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Draft Environmental Impact Statement

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Conversion to Coal
Baltimore Gas & Electric Company
Brandon Shores Generating Station
Units 1 and 2
Anne Arundel County, Maryland

December, 1983

U.S. Department of Energy
Economic Regulatory Administration
Office of Fuels Programs
Washington, D.C. 20585

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Reponsible Agency:	U.S. Department of Energy Economic Regulatory Administration Office of Fuels Programs Coal and Electricity Division
Title of Proposed Action:	Issuance of Final Prohibition Orders to Brandon Shores Generating Station Units 1 and 2, Anne Arundel County, Maryland
Designation:	Draft Environmental Impact Statement
Further Information:	Ms. Deborah Valentine Office of Fuels Programs Coal and Electricity Division Economic Regulatory Administration 1000 Independence Avenue, S.W. Room GA-045 Washington, D.C. 20585 (202) 252-9504
Abstract:	This draft environmental impact statement (DEIS) assesses the potential impacts associated with the proposed finalization of prohibition orders for Units 1 and 2 of the Brandon Shores Generating Station, located in Anne Arundel County, Maryland. If finalized, the prohibition orders would prohibit the utility from using petroleum products as a primary energy source in the affected units; the utility proposes to conform to the orders by firing Units 1 and 2 on low-sulfur coal. Major issues of environmental concern relating to the proposed prohibition order have been determined through the public scoping process and through discussion with other concerned agencies, and were found to include air and water quality, noise, and waste storage and disposal. These issues, as well as reasonable alternatives in the areas of plant conversion options, fuel type, air and water pollution control, ash disposal, and transportation, are discussed in the EIS.
Closing Date for Comments:	Comments should be sent to Deborah Valentine at the address noted above. The closing date for comments is 45 days after Federal Register publication of a Notice of Availability by EPA.

SUMMARY AND CONCLUSIONS

The United States Department of Energy's (DOE's) Economic Regulatory Administration (ERA) issued on November 9, 1979, proposed Prohibition Orders to the Baltimore Gas and Electric Company (BG&E) for the Brandon Shores Generating Station Units 1 and 2. Authority for this action was derived from the Powerplant and Industrial Fuel Use Act of 1978 (FUA), as amended by the Omnibus Budget Reconciliation Act of 1981 (OBRA). The perfection and issuance of a Prohibition Order for Brandon Shores would prohibit the further use of petroleum as the major fuel in this generating station. Because the ERA has determined that the issuance of those Prohibition Orders is a major Federal action, DOE is providing this Draft Environmental Impact Statement (DEIS) to address the environmental effects of the proposed action and reasonable alternatives as required by the National Environmental Policy Act of 1969 (NEPA) and Council on Environmental Quality NEPA regulations.

In addition, on June 30, 1975, Prohibition Orders were issued to BG&E for its Crane Generating Station Units 1 and 2, Riverside Generating Station Units 4 and 5, and Wagner Generating Station Units 1 and 2. These orders, which could have been perfected by issuance of Notices of Effectiveness, were issued pursuant to the Energy Supply and Environmental Coordination Act of 1974 (ESECA). Following enactment of OBRA, when the ERA allowed utilities with outstanding FUA and ESECA orders to elect continued coverage under those acts, BG&E exercised its option so not to elect. As a result, the Crane, Wagner, and Riverside ESECA orders were allowed to lapse.

Thus, the proposed action which is the subject of this DEIS is the finalization of the FUA Prohibition Orders for Units 1 and 2 at Brandon Shores. BG&E has indicated that finalization of these orders and subsequent operation of these units on low-sulfur coal are the preferred alternative (scenario 3).

Independent of DOE action, BG&E is pursuing voluntary conversion of Crane's Unit 1 to coal and refuse-derived fuel, and Unit 2 to coal. In addition, BG&E's Wagner Station is contiguous with the Brandon Shores station and operates 4 units totaling 990 MW. Two of the Wagner Units are coal-fired. Concern has been expressed at State and local levels about the interactive and cumulative effects of the conversion of the Brandon Shores units (the result of proposed action), and the Crane conversions, and the continued operation of the Wagner Units. The eight units may share or compete for the same air, water, and solid-waste-disposal resources. Therefore, this DEIS addresses the effect of the Crane conversions and the continued operation of the Wagner Station, as appropriate.

