Acurex Project 7385

STANDARDS SUPPORT PLAN FOR ENVIRONMENTAL ASSESSMENT OF CONVERSION OF BIOMASS TO ENERGY GASOHOL

W. C. Kuby, N. L. Concion, G. R. Offen, R. D. Shelton

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February 1980

ACUREX DRAFT FINAL REPORT 80-44/EE

Prepared for
R. E. Mournighan — Technical Project Monitor

Environmental Protection Agency
Industrial Environmental Research Laboratory
5555 Ridge Avenue
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Contract 68-03-2567

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SECTION 1

INTRODUCTION

Fuels containing non-petroleum-based alcohols can provide one effective approach for limiting the increasing dependence by the United States on foreign oil. Gasohol, a blend of 10 percent ethanol produced from agricultural and waste feedstocks and 90 percent unleaded gasoline, is the most promising, near-term application of alcohol fuels. Currently, ethanol is the only commercially available alternate fuel and will remain the only one available in significant quantities prior to 1985. Production of ethanol fuel through 1985 will be limited by the capacity to convert agricultural and waste materials to ethanol, rather than by the availability of feedstock. Although alcohol fuels are not expected to totally eliminate our nation's dependency on foreign oil sources, they could become an important part of the national plan to stabilize our energy balance.

The Environmental Protection Agency (EPA) is the Federal organization with primary responsibility for controlling adverse environmental effects of pollutant emissions. This Standards Support Plan (SSP) shows how EPA's Office of Research and Development (ORD) plans to support the media Program Offices in setting standards for the emission effluents from fuel-grade alcohol production facilities. Since it is anticipated that ethanol will be the only alcohol produced in significant quantities until 1985, this SSP is limited to ethanol production.

There are several aspects to the environment impact of gasohol production and use, namely production of the feedstock; transportation; transfer, storage, and blending of the alcohol with gasoline; and end-use combustion in mobile sources. Although there could be significant environmental problems in each of these areas, this study by ORD's Industrial Environmental Research Laboratory at Cincinnati, Ohio (IERL-Ci) is limited to fuel-grade alcohol production, from feedstock preparation to the generation of 200-proof alcohol. Other emissions, including end-use emissions, need to be reviewed by the ORD laboratories with direct responsibilities in these areas of concern.

In this SSP, a detailed plan pertaining to the fuel-grade alcohol industry is developed for activities over the next 2 years. This report also projects a continuing activity resulting from the monitoring of growth and development of other alcohol production technologies. The purpose and content of this SSP are as follows:

- To explain the Agency's standards development and supporting R&D program, with special emphasis on sampling and analysis for emission/effluent and treatability/control data at fuel-grade ethanol plants
- To show how the ORD/IERL-Ci component of this program is integrated with the efforts being conducted by the media Program Offices, namely, the Office of Air Quality Planning and Standards (OAQPS), the Office of Solid Wastes (OSW), and the Office of Water Planning and Standards (OWPS)

- To relate the overall data collection program to the media offices' timelines for setting standards and the Regional Offices' requirements for permitting new sources
- To establish the various agency activities and the responsibilities for each of those activities in terms of the overall plan and timeline for occurance of various elements of the studies
- To present other information to allow the reader to gain a knowledgeable perspective on the industry being studied and the methodology of setting standards

Thus, this SSP is a practical working document. It presents the Agency's program for determination of the emissions from gasohol facilities and the approach necessary to define these emissions. In terms of a sampling and analysis program, it details the test plan, including the sites, number of samples to be collected, pollutants to be sampled, and analyses to be performed. The results of this sampling and analysis program, as well as other studies that will be done concurrently, are coordinated with a schedule put forth by the Program Offices for determining the appropriateness of standards and for setting those standards required.

In order to facilitate the generation of a consensus plan leading to a coordinated effort between the ORD study and each of the Program Offices as they move toward the development of standards, a series of meetings were held between IERL-Ci personnel and the staff members from the Effluent Guidelines Division (EGD) of OWPS, the Emission Standards and Engineering Division (ESED) of OAQPS, and the Hazardous and Industrial Waste Division (HIWD) of OSW. Since the major impetus for the interest in fuel-grade alcohol production came from an increase in permit requests in Region VII for on-farm facilities, Region VII personnel also participated in these meetings.

SECTION 2

ALCOHOL FUELS PRODUCTION

The following section is a technical description of the commercial and on-farm processes used for alcohol fuels production. The major emphasis is on ethanol production facilities by biological conversion of various feedstocks. However, two other alcohol fuel production technologies, namely the production of methanol from synthesis gases and butanol via biological conversion, are included. The discussion for each technology provides specific examples of the emissions and effluents, pollution control systems, liquid and solid wastes, and new technologies for alcohol production facilities.

The first portion of the discussion describes both commercial-scale and on-farm ethanol production technologies via biological conversion of feedstocks. Three specific feedstocks were chosen because they are typical of currently used or anticipated feedstocks for ethanol production. These are:

- Corn, a starch
- Corn stover, a cellulose
- Cheese whey, a sugar

The methanol and butanol production processes are included as technologies of the future.

2.1 COMMERCIAL-SCALE ETHANOL PRODUCTION

Fuel-grade ethanol can be produced from a variety of carbohydrate feedstocks via biological conversion. These feedstock materials can be broadly classified as starches, celluloses and sugars. The following items are discussed for each feedstock:

- Process description
- Emissions and effluents
- Pollution control systems
- Liquid and solid waste disposal
- New and emerging technologies

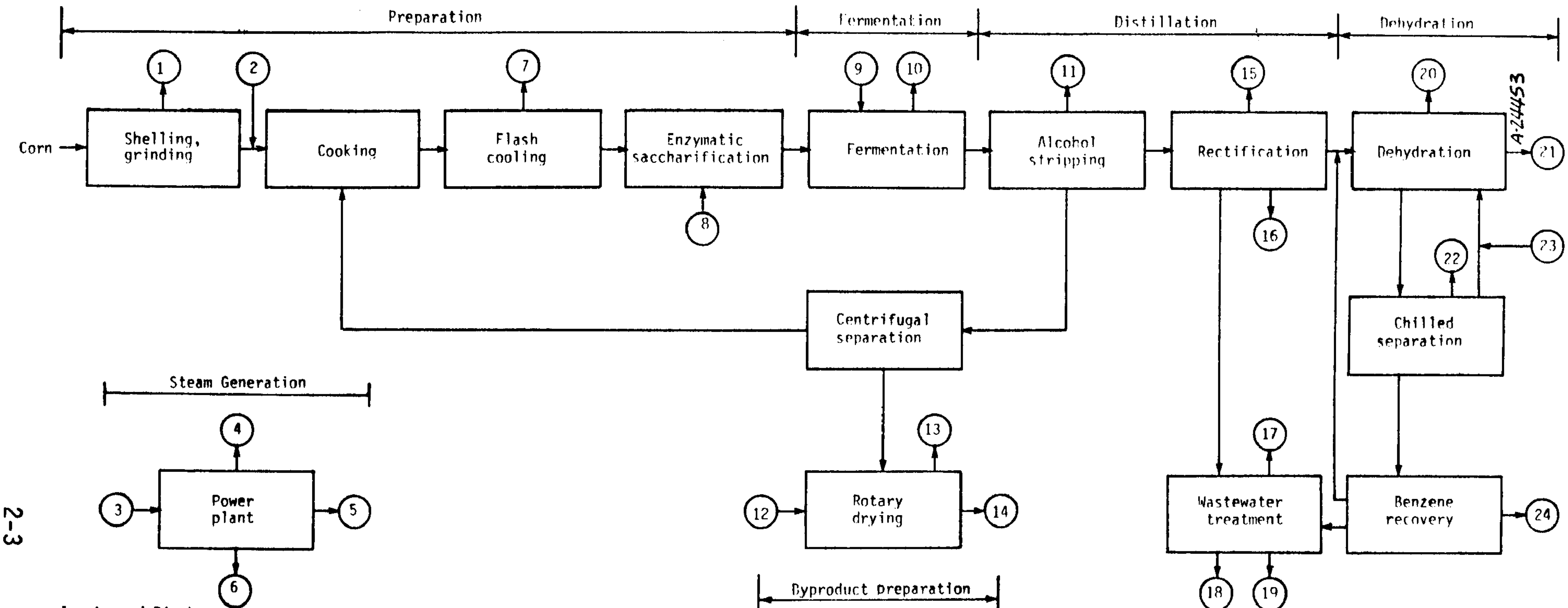
2.1.1 Ethanol from Starches

Starches (polysaccharides) are present in a wide variety of food crops, such as rice, wheat, potatoes, and corn. This discussion uses corn as a representative starch feedstock.

2.1.1.1 Process Description

Figure 2-1 is a flow diagram of a typical ethanol from corn process. The process begins by grinding the grain in a milling process (e.g., a hammermill) and slurrying the grain with water to form a mash. The mash is cooked by injecting steam (at approximately 150°C) to solubilize the starches. The mash is then cooled and enzymes are added to transform the complex starches into fermentable sugars.

These sugars are then introduced into the fermentation vessels with yeast to be converted to alcohol and carbon dioxide by the metabolic processes of the yeasts. The fermented mash (approximately 10 percent alcohol) is then pumped to the alcohol stripping column. This distillation column removes the solids and most of the water to produce a



Inputs and Discharges

- (1) Fugitive dust
- (2) Water
- (3) Fuel
- (4) Combustion products including PM, NO_x, SO_x
- (5) Process steam
- (6) Captured particulates
- (7) Hydrocarbon emissions
- (8) Enzymes
- (9) Yeast
- (10) CO_2, uncondensed hydrocarbon emissions
- (11) (15) Uncondensed hydrocarbon emissions
- (12) Fuel
- (13) Combustion products, uncondensed hydrocarbon emissions
- (14) Dried distiller's grain
- (16) Fusel oils, aldehydes
- (17) Uncondensed hydrocarbon emissions
- (18) Treated wastewater
- (19) Sludge
- (20) (22) Uncondensed hydrocarbon emissions
- (21) Ethanol
- (23) Benzene make-up
- (24) Uncondensed hydrocarbon emissions

Figure 2-1. Typical ethanol production from corn feedstock.

stream containing 80 percent ethanol, 19 percent water, and about 1 percent impurities (fusel oils and aldehydes).

The product stream is purified in a rectification column, producing a 95 percent ethanol, 5 percent water azeotrope. The fusel oil and aldehyde impurities are separated and removed in a side stream. These can be combined with the final ethanol fuel product.

Dehydration of the ethanol-water azeotrope is necessary to produce an anhydrous product. A dehydrating agent (benzene) is added to the azeotrope in the dehydration column. The column produces a stream of anhydrous ethanol and a stream containing benzene, ethanol, and water. This latter stream is treated in a chilled separator. The separator produces an ethanol/benzene-rich stream that is recycled to the dehydration column. An ethanol/water-rich stream is also produced in the separator. Ethanol and trace benzene are recovered from this stream in the benzene recovery column and are returned to the dehydration column. The separated water is sent to the wastewater treatment facility.

Typically, the byproduct stillage from the alcohol stripping column is treated to recover the solids, rather than used directly or processed in wastewater treatment. Water is removed from the stream using centrifugation and evaporation. The water from centrifugation is recycled to the cooker or evaporated. The solid product contains proteins and dead yeast and is used as a cattle feed supplement, dried distillers grain (DDG). The DDG drying operation may be fueled by oil or gas. Process steam is produced on-site by a boiler, typically oil- or coal-fired.

2.1.1.2 <u>Emissions and Effluents</u>

The majority of the air pollutants from this process are produced by fuel combustion in the boiler and rotary dryer (see streams 5 and 13 in

Figure 2-1) and consist mainly of particulates, SO_x, and NO_x. Fugitive hydrocarbon (gaseous and condensed) emissions are produced by flash cooling, fermentation, alcohol stripping, rectification, - dehydration, chilled separation, benzene recovery, wastewater treatment, and rotary drying process (streams 7, 10, 11, 13, 15, 17, 20, 22, and 24). Fugitive particulates are produced by corn shelling and grinding (stream 1).

