grown within a 50-mile radius of the plant. Bagasse contains an insignificant amount of sulfur, so the emission of primary concern from

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*Bagasse is the cellulose pulp residue from sugar cane used in the production of raw sugar.

bagasse combustion in the boiler is particulate matter. State-of-the-art particulate emissions control equipment was included in the boiler design.

Subsequent planning for bagasse supplies revealed that a reliable year-round supply of bagasse did not exist and that the quality of bagasse commercially produced was unacceptable because of high moisture and ash contents. Reliable year-round wood chip supplies were found in forestry operations located within a 70-mile radius of the plant. The original plan to use bagasse was discarded, and the 175-ton/d solid-fuel requirement was changed to wood chips. The sulfur content of wood chips is too low to warrant sulfur oxides emission control, but particulate emissions must be controlled. The boiler design was revised to incorporate wood chips (the particulate control equipment needed no revision).

Site description

The Agrifuels site is located in southern Louisiana, in western Iberia Parish, just east of the city of New Iberia, and north of the town of Morbihan (Fig. B-5). New Iberia is approximately 50 miles southwest of Baton Rouge and about 105 miles west of New Orleans. The Agrifuels site consists of about 28 acres of level land that had been under cultivation in sugarcane for many years. It is directly adjacent to a large sugar mill, the Cajun Sugar Cooperative. Access to the site is by Parish Road 344, off State Highway 86 (Fig. B-5). The area surrounding the site is sparsely populated and rural in character, and the principal land use is agriculture.

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