All liquid effluent leaving the plant exits after wastewater treatment (stream 18). The cooling tower blowdown contributes to the wastewater. The rectification and benzene recovery columns also produce wastewater. Equipment washes periodically produce wastewater. Solid wastes include collected coal dust flyash from the coal-fired boiler, sludge from wastewater treatment (stream 19), and collected grain dust from the grinding process (stream 1).

2.1.1.3 Pollution Control Systems

Mechanical particulate collectors or wet scrubbers for flue gas cleaning are used at the boiler and rotary dryer. Mechanical collectors are also used to capture and recycle dust emissions from milling. Condenser vents are used to reduce hydrocarbon emissions from the fermentation tank, columns, and separator. Condensates from the vents are returned to the associated processes. Based on measurements at distilleries, these emissions are minimal and of little concern.

The wastewater treatment system employed is an extended aeration activated sludge unit. This technology was selected primarily because it reflects current operating practices in the beverage-grade alcohol industry. Mean cell residence times of 20 to 30 days (hydraulic retention time of 18 to 36 hours) are typical for this type of unit with a biochemical oxidation demand (BOD) removal efficiency of 75 to 79 percent.

2.1.1.4 Liquid and Solid Waste Disposal

The liquid effluent from wastewater treatment is discharged to a waterway. As stated earlier, the DDG can be used as a cattle feed supplement. In addition, the collected grain dust from milling can be added to th DDG. The remaining process solid wastes, coal dust, flyash, and wastewater sludge, must be disposed of via landfilling or land spreading.

2.1.1.5 New and Emerging Technologies

It is not possible to fully assess the impacts of new and emerging technologies on emissions and effluents. However, there are several new process technologies that could affect the efficiencies and yields of the ethanol fermentation process and should be noted. For instance, gasoline has been substituted for benzene as the dehydrating agent and other dehydrating chemicals are also under investigation. Use of these alternatives could remove the potential for emissions of benzene, a hazardous pollutant. Alternate alcohol/solids/water separation technologies, such as selective adsorption, membrane separation, and supercritical fluid extraction, are being investigated to replace the distillation step.

Continuous fermentation with yeast recycle is possible. In addition, vacuum distillation can be coupled to the process, permitting continuous alcohol removal from the fermenter. New strains of yeasts and better saccharification enzymes are being developed to increase yields.

Finally, anaerobic digestion of the stillage can be implemented. This eliminates drier energy consumption and produces methane that can be burned for process steam generation. The stillage can also be used without drying as a feed supplement, further reducing energy consumption and related emissions. However, the wet stillage must be used immediately since even short-term storage causes the material to become rancid.

2.1.2 Ethanol from Celluloses

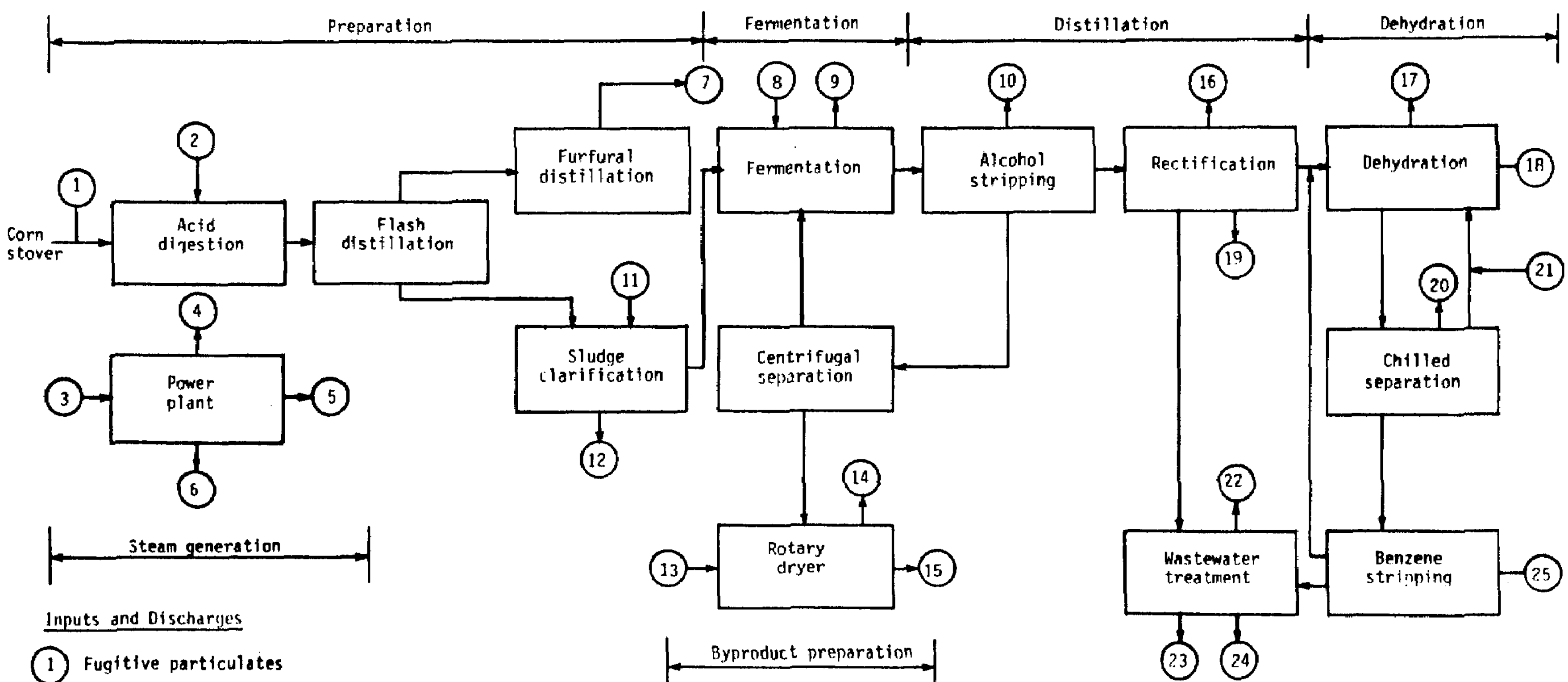
Cellulose is the structural fiber in trees, herbaceous plants, and paper products. This discussion focuses on corn stover as a representative cellulosic feedstock.

2.1.2.1 Process Description

Figure 2-2 is a conceptual flow diagram for a typical ethanol from corn stover process. The process begins by reducing the stover size and breaking down the cellulose into fermentable simple sugars by acid hydrolysis. Dilute sulfuric acid ($\leq$ 5 percent) is contacted with the stover to transform the cellulose. This produces furfural and simple sugars. The solubilized products are separated in a flash distillation step. The sugars are neutralized to remove the contaminants (lignin, etc.) and to alter the pH to provide a proper environment for the fermentation yeast.

The simple sugars are then converted to alcohol and carbon dioxide by the metabolic processes of the yeasts. The fermented mash (approximately 10 percent alcohol) is then pumped to the alcohol stripping column. This distillation column removes the solids and most of the water to produce a stream containing 80 percent ethanol, 19 percent water, and about 1 percent impurities (fusel oils and aldehydes).

The product stream is purified in a rectification column, producing a 95 percent ethanol, 5 percent water azeotrope. The fusel oil and



Inputs and Discharges

1. Fugitive particulates
2. Dilute sulfuric acid
3. Coal
4. Combustion products including PM, NO_x, SO_x
5. Steam
6. Captured particulates
7. Furfural
8. Yeast
9. CO_2, uncondensed hydrocarbon emissions

10, 16. Uncondensed hydrocarbon emissions

11. Lime
12. Lime sludge, lignin, unreacted cellulose, decomposed sugars
13. Fuel oil
14. Uncondensed hydrocarbon emissions
15. Dried stillage

17, 20. Uncondensed hydrocarbon emissions

18. Ethanol
19. Fusel oil, aldehydes
21. Benzene
22. Uncondensed hydrocarbon emissions
23. Treated wastewater
24. Sludge

Figure 2-2. Typical ethanol production from corn stover cellulosic feedstock.

aldehyde impurities are separated and removed in a side stream. These can be combined with the final ethanol fuel product.

Dehydration of the ethanol-water azeotrope is necessary to produce an anhydrous product. A dehydrating agent (benzene) is added to the azeotrope in the dehydration column. The column produces a stream of anhydrous ethanol and a stream containing benzene, ethanol, and water. This latter stream is treated in a chilled separator. The separator produces an ethanol/benzene-rich stream that is recycled to the dehydration column. An ethanol/water-rich stream is also produced in the separator. Ethanol and trace benzene are recovered from this stream in the benzene recovery column and are returned to the dehydration column. The separated water is sent to the wastewater treatment facility.

Typically, the byproduct stillage from the alcohol stripping column is treated to recover the solids, rather than used directly or processed in wastewater treatment. Water is removed from the stream using centrifugation and evaporation. The water from centrifugation is recycled to the fermentation tank or evaporated. The solid product contains unconverted materials and dead yeast. The solids are relatively low in nutrient value and are not typically used as a food supplement. The drying operation may be fueled by oil or gas. Process steam is produced on-site by a boiler, typically oil- or coal-fired.

2.1.2.2 Emissions and Effluents

The majority of the air pollutants from this process are produced by fuel combustion in the boiler and rotary dryer (streams 4, 19) and consist mainly of particulates, SO_x, and NO_x. Fugitive hydrocarbon (gaseous and condensed) emissions are produced by flash cooling, fermentation, alcohol stripping, rectification, dehydration, chilled separation, benzene recovery, wastewater treatment, and rotary drying (process streams 9, 10, 16, 17, 19, 20, 22, and 25). Fugitive particulates are produced by stover preparation (stream 1).

All liquid effluent leaving the plant exits after wastewater treatment. The cooling tower blowdown contributes to the major volume of wastewater. The rectification and benzene recovery columns and equipment washes and blowdown from a scrubber also contribute to wastewater. The distilled furfural can be sold (stream 7). Solid wastes include collected coal dust flyash from the coal-fired boiler, sludge from wastewater treatment, and collected stover dust from the preparation process. Sludge is produced from the neutralization of the hydrolyzed cellulose (stream 12).

2.1.2.3 Pollution Control Systems

Mechanical particulate collectors and wet scrubbers for flue gas cleaning are used at the boiler and rotary dryer. Mechanical collectors are also used to capture and recycle dust emissions from stover preparation. Condenser vents are used to reduce hydrocarbon emissions from the columns, fermentation tank, and separator. Condensates from the vents are returned to the associated processes. Lime addition and sludge clarification are used to capture the unusable fraction of the hydrolyzed wood.

The wastewater treatment system employed is an extended aeration activated sludge unit. This technology was selected primarily because it reflects current operating practices in the beverage-grade alcohol industry. Mean cell residence times of 20 to 30 days (hydraulic retention time of 18 to 36 hours) are typical for this type of unit with a BOD removal efficiency of 75 to 79 percent.

2.1.2.4 Liquid and Solid Waste Disposal

The liquid effluent from wastewater treatment is discharged to a waterway. The remaining process solid wastes, coal and stover-dust, flyash, lime sludge, stillage, and wastewater sludge (streams 1, 12, 15, and 24), must be disposed of via landfilling or land spreading.

2.1.2.5 New and Emerging Technologies

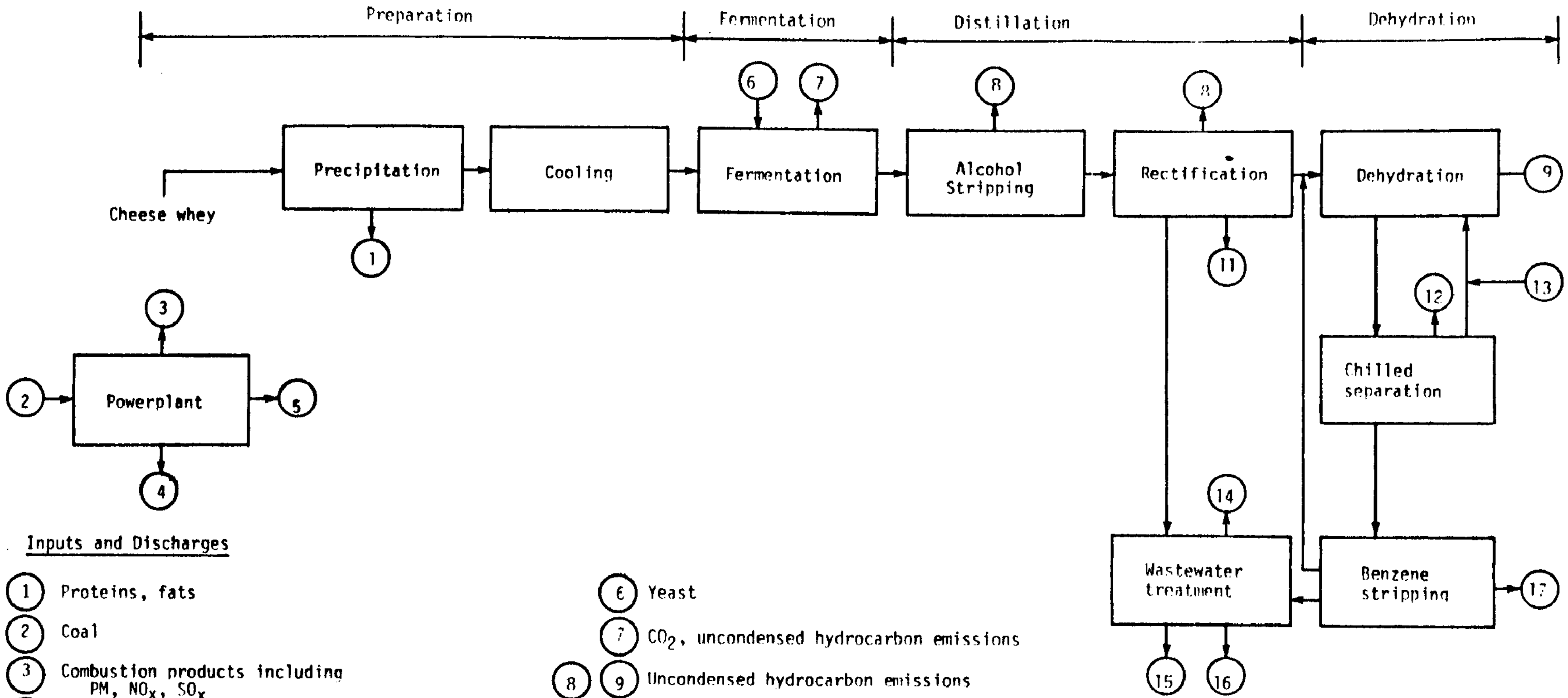
There are several new and developing technologies for increasing the yields and efficiencies of conversion of cellulose to ethanol. For example, there are many different types of hydrolysis, including weak acid pretreatment, strong acid hydrolysis, and enzymatic hydrolysis. An explosive defibration technique to thermo-mechanically break down the cellulose from its contaminants (lignin) is under development. In addition, solvent removal of lignin prior to acid digestion is being investigated. Improved fermentation and alcohol separation technologies that are applicable to starch feedstocks are also applicable to cellulosic alcohol production.

2.1.3 Ethanol from Sugars

Sugars (mono- and disaccharides) are present in many foods, including fruits, sugar beets, sugar cane, and milk. Most sugars can be converted directly to ethanol by yeast. This discussion focuses on lactose from the industrial waste cheese whey as a representative sugar feedstock.

2.1.3.1 Process Description

Figure 2-3 is a flow diagram for an ethanol from cheese whey process. The process begins with raw cheese whey, which is a waste product of the cheese industry. Typical cheese whey consists of water, lactose, and small amounts of proteins and fats. The fats and proteins



Inputs and Discharges

1. Proteins, fats
2. Coal
3. Combustion products including PM, NO_x, SO_x
4. Collected particulates
5. Steam
6. Yeast
7. CO_2, uncondensed hydrocarbon emissions
8. 9. Uncondensed hydrocarbon emissions
10. Gasohol product
11. Fusel oils, aldehydes
12. Uncondensed hydrocarbon emissions
13. Benzene
14. Uncondensed hydrocarbon emissions
15. Treated wastewater
16. Sludge
17. Uncondensed hydrocarbon emissions

are precipitated from the lactose solution by controlled heating and pH adjustment. This eliminates the need for solids removal in the distillation operations. The lactose soultion is cooled and sent to the fermentation tank where it is converted to alcohol and carbon dioxide by added yeast.

The fermented product (approximately 10 percent alcohol) is then pumped to the alcohol stripping column. This distillation column removes the solids and most of the water, producing 80 percent ethanol, 19 percent water, and about 1 percent impurities (fusel oils and aldehydes).

The product stream is purified in a rectification column, producing a 95 percent ethanol, 5 percent water azeotrope. The fusel oil and aldehyde impurities are separated and removed in a side stream. These can be combined with the final ethanol fuel product.

Dehydration of the ethanol-water azeotrope is necessary to produce an anhydrous product. A dehydrating agent (benzene) is added to the azeotrope in the dehydration column. The column produces a stream of anhydrous ethanol and a stream containing benzene, ethanol, and water. This latter stream is treated in a chilled separator. The separator produces an ethanol/benzene-rich stream that is recycled to the dehydration column. An ethanol/water-rich stream is also produced in the separator. Ethanol and trace benzene are recovered from this stream in the benzene recovery column and are returned to the dehydration column. The separated water is sent for wastewater treatment. Process steam is produced on-site by a boiler, typically oil- or coal-fired.

2.1.3.2 Emissions and Effluents

The majority of the air pollutants from this process are produced by fuel combustion in the boiler (stream 3) and consist mainly of particulates, SO_x, and NO_x. Fugitive hydrocarbon emissions are produced by flash cooling, fermentation, alcohol stripping, rectification, dehydration, chilled separation, benzene recovery and wastewater treatment (streams 7, 8, 9, 12, 14, and 17).

All liquid effluent leaving the plant exits after wastewater treatment. The cooling tower blowdown contributes to the major volume of wastewater. The rectification and benzene recovery columns also produce wastewater. Equipment washes periodically produce wastewater.

Solid wastes include collected coal dust, flyash from the coal-fired boiler, sludge from wastewater treatment, and precipitated proteins and fats from the whey (streams 1, 3, and 16).

2.1.3.3 Pollution Control Systems

This process includes the use of mechanical particulate collectors or wet scrubbers for flue gas cleaning at the boiler. Condenser vents are used to reduce hydrocarbon emissions from the fermentation tank, columns, and separator. Condensates from the vents are returned to the associated processes.

The wastewater treatment system employed is an extended aeration activated sludge unit. This technology was selected primarily because it reflects current operating practices in the beverage-grade alcohol industry. Mean cell residence times of 20 to 30 days (hydraulic retention time of 18 to 36 hours) are typical for this type of unit with a BOD removal efficiency of 75 to 79 percent.

2.1.3.4 Liquid and Solid Waste Disposal

The liquid effluent from wastewater treatment is discharged to a waterway. The remaining solid wastes, coal dust, flyash, and wastewater sludge, must be disposed of via landfilling or land spreading. The precipitated fats and proteins are also landfilled.

2.1.3.5 New and Emerging Technologies

It is not possible to fully assess the impacts of new and emerging technologies on emissions and effluents. However, there are several new process technologies that could affect the efficiencies and yields of the ethanol fermentation process and should be noted. For instance, gasoline has been substituted for benzene as the dehydrating agent. Other dehydrating chemicals are also under investigation. Alternate chemicals could remove the potential for benzene emissions. Alternate alcohol/solids/water separation technologies, such as selective adsorption, membrane separation, and supercritical fluid extraction, are being investigated to replace the distillation steps.

Continuous fermentation with yeast recycle is possible. In addition, vacuum distillation can be coupled to the process, permitting continuous alcohol removal from the fermenter. New strains of yeasts and better saccharification enzymes are being developed to increase yields.

2.2 ON-FARM ETHANOL PRODUCTION

In general, on-farm ethanol production will use technologies identical to those used in commercial-scale production. However, the smaller size of the on-farm process causes some notable differences, especially in regard to pollution control equipment.

2.2.1 Process Description

In the near-term, on-farm ethanol production will use corn as a feedstock. The process will be identical to the commercial process, except for the following:

1. A low-pressure boiler (firetube) will be used to allow easy operation by a farmer. It will be oil-, gas-, or waste-fired in most cases.
2. If corn is used as the feedstock, the stillage from the alcohol stripping column will not be dried. It will be used directly as a cattle feed supplement. This neccesitates immediate usage since even short-term storage will cause the stillage to become rancid.
3. Wastewater and stillage will not be treated on-site.

2.2.2 Emissions and Effluents

The emissions and effluents from the on-farm process will be the same as in commercial production, except that there will be no drier emissions.

2.2.3 Pollution Control Systems

The on-farm system will be very small and will have few pollution control systems. The boiler will be uncontrolled because of its small size. There will not be any condenser vents on the fermentation tank and distillation/dehydration columns. Also, no dust collection devices will be used. The wastewater will be discharged to an existing wastewater system. On-site wastewater treatment will not be available.

2.2.4 Liquid and Solid Waste Disposal

The stillage, although undried, will be disposed of as on-site cattle feed if feasible. Wastewater will be discharged and not treated on-site.

2.2.5 New and Emerging Technologies

The new technologies potentially affecting on-farm ethanol production are the same as those in commercial application, with the exception of supercritical fluid extraction of ethanol. This process is not applicable to on-farm processes because of its complexity and cost. Increased automatic control (especially with a continuous fermentation system) would be a major improvement, but this would not alter the process or effluents.

2.3 OTHER ALCOHOL FUELS PRODUCTION

The production of methanol and butanol fuels is technically feasible, although the technologies are not as ready for commercialization as ethanol production technologies. This section describes the production of methanol via catalysis of synthesis gas and the production of butanol via biological conversion.

2.3.1 Methanol Via Catalysis of Synthesis Gas

Methanol is produced by the catalytic reaction of hydrogen and carbon monoxide at a temperature of approximately 315°C and a pressure of 105 to 350 kg/cm^2 ($2H_2 + CO \rightleftharpoons CH_3OH$). The hydrogen and carbon monoxide precursors can be generated in several fashions. The gases are available from industrial off-gases or from the gasification of carbonaceous feedstocks. These carbonaceous feedstocks include coal, lignite, peat, and the celluloses, wood, refuse-derived fuel, and biomass.

The gasification of these feedstocks can occur at different temperatures and pressures. This discussion concerns itself with atmospheric pressure, air-fed gasifiers, which have been demonstrated with all of the carbonaceous feedstocks. The gasifiers reform the carbonaceous feedstock into a crude gas, consisting mainly of hydrogen, carbon monoxide, and carbon dioxide. The crude gas is scrubbed to remove organics and then compressed to approximately 10 kg/cm^2. The gas is subsequently passed through a hot potassium carbonate scrubber and a monoethanolamine scrubber to remove the carbon monoxide.

The CO_2-free gas is treated cryogenically to remove methane, hydrocarbons, and nitrogen. The gas is compressed to approximately 30 kg/cm^2 and reacted over an iron shift catalyst. Water vapor and carbon monoxide are reacted to form hydrogen. Enough gas is reacted until the requisite hydrogen-carbon monoxide ratio is reached (2:1).

The CO_2 produced during this shift catalysis is removed in another potassium carbonate scrubber. The synthesis gas is compressed to approximately 175 kg/cm^2 and fed to the nickel chrome catalytic reactor. These reactor products are distilled in two columns to remove the light ends and higher alcohols from the methanol product.

The major effluent from this process is the solid residue from the feedstock gasification, which contains feedstock inerts and some carbon. This is disposed of by landfill. The major source of wastewater is from the hydrocarbon scrubber just downstream of the gasifier. This water contains particulates as well as hydrocarbons and requires appropriate wastewater treatment.

There will be fugitive hydrocarbon emissions from the distillation columns and scrubbers. Condenser vents will be used to control these.

2.3.2 Butanol Production Via Biological Conversion

Butanol can be produced biologically from pentoses in a process similar to ethanol fermentation. This process is still under evaluation and development, and only a short discussion of it is possible at this time.

Pentoses are produced via hydrolysis of pentosans found in cellulosic wastes or grain. These simple sugars are fermented with a select strain of yeast that enzymatically converts the five-carbon sugar into butanol and carbon dioxide. Subsequent process steps refine the alcohol and remove the water, solids, and other hydrocarbons. Fuel-grade butanol is the final product.

The exact process characteristics of this alcohol production technology are not certain. The process is very similar to ethanol fermentation from cellulosic feedstocks. Based on this, it is expected that the emissions and effluents, control technologies, and disposal characteristics will be similar.

SECTION 3

THE STANDARDS SUPPORT SCHEDULE

3.1 DESCRIPTION OF THE SCHEDULE

The heart of an SSP is the schedule showing the temporal relationships among the various activities required to develop standards for a source category. Specifically, the schedule shows how IERL-Ci will support the development of standards by indicating the laboratory's commitment to carry on various research activities prior to and concurrent with Program Office dates for the development of standards. As a result of these efforts, several reports will be prepared and a sampling and analysis (S&A) program on fuel-grade alcohol production facilities will be carried out. The timeline for the various studies and the content of each of the activities are discussed in Section 3.2. Section 3.3 explains the responsibilities and working interactions between IERL-Ci, Region VII, and the various Program Offices.

As indicated previously, this SSP was developed with the consensus of the cognizant Program Offices: OWPS/EGD, OAQPS/ESED, and OSW/HIWD. Since the original impetus for such a study came from an increase in requests for permits for fuel-grade alcohol production facilities on the farms in Region VII, representatives of Region VII also participated in the development of the plan. Through a series of meetings the salient elements and requirements of the research study in terms of Program Office needs were discussed. Based on these discussions, the time framework for the various studies and an S&A program were developed for both commercial and on-farm fuel-grade alcohol producing facilities. Additionally, responsibilities for certain elements of the plan were delegated. The specific details of the time framework of and responsibilities within the IERL-Ci research program are discussed in Section 3.2.

3.2 PROGRAM SCHEDULE

As a result of a series of meetings among IERL-Ci, the Program Offices, and Region VII, a program schedule evolved for the research effort required to establish the need and/or basis for environmental standards applied to fuel-grade alcohol production. Initially, the production of ethanol, methanol, and butanol was considered; however, the current plan has been limited to ethanol production, which will dominate in the near term. As will be discussed, future consideration will be given to the other two alcohol fuels.

There are four important phases to this research: (1) information surveys of the processes, (2) engineering analysis, (3) environmental data acquisition, and (4) documentation including a Pollution Control Guidance Document (PCGD), a Health and Ecology Effects Report, and an Environmental Assessment Report (EAR). Based on the above, the Program Offices will determine the appropriate standards as required. Figure 3-1 shows the schedule for the various activities and the relationship agreed upon by the agency offices.

The activities discussed in this SSP are limited to the production of ethanol; they focus on processes using grain as a feedstock, but also include those which use industrial waste stocks, such as cheese whey and cellulosic materials as inputs. The program distinguishes between

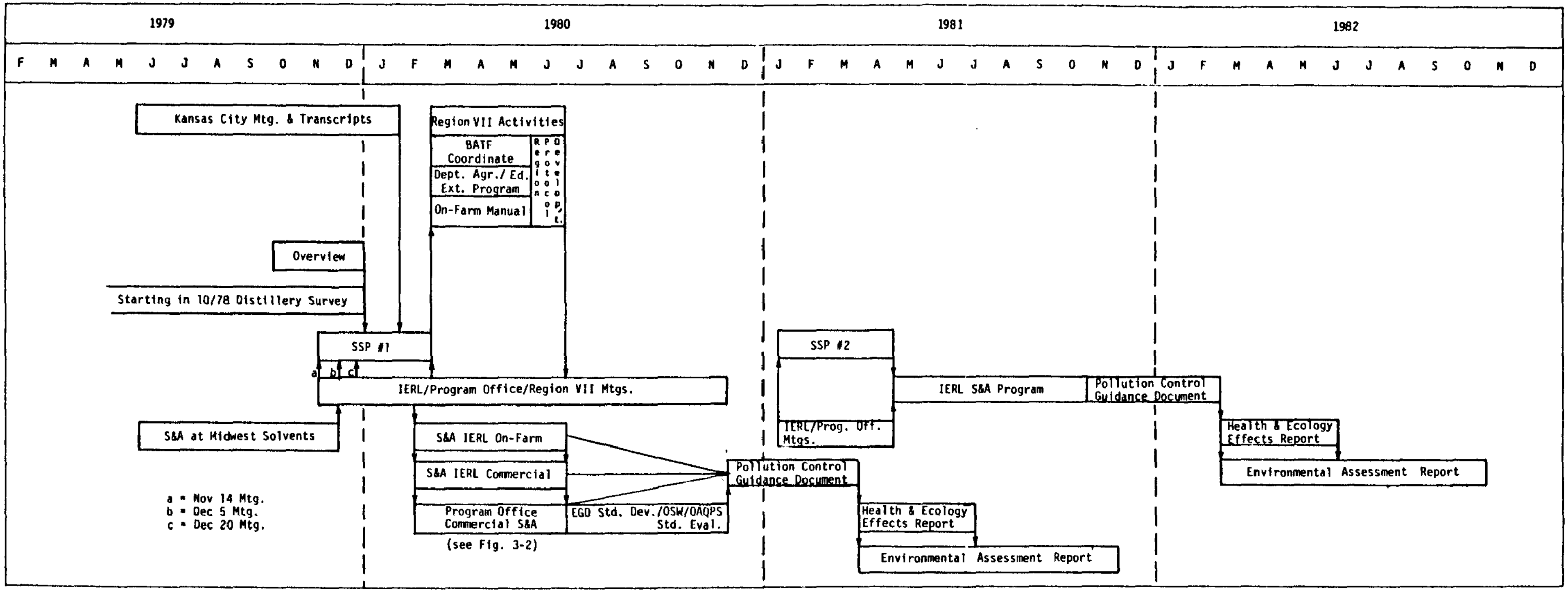


Figure 3-1. IERL program schedule for gasohol.

commercial production and on-farm production for private use by an individual farmer. The latter appears to be increasingly important as more farmers are turning to alcohol fuel to ensure an adequate energy supply for their needs.

The following briefly describes each of the elements of the Gasohol program shown in Figure 3-1.

- <u>Information Surveys</u>
  - -- The Gasohol Overview Report is an update of similar overview reports by the Office of Technology Assessments (OTA) and the Department of Energy (DOE), but from an EPA perspective. This report focuses on an examination of the state-of-the-art technology, the economics, environmental issues, impediments to wide-spread use, and Federal initiatives to promote gasohol's use.
  - -- A review of major existing ethanol production facilities, listing the major U.S. producers of ethanol, whether the product is used for fuel or not (i.e., includes some distilleries), and the salient information about each operation.
  - -- The transcript of a meeting at Region VII, Kansas City, presents an overall discussion and information transfer on the subject of gasohol, including environmental, economic, and energy issues.
- <u>Engineering Analyses</u>
  - -- IERL has previously supported a study at Midwest Solvents (MWS) plant. Information developed in that study was the basis for the analysis to determine the extent of the

potential environmental problems associated with fuel-grade alcohol production and the media specific priorities and analytical detail required in continued research directed toward these facilities.

-- Based on the review of major existing ethanol production facilities, the important characteristics of near-term technologies and feedstocks were determined and typical facilities identified for continued study.

- Environmental Data Acquisition

  -- An S&A program has been planned for each of the three media: water, solid, and air discharges. The IERL S&A program was developed in consensus with the three Program Offices and Region VII. The data provided by this program will be used in the preparation of a PCGD -- see below -- and will be of assistance in permit writing and standards development. The choice of commercial facilities resulted from a review of the existing facilities listed in the ethanol production survey. The facilities selected by IERL and the Program Offices are shown in Table 3-1. It should be noted that the MWS plant had previously been studied by IERL, except for trace metals. Additional samples will be obtained by Region VII and analyzed for trace metals by EGD. Two on-farm facilities will be investigated in addition to the commercial plants. Table 3-2 lists agency office responsibilities by activity and agency office. The test matrix is shown in Table 3-3. The bases for this matrix are the results obtained at MWS.

TABLE 3-1. SUMMARY OF S&A INTEREST IN ALCOHOL PRODUCTION PLANTS BY PROGRAM OFFICES/ORD

Plant	Program Office/ORD Involvement[a]			
	OWPS/EGD	OSW/HIWD	OAQPS/ESED	ORD/IERL
Midwest Solvents	C*	C	C	C*
Georgia-Pacific	I	NI	NI	I
American Distilling	I	I	C	I
Milbrew	I	I	I	I
Muscatine	I	I	I	I
Natick	I	I	NI	I
On-Farm (2)				I

[a]Legend
- I -- Interested
- NI -- No interest
- C -- Sufficient testing completed
- * -- Need trace metal analysis for completion; to be sampled by Region VII and analyzed by EGD

TABLE 3-2. AGENCY OFFICE RESPONSIBILITIES

Activity	Responsible Agency Office
Overview Report	ORD/IERL-Ci
Alcohol Production Survey	ORD/IERL-Ci
Information Transfer Meeting at Kansas City	ORD/IERL-Ci & Region VII
S&A Study at MWS	ORD/IERL-Ci
SSP for Ethanol Production (Meeting of Agency Offices)	ORD/IERL-Ci
S&A On-Farm Facilities	ORD/IERL-Ci & Region VII
S&A Commercial Facilities (Air)	ORD/IERL-Ci
S&A Commercial Facilities (Water & Solids)	OWPS/EGD
Standards Development	Program Offices
Regional Enforcement Model	Region VII
Environmental Operation Manual	ORD/IERL-Ci & Region VII
PCGD	ORD/IERL-Ci
EAR (with Health and Ecology Effects Report)	ORD/IERL-Ci
Continued Research	ORD/IERL-Ci

TABLE 3-3. SAMPLING AND ANALYSIS PROGRAM MATRIX

I. On-Site Sampling/Analysis*

Solids: Two locations -- dryer waste, coal

Sample dryer waste five times/day for 3 days, therefore, 15 samples or three daily composites

Sample one coal/test

Liquids: Four locations -- influent, effluent, sludge, makeup

Each location sampled five times/day for 3 days, therefore,
five samples/day x 3 days/plant x four locations = 60 samples or three daily composites at each location

Air: Two locations (i.e., dryer vent and grain handling)

Test each location once/day for 3 days

Test Type	Method
Particulate	EPA Method-5
NO_x	EPA Method-7
SO_2	EPA Method-6
CO, CO_2, O_2	EPA Method-3
Hydrocarbons	GC w/FID

II. Laboratory Analysis

Solid Streams: Phenols, Cyanides, Ammonia Sulfate, Sulfites, Nitrates, 22 Metals, Including Solid Extraction

Organics by GC/MS, Acid Fraction, Base Neutral Fraction, Pesticides

Liquid Stream: Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), Total Suspended Solids (TSS), Phenols, Cyanides, Ammonia

Nitrates, Sulfates, Sulfites, 22 Metals

Organics by GC/MS, Volatile Organic Analysis (VOA), Acid Fraction, Base Neutral Fraction, Pesticides

Air Stream: Particulate -- Sulfates, Nitrates

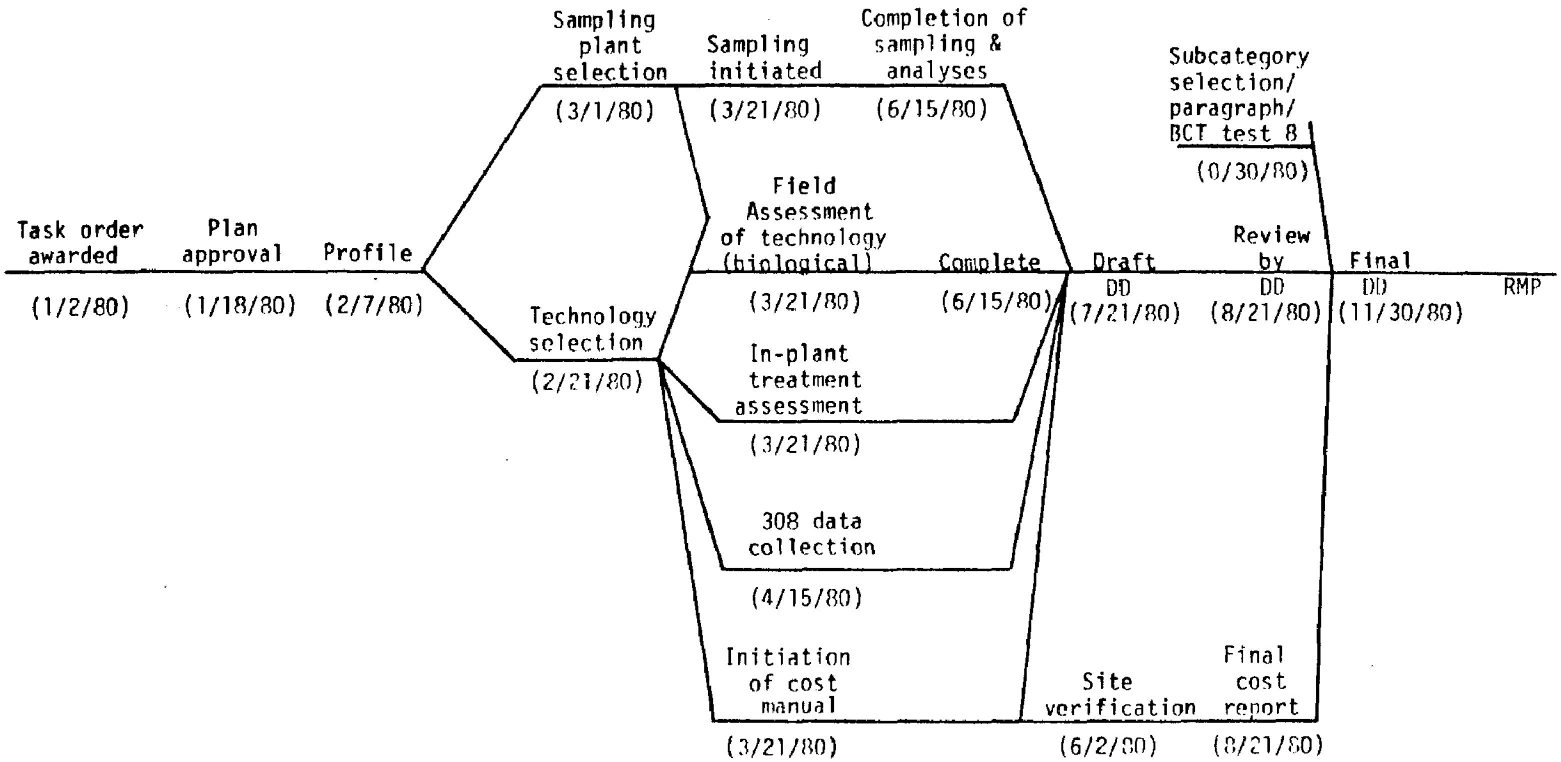
*The sample frequency is site specific; the above is only typical of the level of effort.

-- The sampling and analysis will be coordinated with the Program Office efforts. Figure 3-2 shows a schedule for effluent guidelines development leading to the establishment of water effluent standards, if warranted. OSW will establish priorities based on this S&A program regarding future standards that may be enforced through their permitting system. OAQPS will use the results to establish the need for developing a New Source Performance Standard (NSPS) for ethanol production. At present, however, they do not anticipate a need for an NSPS for air emissions.

- <u>Documentation</u>

  -- The PCGD report will define the processes currently in use (both commercial and on-farm), characterize the process flow and emission streams, identify options for management and control of waste streams, and provide information on expected environmental control costs. The PCGD will be based on the results of the S&A program and the engineering analyses. As shown in Figure 3-2, EGD plans to publish a draft Development Document (DD) based on their standards development activities prior to the planned start of the PCGD. Before actually starting the PCGD, the DD will be reviewed to determine its adequacy in replacing (eliminating the need for) the PCGD.

  -- The Environmental Operations Manual will provide guidance to the BATF on what environmental questions should be examined when issuing their permit for a still and



Approximately 10 plants will be sampled.
One project officer full time is required.

Figure 3-2. Gasohol effluent guidelines development.

practical advice to the farmers on how to manage wastes from their on-farm processes. As part of this activity, Region VII will establish a liaison with the Department of Agriculture/Educational Extension to develop a program assuring farmer awareness of the environmental impacts and proper operational practices to acceptably minimize these impacts. It is also planned to monitor the initial on-farm installation through a cooperative effort by the BATF, who inspects facilities before start-up as part of their permit process. The manual and protocol established by Region VII will be used as a model for other Regions.

-- The results of the IERL program will form the basis for the preparation of a Health and Ecology Effects Report which is one of the essential elements of an EAR. Environmental Assessment Reports are designed to provide a comprehensive overview for a given technology. An EAR dealing with alternative modules that comprise a given system within a given technology is prepared by drawing together technical, economic, and environmental impact data for that system. The major topics addressed are process description, characterization of input materials, products and waste streams, performance and cost of control alternatives, analysis of regulatory requirements, and environmental impacts.

As a result of the meetings between IERL-Ci, the Program Offices, and Region VII, responsibilities for the various activities identified in this SSP were assigned. EGD will carry out the solid and liquid waste S&A

program for the commercial units. Two of the commercial units will be sampled for air emissions, and a complete sampling program for solid, liquid, and air effluents will be carried out at two on-farm facilities. Responsibility for these tests lies with IERL-Ci. A manual will be produced to serve as a guideline to the farmers who construct or install fuel-grade alcohol production facilities and to the Bureau of Alcohol, Tobacco and Firearms (BATF) who issues permits with respect to BATF regulations. The preparation of this manual will be the responsibility of IERL in conjunction with Region VII. Region VII is also responsible for developing cooperation between the Department of Agriculture/Educational Extension and the BATF. Through the establishment of these contacts and the development of a regulatory procedure, Region VII will serve as a model region with respect to the control of on-farm facilities.

As stated previously, the IERL program has focused on current technology for the production of ethanol. As the alcohol fuels industry progresses, additional technologies and feedstocks will be developed for ethanol production, and other alcohols, e.g. methanol and butanol, may become more important. For these reasons, the IERL program will continue beyond that currently planned in the SSP. Since several of the developments indicated are expected to be, at least, in pilot-plant stage by 1981-1982, it is recommended that a second SSP on fuel-grade alcohol production be prepared in April 1981, followed by a second PCGD presenting an engineering analysis of emerging production capabilities.

3.3 RESPONSIBILITIES AND WORKING INTERACTIONS

The responsibilities and working interactions that have been developed under this SSP stem from the overall mission of each group involved. These are shown in Table 3-3. ORD's role is to respond to the needs of the Program Offices to obtain the data necessary for those offices to establish appropriate standards. In addition, they are to provide guidance to the users of alcohol facilities, the Regions, and the Program Offices to quantify effects beyond those required by the Program Offices in order to fully understand the environmental impact of the facilities under study. The responsibilities developed during the organization meetings clearly respond to these missions.

IERL-Ci is responsible for the generation of the background data and the appropriate S&A program, both of which will lead to the generation of a PCGD and an EAR. Additionally, at the termination of the current SSP, IERL will be involved in looking at the emerging technologies for fuel-grade alcohol production. Should these appear important, more SSP's and/or PCGD's will be generated.

The Program Offices are required to establish the appropriateness of emissions standards to assure that no significant environmental damage will result from the facilities under study. They also must develop data of a type and quality needed for legally defensible standards and to ultimately promulgate the standards required. Since OAQPS does not anticipate needing standards in this area, their responsibilities to the program are minimal. However, for solid and liquid wastes, EGD will assume the responsibility for carrying out a portion of the ORD/IERL-Ci S&A program. These activities, occurring at the commercial facilities identified, result from general interest in promoting the new development of these sources and the immediacy of obtaining data to assess their impact.

The Regions have the responsibility of enforcing the standards, normally through permits (such as under the National Pollution Discharge Elimination Systems, or NPDES, for sources discharging a liquid), and putting into place mechanisms to alert the EPA to potential problems due to the proliferation of fuel-alcohol facilities. As part of this role, they are developing liaisons with both the Agricultural Department/ Educational Extension and the BATF, assisting with the development of the Environmental Operations Manual, and identifying the on-farm facilities to be studied. These liaisons and the resulting mechanisms developed in Region VII will serve as a model for other regions dealing with the buildup of fuel-grade alcohol facilities on the farm.

The organizational units involved in this study have designated individuals as principal contacts for the program. Table 3-4 lists the organizational unit, the responsible person, and the address and phone number for that person.

TABLE 3-4. ALCOHOL FUEL/ENERGY COORDINATORS/CONTACTS

ORD/IERL-Ci	Robert Mournigham	(513) 684-4334
OAQPS/ESED	Dave Markwordt	(919) 629-5371
OWPS/EGD	John Lum	(202) 426-2707
OSW/HIWD	Yvonne Carbe	(202) 755-9190
ORD/EPD	David Berg	(202) 755-0205
Region 1	Dick Keppler	(617) 223-3477
Region 2	Paul Pruchan	(212) 264-7665
Region 3	Bernard Purinski	(215) 597-9944
Region 4	Frank Redmond	(404) 257-3004
Region 5	Jim Phillips/Cliff Risley	(213) 886-6054
Region 6	John Accardi	(214) 729-2650
Region 7	Charles Hajinian	(816) 758-2921
Region 8	Terry Thoem	(303) 327-5914
Region 9	Carl Kohnert	(415) 556-7858
Region 10	George Hofer	(206) 399-1125

SECTION 4

DISCUSSION OF THE STANDARDS SUPPORT PLAN ELEMENTS

To provide a perspective on the future importance and potential environmental impact of this source category, the status and projected development of the alcohol-for-fuels industry is described in Section 4.1. Regulatory requirements for EPA and the Bureau of Alcohol, Tobacco and Firearms (BATF) that could apply to these sources under existing statutes are discussed in Section 4.2, as are the responses of these agencies to these legislative mandates.

4.1 ALCOHOL FUELS DEVELOPMENT

Alcohol fuels represent an important source of domestic renewable energy. The use of alcohol in motor vehicles is not a new technology. The Model T Ford was designed to run on alcohol, gasoline, or any mixture of the two fuels. However, as gasoline became relatively inexpensive and plentiful, the market for alcohol fuels diminished. The recent increases in the price of petroleum products and the planned reduction of United States dependency on foreign sources of energy has led to an increase in the demand for alcohol fuels. (For Section 4.1, see References 4-1, 4-2, and 4-3.)

4.1.1 Potential Oil Savings from Alcohol Fuels

The amount of oil that alcohol fuels can displace is equal to the amount of oil they save or replace in combustion processes minus any difference in the amount of oil used to produce each fuel. Two alcohol fuels, ethanol and methanol, are commercially available today. In the near term (1980 to 1985), ethanol will be the alcohol fuel available in significant quantity for use in the commercial fuel market. A mixture of 10 percent ethanol and 90 percent gasoline, called gasohol, can be used in motor vehicles without engine modifications.

Ethanol used in gasohol not only extends gasoline supplies by replacing 1 gallon of gasoline for every 10 gallons of fuel consumed, but also acts as an octane enhancer. Since the presence of alcohol in gasohol increases the octane rating, the reforming requirements for the production of the unleaded fuel are reduced. This reduction increases the production yield and decreases the amount of heating oil required in the reforming process. The combined effect of these two savings further increases alcohol's value relative to gasoline. Industry estimates that these effects merit a premium of roughly $0.10 per gallon of alcohol.*

4.1.2 Supply and Demand

Current demand for gasohol is increasing. The National Gasohol Commission estimates that the number of retail outlets selling gasohol have increased from 500 in March 1979 to about 2,000 in October 1979. Three factors contribute to the increase in demand for gasohol. These are:

- Driver perceived improved vehicle performance from higher octane ratings than those of unleaded gasolines
- Consumer preference (particularly by residents of farm states) for vehicle fuels derived from renewable agricultural products

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*At 1979 prices.

- Lower selling price at the pumps than higher octane unleaded gasolines because the $0.04 Federal tax is not applied to gasohol
- Government incentives including eligibility of alcohol fuels for DOE entitlements worth approximately 2 to 3 cents per gallon. U.S. Department of Agriculture has made loan guarantees available for alcohol pilot plants.

The U.S. is currently producing 80 million gallons of ethanol for fuel use per year (4,000 barrels per day). By 1982 ethanol production is expected to reach 300 million gallons per year (20,000 barrels per day). Increased ethanol production will come primarily from excess distillery capacity and expansions in currently operating facilities. By 1985, if the proposed Federal incentives materialize, ethanol production could reach 500 to 600 million gallons per year. This level of production is beyond the capacity of existing facilities and would occur only with the construction of new facilities. The design, construction, and startup of a new ethanol facility can take 1 to 3 years, depending on the size of the plant.

Wine producers throughout the United States are currently investigating the feasibility of producing fuel-grade alcohol. At this time, it is not possible to accurately project what impact these facilities would have on the alcohol fuels industry. However, a number of refineries have the capacity to produce 100 million gallons of alcohol per year.

Beyond 1985 ethanol production will depend on:

- The availability of inexpensive feedstocks
- New technological developments that decrease capital and energy requirements and, therefore, the cost of conversion
- The relative cost of competing fuels

Methanol derived from coal is also an attractive alternative for extending U.S. supplies of high quality liquid fuels. However, it is unlikely that methanol will be used extensively before 1990, when new conversion facilities should be operating. At present economies of scale, profitable plants must be large, producing 20,000 to 50,000 barrels per day. A plant of this size requires an investment of $500 million to $1 billion and can take up to 4 years to build. Once such facilities are in operation, methanol could be produced more economically and in larger quantities than ethanol.

Originally methanol was made from wood, hence the common name wood alcohol. Today methanol is made almost entirely from natural gas and oil. In 1976 the U.S. produced 1.2 billion gallons of methanol, primarily from these fossil fuels. In the future production of methanol will most likely come from coal, wood, and agricultural residues.*

Methanol has essentially the same octane enhancing characteristics as ethanol. However, the use of methanol in quantities greater than several percent requires modifications to existing engines.

In the long term (late 1980's and beyond) methanol is being considered for use in gas turbines and may also be used as a petrochemical feedstock. Diesel engines, boilers, and utility fuel cells may be potential future uses for methanol, but additional research and development are required.

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*Methanol produced by the liquefaction of coal and gasoline produced from such coal-derived methanol are under investigation by EPA as part of the Indirect Liquefaction Program. These processes will be the subject of separate PCGD's and EAR's.

If adapting motor vehicles and/or distribution systems to accommodate methanol proves to be difficult, it may be converted directly to high quality gasoline or MTBE, which is chemically closer to petroleum. Methanol/ethanol/gasoline blends are also under consideration; however, at this point it is impossible to project what the proportions of each fuel might be and what the market penetration will be in 1985 and beyond.

4.1.3 Biomass Availability

Approximately 800 million dry tons of biomass are available annually for alcohol production. By the year 2000 it is projected that over 1.1 billion tons will be available. Available feedstocks are generally those feedstocks that are noncompetitive. For example, "available wood" does not include wood that would be used for lumber or paper. Available grain crops are residues and grains not needed for projected demands of food, feed, or for export. A breakdown of the projected biomass resource availability is shown in Table 4-1.

In order to estimate the amount of alcohol fuels that could be produced from available feedstocks, it is necessary to consider the conversion processes currently demonstrated, those expected to be demonstrated in the future, and the resulting conversion efficiencies of each process.

Conversion of all grains, sugar crops, and food processing wastes could yield a maximum of 4.4 billion gallons of ethanol per year by 1980, rising to 12.2 billion gallons in the year 2000. Ethanol production potential could be greatly increased by conversion of wood, agricultural residues, and municipal solid waste (MSW) to ethanol. In 1980 ethanol

TABLE 4-1. PROJECTED MAXIMUM U.S. BIOMASS AVAILABLE FOR ALCOHOL PRODUCTION
(million dry tons per year)

Biomass Source	1980		1985		1990		2000	
	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent
Wood[a]	499	61	464	56	429	49	549	48
Agricultural residues	193	23	220	26	240	28	278	24
Grains[b]	38	5	38	5	28	3	23	2
Sugars[b]	--	--	8	1	69	8	172	15
Municipal solid waste (MSW)	86	10	92	11	99	11	116	10
Food processing wastes	6	1	7	1	8	1	10	1
Total	822	100	829	100	873	100	1,148	100

[a]Assumes wood from sivicultural energy farms starting in 1995
[b]Estimates for grains and sugars assume development program to establish sweet sorghum as a cash crop

production could reach 39.2 billion gallons per year, rising to 54.0 billion gallons per year by 2000.

Table 4-2 shows the projected maximum alcohol production from U.S. biomass resources. It is important to note that the ethanol and methanol quantities cannot be added because the same feedstock resources are assumed to be used for one or the other. Conversion of wood, agricultural residues, and MSW could produce 128.3 billion gallons of methanol by 1980. However, due to the lack of existing facilities, it is highly unlikely that there will be significant methanol production before 1990. In the year 2000 sufficient biomass could be available to produce either 54.0 billion gallons of ethanol or 154.7 billion gallons of methanol. These figures represent a physical -- though not necessarily economic -- possibility of alcohol fuels production. Actual alcohol fuels production will be considerably less than physical capacity.

4.2 REGULATORY REQUIREMENTS AND PLANS

4.2.1 Bureau of Alcohol, Tobacco, and Firearms

The BATF is responsible for administering the laws in the Internal Revenue Code relating to distilled spirits (alcohol). The code (26 U.S.C., Section 5002) defines distilled spirits as those substances known as ethyl alcohol, ethanol, or spirits of wine, including all dilutions and mixtures thereof, from whatever source, by whatever process produced. Although these laws relate primarily to the beverage alcohol industry, all producers of alcohol must comply with them. The primary responsiblity of BATF is to protect revenue. (For Section 4.2.1, see References 4-4 and 4-5.)

There are two types of distilled spirits plants (DSP's) currently authorized by law: commercial DSP's and experimental DSP's. Under the

TABLE 4-2. PROJECTED MAXIMUM ALCOHOL PRODUCTION FROM U.S. BIOMASS RESOURCES
(billion gallons per year)

Biomass Source	1980		1985		1990		2000	
	Ethanol	Methanol	Ethanol	Methanol	Ethanol	Methanol	Ethanol	Methanol
Wood[a]	23.5	86.3	21.8	80.2	20.2	74.2	25.8	95.0
Agricultural residues	9.1	33.4	10.3	38.1	11.3	41.5	13.1	48.1
MSW	2.2	8.6	2.3	9.2	2.5	9.9	2.9	11.6
Subtotal	34.8	128.3	34.4	127.5	34.0	125.6	41.8	154.7
Sugars	--	--	0.4	--	3.7	--	9.0	--
Grains	3.9	--	3.8	--	2.8	--	2.3	--
Food processing wastes	0.5	--	0.6	--	0.7	--	0.7	--
Subtotal	4.4	--	4.8	--	7.2	--	12.2	--
Total	39.2	128.3	39.2	127.5	41.2	125.6	54.0	154.7

law, a commercial facility can produce beverage or industrial alcohol. Qualification as a commercial facility requires registering the plant, obtaining an operating permit, filing a bond, having a continuous and closed distilling system, and providing adequate facilities for all operations including production, warehousing, denaturation, and bottling. Extensive requirements also govern the location, construction, arrangement, and protection of the facility. These commercial facilities are areas under direct onsite supervision by BATF inspectors. The law also requires that in order for alcohol to be removed from the facility free of tax, it must be denatured; this denaturation renders the alcohol unfit for beverage use.

The second type of DSP, the experimental facility, is authorized by law to produce alcohol for experimental or developmental purposes only; no alcohol may be sold or given away. Generally the duration of the operating permit is 2 years. Because of these limitations, the experimental DSP is not subject to the extensive controls and requirements mandated for a commercial facility.

In the first 7 months of 1979, BATF received over 2,000 applications for experimental DSP's. All of these applications were for production of fuel-grade alcohol, and most were by individuals who wanted to produce fuel-grade alcohol for their personal use. Although it is not clear if the use of the experimental provision was intended for the production of fuel-grade alcohol, BATF has moved to approve these applications since there is no other provision under current law, and they do not wish to hinder the production of fuel-grade ethanol.

In an effort to provide a long-term solution to regulation of the production of fuel-grade alcohol, BATF has presented to Congress changes to the Internal Revenue Code. The submitted proposal will provide BATF with the flexibility required to meet the needs of the alcohol fuels industry. The proposed changes establish a third type of DSP, the fuel producer.

Under the proposed plan, the fuel producer will be regulated in direct proportion to the danger of loss of revenue, based on production. There will be three categories, or sizes, of producers. They are:

- Small producers -- producing less than 5,000 (100 proof) gallons of alcohol per year
- Medium producers -- producing less than 100,000 (100 proof) gallons of alcohol per year
- Large producers -- producing over 100,000 (100 proof) gallons of alcohol per year

While specific regulatory controls will vary at each level of production, all fuel alcohol plants will be required to: file a simplified application; denature their alcohol; maintain security necessary to prevent diversion of alcohol to uses other than fuel; and maintain limited records with respect to production and disposition of the alcohol. The small producer would not be required to file a surety bond, but the medium and large producers will.

Commercial distillers are currently required to denature alcohol using specified formulae requiring substances such as gasoline, kerosene, and other chemicals. Denaturation must be conducted under the direct supervision of BATF inspectors or through metered systems. Under the proposal, BATF will work with the fuel producer to develop an acceptable formula that will meet the needs of the individual producer.

As previously mentioned, the primary responsibility of BATF is to protect revenues. However, BATF has certain responsibilities under the National Environmental Policy Act (NEPA) of 1969, the Federal Water Pollution Control Act of 1972 (FWPCA) as amended in 1977, and the National Historic Preservation Act (NHPA) of 1966 as amended. BATF has published a handbook on environmental protection that serves as a guideline for BATF personnel to ensure compliance with the above mentioned laws. The IERL program for gasohol calls for publication of an Environmental Operations Manual to guide BATF as to what environmental questions to examine when issuing permits for a DSP. In practice it will also serve as a guide to farmers on how to manage wastes from their on-farm processes. This manual will be a cooperative effort between BATF and EPA.

4.2.2 Office of Air Quality Planning and Standards

The Clean Air Act (CAA) as amended in 1977 is the legal authority for the air pollution control program. The OAQPS is responsible for administering the provisions of the CAA for control of air pollutants from stationary sources. The objective of the CAA is to achieve and maintain air quality sufficient to protect public health and welfare, including the maintenance of low pollutant concentrations in currently "clean" areas. The enactment of the act provided the basis for a series of national, state, and local actions designed to protect air quality and limit the emissions of certain air pollutants. In addition to any regulations developed independently by state and local authorities, the following federally mandated regulations could apply to the alcohol fuels industry:

- National Ambient Air Quality Standards (NAAQS)
- State Implementation Plans (SIP's)
- New Source Performance Standards (NSPS)

- Nonattainment New Source Review (NSR)
- Prevention of Significant Deterioration (PSD)

(For Section 4.2.2, see Reference 4-6.)

4.2.2.1 National Ambient Air Quality Standards and State Implementation Plans

National Ambient Air Quality Standards are intended to protect health and welfare by specifying maximum allowable ambient pollutant concentrations. To date NAAQS have been promulgated for sulfur oxides, particulate matter, carbon monoxide, photochemical oxidant, lead, hydrocarbons, and nitrogen oxides. Each state must then develop an implementation plan outlining the state's strategy for attaining and maintaining the NAAQS. The SIP for a particular pollutant includes regulations as needed on new and/or existing sources to achieve sufficient emission reductions to attain and maintain the NAAQS. It is, therefore, a plan for implementation, maintenance, and enforcement of emission limitations and other measures for particular sources.

4.2.2.2 New Source Performance Standards

Under Section 111 of the CAA, EPA is directed to establish NSPS for new and modified stationary sources deemed to have a significant impact on health and welfare. These standards are nationally applicable direct emission limitations for specific source categories (e.g., fossil-fuel-fired steam generators). NSPS regulations require emission reductions achievable through application of the best demonstrated continuous control technologies taking into account non-air quality factors such as energy requirements and the cost of achieving such reductions.

By 1982 NSPS are to be established for all categories of major sources -- sources with the potential to emit more than 91 Mg (100 tons) per year. EPA may, however, develop standards for sources emitting less than that amount, especially for certain minor sources that together represent a large quantity of emissions.

4.2.2.3 National Emission Standards for Hazardous Air Pollutants

Section 112 of the CAA requires EPA to establish National Emission Standards for Hazardous Air Pollutants (NESHAP's). NESHAP's are specific emission limitations applicable to any new source or modified existing source. A hazardous air pollutant is defined as a pollutant for which no ambient air quality standard has been set, but which may cause or contribute to an increase in mortality or serious illness. NESHAP's have been established for asbestos, beryllium, mercury, and vinyl chloride. By February 1980 the proposed NESHAP for benzene will be complete.

4.2.2.4 Nonattainment and New Source Review

A major new source planning to build a facility or modify an existing one in a region where an ambient standard is being exceeded (called a nonattainment area) must obtain a New Source Review (NSR) permit. To issue the NSR permit, the state must show that the total emissions from all sources in the area, including the proposed new one, will be sufficiently less than the total emissions due to all existing sources. In addition the new source must use controls that reduce emissions as much as required by the most stringent limitation in any SIP or as obtained in practice -- called Lowest Achievable Emission Rate (LAER). LAER determinations do not take cost into account as in NSPS and BACT (see Section 4.2.2.5).

4.2.2.5 Prevention of Significant Deterioration and Best Available Control Technology

While the purposes of nonattainment provisions and the SIP are to attain and maintain standards, the objective of PSD is to prevent significant deterioration of air that is already cleaner than NAAQS. Under PSD, all areas in the U.S. meeting air quality standards are classified Class I, Class II, or Class III, with varying limits on increased pollutant levels.

Increases in pollution are restricted by numerical limitations called increments. Each increment is a numerical definition of the amount of additional pollution allowed through the combined effects of all new growth in a particular area.

At the present time EPA is considering alternatives to the increments approach used to control emissions of SO_2 and particulate matter. It is expected that PSD regulations for other criteria pollutants will be promulgated in 1981.

A new source entering a PSD area must use the Best Available Control Technology (BACT) in order to minimize air quality impact. BACT determinations, which include cost and energy trade-offs, are made by the states on a case-by-case basis. If an NSPS exists for a source category, the BACT emission level must not exceed the NSPS limit.

4.2.2.6 Regulatory Decision Making Process

Figure 4-1 shows the analysis and decision making process used by EPA in selecting the preferred regulatory approach for air emissions from stationary sources. The initial decision is based on health and ecological effects, requiring that atmospheric emissions data be known.

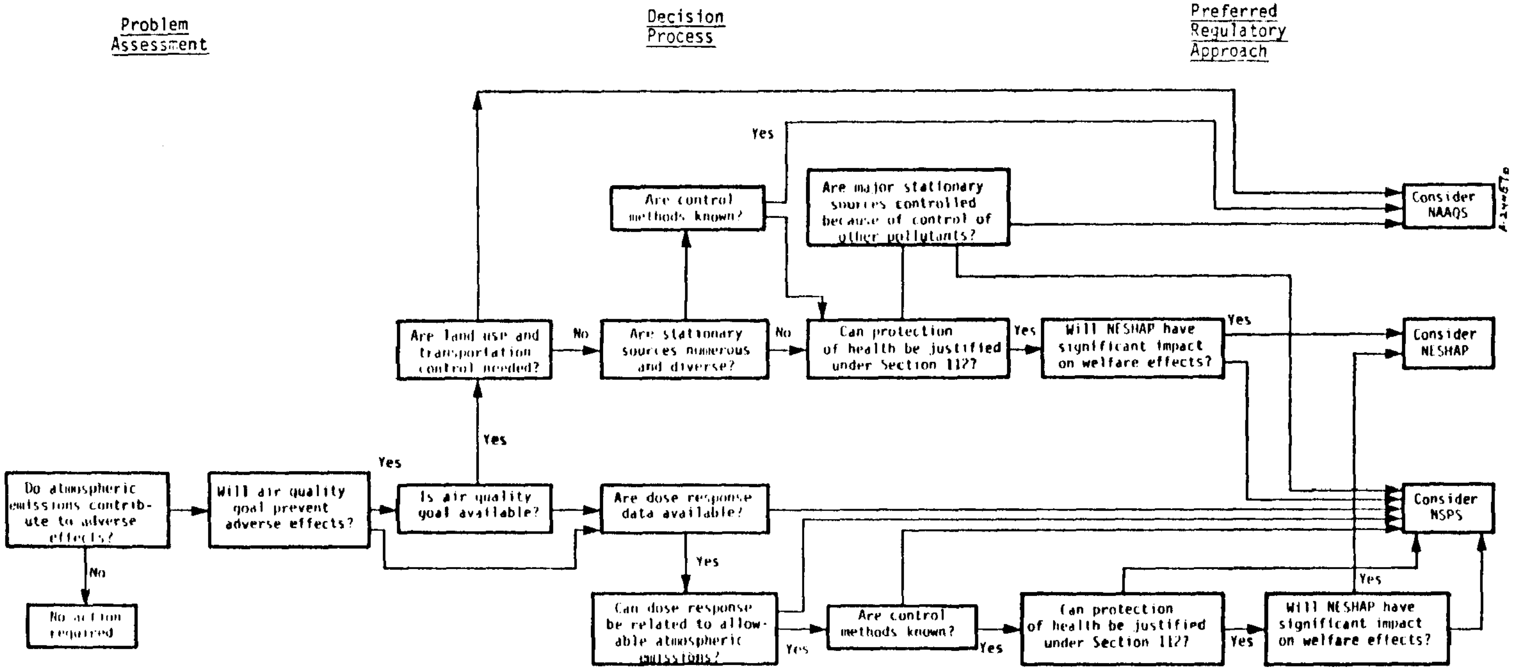

Figure 4-1. Preferred standards path analysis flow chart for air quality programs.

If these emissions are found to cause adverse affects, a branching chain of possible actions based on specific questions follows. Information is also needed on available control technologies (if known) and their performance.

4.2.2.7 Current Regulations

The major potential sources of air pollution from alcohol fuel production are discussed in Section 2. There are no federal or state air regulations that specifically address these emissions. Although federal regulations do exist for particulate, SO_2, and NO_x emissions from boilers greater than 73 MW (250 x 10^6 Btu/hr) heat input, the boiler in a typical alcohol plant producing 20 million gallons is less than half that size. In the future, emissions from industrial boilers, whether they are fossil-fuel-fired and smaller than 73 MW (250 x 10^6 Btu/hr) heat input or non-fossil-fuel-fired and of any size, will be covered by NSPS requirements currently being generated by EPA. There are also federal opacity standards for dryers, grain elevators, truck or railcar loading, and other grain handling operations that might apply to alcohol fuels production. A number of states have emission standards for particulates from industrial incinerators, dryers, and steam generating equipment.

If the fugitive emissions of benzene from the benzene dehydration process are found to be significant, other processes such as using ethyl ether and hexane can be implemented. The EPA is currently working on a NESHAP standard for benzene; it is unclear at this time what effect this standard will have on the use of benzene to produce alcohol.

Although none of these regulations apply specifically to the alcohol fuels industry, regulations governing specific emissions from a particular piece of equipment would probably be applied to such equipment as it is used in alcohol fuels production.

4.2.2.8 Regulatory Plans

At this time OAQPS does not foresee any new regulatory actions directed specifically toward controlling air emissions from facilities producing fuel grade alcohol. OAQPS will participate in a sampling program coordinated by IERL. OAQPS will use the results of this program in the analysis scheme depicted in Figure 4-1 to establish if there is a need to institute the NSPS process of alcohol fuels production.

4.2.3 Office of Water Planning and Standards

The FWPCA of 1972, as amended* provides the statutory authority for the regulatory programs of OWPS. The major objective of the CWA is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters.

The regulatory mechanisms authorized by the CWA that could be applied to control effluents from alcohol fuels production are as follows. (For Section 4.2.3, see References 4-7 and 4-8.)

4.2.3.1 Effluent Limitations

Section 301 provides for the establishment of nationally applicable effluent limitations on an industry-by-industry basis. These effluent limitations, with minor exceptions, establish a nationwide base level of treatment for existing direct discharge sources in every significant industrial category. These limitations are to be accomplished in phases.

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*The Federal Water Pollution Control Act Amendments of 1972, (PL 92-500) further extended the scope of the FWCPA of 1965, as previously amended in 1966 and 1970. New ammendements to this legislation, the Clean Water Act (CWA) of 1977 (PL-92-217) were signed into law in December 1977.

The first phase of treatment requires application of the Best Practicable Technology (BPT). BPT has been defined as "the average of the best existing performance by well operated plants within each industrial category or subcategory." In developing BPT, impacts on industry and economy as a whole are taken into account.

Section 301 provides for three categories of pollutants for the next phase of cleanup: toxic, conventional and non-conventional. By July 1, 1980 EPA must issue effluent limitations for 65 toxic substances. These effluent limitations will require applications of BAT by July 1, 1984. For any chemical added to the toxic list, EPA must promulgate BAT regulations as soon as practicable. Industry must comply with BAT not later than 3 years after the standard is set. EPA must identify conventional pollutants; these include suspended solids, certain bacteria, pollutants affecting BOD and alkalinity-acidity. Discharges of conventional pollutants are required to install Best Control Technology (BCT) by July 1, 1984. BCT is defined as a technology that is considered to be economically reasonable for an industry, that is, at least as stringent as the base level or BPT and less than or as stringent as the Best Available Technology (BAT). BAT is defined as the "very best control treatment measures that have been or are capable of being achieved" considering the cost impact of the industry.

For all conventional pollutants (pollutants other than toxic or conventional) industry must comply with BAT by July 1, 1987. EPA may modify the BAT requirements however if a facility has compiled with BPT and is meeting water quality standards, if no additional burden on other dischargers will result, and if no public health or environmental risk is anticipated.

Thus, BAT is applicable to both toxic and nonconventional pollutants, though the deadlines differ depending on the type of discharge being regulated. Industries may propose to meet BAT by replacing existing production processes with an innovative process or control technique resulting in significant effluent reduction or lower costs and that may have industry-wide application. These industries will have the longest timetable available.

In addition to setting effluent limitations, EPA must now publish regulations to contol plant site runoff, leaks, waste disposal, spillage, and drainage from raw material storage of toxic and hazardous pollutants associated with an industrial manufacturing or treatment process. Called Best Management Practices (BMP's), these controls must be included in any permit issued under Section 402.

Under Section 306 of the CWA, EPA is directed to establish national standards of performance for new sources. The general approach to the establishment of NSPS is similar to that established for existing sources, with some distinct differences. A standard of performance is defined as a standard for the control of discharge of pollutants reflecting the greatest degree of reduction. This reduction can be achieved through application of the best available demonstrated control technology, processes, operating methods, or other alternatives including, where practicable, standards permitting no discharge of pollutants. The primary differences between this criteria and BPT or BAT is that under Section 306 EPA is specifically required to consider not only pollution control and abatement processes and techniques, but also various alternative production processes, operating methods, in-plant control procedures, etc. In addition, NSPS do not require detailed consideration of economic and technological factors, but Section 304 does.

4.2.3.2 Pretreatment Regulations

The primary intent of the pretreatment regulation is to protect the operation of publicly owned treatment works (POTW) and to prevent inadequate treatment of discharged pollutants. The discharge limits are based on best available technology economically achievable for industrial uses of both new and existing sources.

4.2.3.3 Water Quality Criteria

As mentioned previously, the technology based effluent limitations function primarily as a nationwide base level of treatment. Section 302 of the CWA makes specific provisions for the establishment of effluent criteria. These criteria can be more stringent than the BAT guidelines, when necessary, to attain or maintain water quality that assures protection of public water supplies, agricultural and industrial uses, and fish and wildlife. These criteria may require that an industrial facility, located either in areas of heavy discharge concentration or near waters where very stringent water quality standards have been established, provide a level of treatment considerably higher than the base level established by the technology related effluent limitations.

4.2.3.4 National Pollutant Discharge Elimination System

The primary enforcement mechanism for the federal effluent limitations, NSPS, and pretreatment requirements is a nationwide permit program, called NPDES, established under Section 402 of the Act. Under this program, every point source is issued a permit by EPA or the state. These permits specify maximum permissible levels of each pollutant that can be discharged, a compliance schedule for reaching these limits, and requirements for monitoring and reporting discharges to the states and EPA. These guidelines and standards are technology based (as opposed to being based on meeting specific water quality or health goals). These guidelines and standards do not require that specific control technology be used; the level of control, however, is based on physical/chemical treatment of the effluent, process modifications, best management practices, or even transferring the discharge to an industrial waste disposal company.

4.2.3.5 Regulatory Decision Making Process

Figure 4-2 shows the analysis used by OWPS in determining the regulatory approach to be used. First, the amount of effluents from the particular source must be known, followed by a determination of the potential adverse effects of the effluent on water quality. If these effects are determined to pose a problem of national or statewide concern, a standard for control is established.

4.2.3.6 Current Regulations

No specific regulations govern the waste stream effluents from alcohol fuels production. Standards on other processes, such as sugar mills and grain mills, which will require secondary treatment may also apply to alcohol fuels production. In addition, general water quality standards for BOD and suspended solids must be maintained. More stringent standards can be found at the state and local levels for pH, organic materials, and other effluents that cannot be discharged into POTW.

Notwithstanding any of the above regulations, the EPA Administrator can establish effluent limitations for a source or sources interfering with the attainment or maintenance of any promulgated water quality standard.

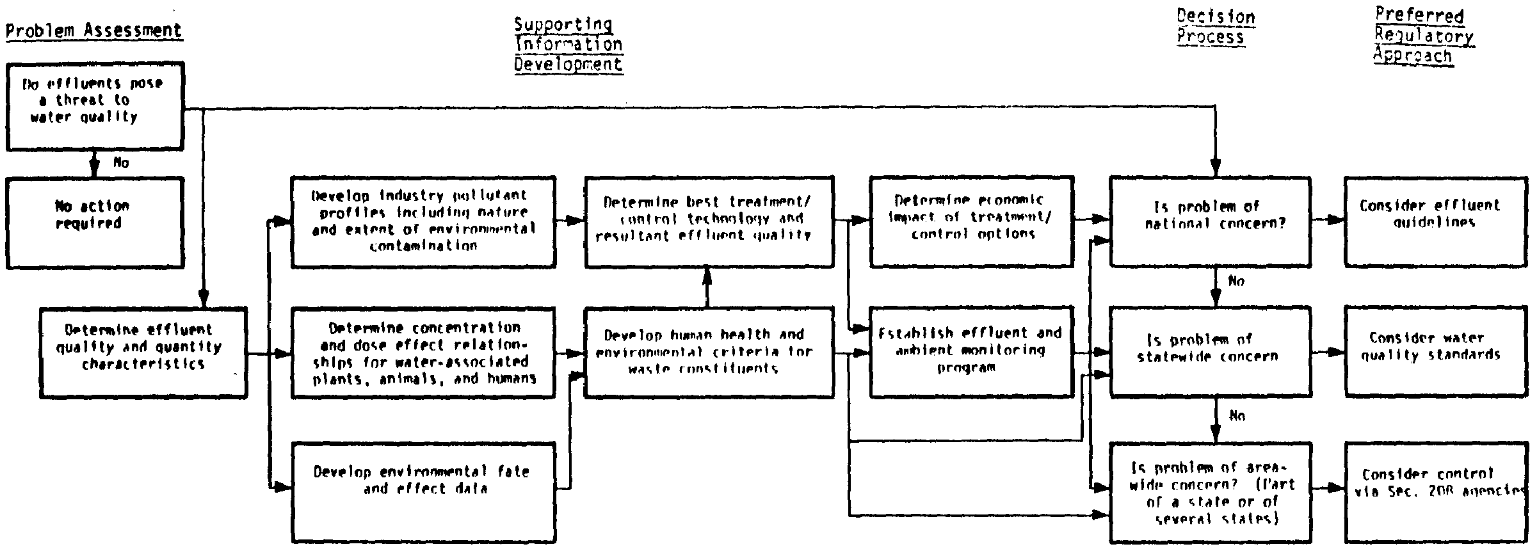

Figure 4-2. Preferred standards path analysis flow chart for water quality programs.

4.2.3.7 Regulatory Plans

The OWPS/EGD prepares and publishes a development document for each industrial category for which the Agency intends to promulgate an effluent guideline. These documents present the data base supporting the Agency's findings on uncontrolled discharges, the availability of control technologies for these discharges, the reductions achievable through the use of control techniques, and the cost, energy consumption and other nonwater quality aspects resulting from the use of these controls. OWPS plans to publish a development document on gasohol by November 1980.

4.2.4 Office of Solid Waste

The program for environmentally safe disposal of solid waste is administered by OSW under the statutory authority of the Resource Conservation and Recovery Act (RCRA). The objectives of RCRA are to protect health and the environment and to conserve valuable material and energy resources. To date no specific regulations have been developed by OSW. The following paragraphs describe the provisions contained in RCRA that could apply to the alcohol fuels industry (see Reference 4-9).

Subtitle C contains the primary enforcement and program authorizations. The content of Subtitle C is to enable a program providing for identification of those waste substances (primarily industrial) that may be hazardous and tracking of them from their generation through transportation and storage to ultimate disposal in an environmentally acceptable manner.

Under RCRA, a distinction is made between hazardous and nonhazardous solid wastes. OSW is currently planning to promulgate standards in 1980 for the criteria and test procedures to be used in determining whether or not a solid waste is hazardous. Among the criteria under consideration are flammability, corrosivity, reactivity, radioactivity, toxicity, and potential for bioaccumulation, persistence, and causing disease. By April 1980 it is expected that OSW will have published a list of hazardous waste substances. In addition to the EPA listing, RCRA allows the governor of any state to petition EPA to identify or list additional substances.

Regulations for a federal permit system applicable to owners and operators of hazardous waste treatment, storage, or disposal systems have also been developed by OSW and should be promulgated by Febuary 1980. Further, by 1980 OSW plans to have promulgated guidelines to assist the states in developing hazardous waste programs. State or regional plans for the management of nonhazardous wastes are administered under Subtitle D of RCRA. OSW guidelines for state plans and criteria for sanitary landfills are also expected to be published in 1980.

4.2.4.1 Current Regulations

There are no federal or state regulations dealing specifically with the solid wastes generated from alcohol fuels production. In general, state regulations require that wastes be handled by a licensed waste hauler and disposed of in a licensed disposal facility.

It is believed that most alcohol fuel producers will dispose of less than 100 kilograms (220 pounds) per month of hazardous wastes (including benzene and pesticides), if any at all. In the event they do dispose of hazardous wastes up to 100 kilograms per month, they must comply with Section 250.29 (persons who dispose of less than 100 kilograms per month of hazardous waste; retailers; and farmers) of the proposed RCRA regulations. In general, this provision requires that any hazardous waste generated, no matter how small the quantity, be disposed of either in:

- A solid waste facility that has been permitted or otherwise certified by the state as meeting the criteria pursuant to Section 4004 (Criteria for Sanitary Landfills) of RCRA
- A treatment, storage, or disposal facility permitted by the Administrator pursuant to the requirements of Section 3005 (Permits for Treatment, Storage and Disposal of Hazardous Wates), or permitted by an authorized state program pursuant to Section 3006 (Guidelines for Authorized State Hazardous Waste Programs) of RCRA

4.2.4.2 Regulatory Plans

At present OSW does not plan to develop regulations for the disposal of solid wastes from the production of alcohol fuels because preliminary tests indicated that these wastes were not hazardous. The OSW, however, will participate in the sampling and analysis program to be conducted by OWPS and IERL-Ci to ensure that these are, in fact, not hazardous.

4.2.5 Office of Toxic Substances

The Toxic Substances Control Act (TSCA) of 1976 is administered by the Office of Toxic Substances (OTS). TSCA has two main goals: the acquisition of sufficient information to identify and evaluate potential hazards from chemical substances and the regulation of production, use, distribution, and disposal of these substances (see Reference 4-10).

Under TSCA, manufacturers or processors of potentially harmful chemicals may be required to conduct tests on the chemicals at their own expense. Testing may be necessary to evaluate a chemical's health or ecological effects.

Manufacturers of new chemical substances must notify the EPA 90 days before the chemical is manufactured for commercial purposes. On June 1, 1979 EPA published an inventory of existing chemicals. Any chemical not on this list is considered new for the purposes of the premarket notice requirement. In addition, the EPA Administrator may designate a use of an existing chemical as a signficant new use. Anyone who intends to manufacture a chemical for such a significant new use also must report this information 90 days before marketing.

TSCA authorizes EPA to issue an order or seek an injunction, if necessary, to keep a new chemical off the market. In addition, the EPA Administrator may prohibit or limit the manufacture, use, or disposal of a chemical substance or mixture if these activities present an unreasonable risk to health or the environment.

4.2.5.1 Current Regulations

The EPA is now in the process of developing programs to fully implement the authorities of TSCA. Intially, more emphasis is being placed on obtaining and analyzing information than on writing specific control regulations. In 1980 the agency will concentrate on devising a premarket notification system. By the end of 1980, all aspects of the TSCA program are planned to be operational.

4.2.5.2 Regulatory Plans

Under the provisions of TSCA, ethanol is not considered toxic. Hence, OTS does not have any plans at this time to require premarket notification or special handling of ethanol. If any of the byproducts of alcohol fuels production are found to be toxic as a result of the sampling and analysis program described in this plan, it is expected that regulation of these substances will be handled by the appropriate media office.

4.2.6 Office of Enforcement

4.2.6.1 Current Regulations

The Office of Enforcement, in cooperation with Regional Offices, has the authority to enforce compliance with federal regulations. In general, day-to-day enforcement activities are the primary responsibility of the states; however, when a state fails to adequately administer its SIP, NPDES, hazardous waste, or other federally mandated environmental program, EPA has the authority to assume this function.

The Office of General Enforcement, Stationary Source Enforcement Division, provides support to the EPA Regional Offices and state environmental control authorities as needed to maintain and enforce the regulations and provisions under the CAA.

The Office of Water Enforcement, Enforcement Division, enforces compliance with water quality standards and effluent limitations in cooperation with state authorities and the EPA regional offices. The Permits Division works with the states to issue discharge permits in an advisory capacity and, for those states not authorized to issue permits (20 out of 50), has the responsibility of application review and permit issuance.

4.2.6.2 Regulatory Plans

The Office of Enforcement needs reliable information on pollutant emission rates and control methods to aid in their guidance for permitting of stationary sources. The information derived from the sampling and analysis program to be conducted by IERL will assist the Office in their permitting, should permitting be necessary in the future.

REFERENCES FOR SECTION 4

4-1. U.S. Department of Energy, "The Report of the Alcohol Fuels Policy Review," June 1979.

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4-3. Brochure, National Gasohol Commission, Inc., Lincoln, Nebraska.

4-4. Department of the Treasury, Bureau of Alcohol, Tobacco, and Firearms, "Informational Brochure Ethyl Alcohol for Fuel Use," ATF P 5000.1, July 1978.

4-5. G. R. Dickerson, Statement presented to the Senate Agricultural Research and General Legislation Subcommittee of the Committee on Agriculture, Nutrition, and Forestry of the United States Senate, July 23, 1979.

4-6. The Clean Air Act Amendments of 1977, P.L. 95-95, 91 Stat. 685; and P.L. 95-190, 91 Stat. 1393.

4-7. Research Triangle Institute, "Standard Support Plan for Technologies for Producing Synthetic Fuels from Coal," Draft, January 1979.

4-8. Federal Water Pollution Control Act of 1972, 33 U.S.C. Section 1251 and P.L. 95-217, 91 Stat. 1566, December 27, 1977.

4-9. Resource Conservation and Recovery Act of 1976, P.L. 94-580, 90 Stat. 2795.

4-10. Toxic Substances Control Act of 1976, P.L. 94-469, 71 Stat. 850.