CONCLUSIONS

This environmental analysis focuses on five fuel scenarios. One of these, the base-case scenario, involves operation of the Brandon Shores Units on oil *and the continued operation of the Crane Units on oil.* In the no-action alternative, *Crane operates on coal and coal with refuse-derived fuel (RDF),* Brandon Shores operates on oil. The three remaining scenarios reflect the probable responses of BG&E and state and local regulatory authorities to finalization of the Prohibition Orders for the Brandon Shores Units. Coal, with or without scrubbing, is considered to be the alternative-of-choice.

The principal areas of concern were identified through the NEPA public scoping process, through recommendations of the State of Maryland, and according to the format given in the CEQ regulations. Major areas of potential impact are briefly discussed in the following paragraphs.

Air Quality

For each of the fuel-conversion scenarios, the magnitude of fugitive-dust and stack-emissions increases that would occur were analyzed. Generally, increases in atmospheric concentrations of

Fugitive-dust emissions from both conversion and operation were considered. Fugitive emissions from construction activities were found not to be restrictive. The utility has demonstrated that with improved coal-handling and -storage methods, the projected TSP increases will be at acceptable levels.

Computations of atmospheric concentrations of pollutants from stack emissions indicate that short-term maximum values for SO_2 and TSP would be more limiting than annual values. All computed SO_2 and TSP concentrations resulting from stack emissions at Brandon Shores *and Crane* would be below the applicable standards.

The consideration of fugitive dust, stack emissions, and PSD consumption shows that no violations will result from conversion of the Brandon Shores and *Crane* units for all scenarios.

Land Use and Solid Waste

The conversion of the Brandon Shores units to coal *and the Crane units to coal and a coal/RDF mixture* would require that coal, and possibly limestone *and RDF*, be stored at the generating station sites. No constraints due to the availability of onsite land for storage are projected.

Combustion ash is projected to be disposed of at a site directly west of the Brandon Shores Station. The site could contain 7 to 10 years projection of solid waste from Brandon Shores. Purchase options on an additional disposal area will allow disposal for the remaining life of the station. *Crane waste will be disposed of at another site.*

Coal is to be brought to the Brandon Shores station by barge, so a new channel has been dredged. Approximately 462,000 cubic yards of spoil were removed. Disposal of the spoils took place at an 80-acre site on Marley Neck, about one mile north of the Brandon Shores station. The site has previously been used to dispose of Baltimore Harbor dredge spoils, and the addition of the spoils from the barge channel resulted in a negligible impact on land use.

Water Quality

Coal Storage

Runoff and leachates from stored coal could contaminate nearby surface or ground waters. Stratigraphic maps of the geologic structure under the expected locations of the Brandon Shores *and Crane* coal piles indicate that relatively permeable layers would separate the coal piles from underlying water tables. The company has announced an intention to install liners or underdrain systems to reduce the possibility of contamination.

Ash and Sludge Leachates

The utility plans to use a tract of land west of the Brandon Shores station for Brandon Shores solid-waste disposal. The site is underlain by a clay layer, which appears to be continuous. If so, this layer would protect ground water. To the extent that BG&E is able to find uses for ash and/or sludge (the utility is actively pursuing this), the amount of waste to be disposed of, and the potential for contamination of surface and ground water, would be reduced.

Ecology

Terrestrial

Options calling for the conversion of the units to coal have the potential for increasing deposition of SO_2. Impacts to plants from these increased SO_2 emissions are judged to be minimal.

No detrimental impacts to terrestrial plants or animals would result from the emission of NO_2 or particulate matter due to fuel conversion.

The disposal of solid waste generated during coal combustion would result in the loss or disruption of natural habitat. The estimated lifetime commitment of land for solid-waste disposal ranges up to 700 acres; the previously mentioned disposal site west of the Brandon Shores station could accommodate the waste generated by the BG&E units for 7 to 10 years, so it is possible that additional land may be disturbed. Land used for solid-waste disposal would be disturbed for 35 to 45 years.

Aquatic

Dredging at Brandon Shores, which presented the greatest potential for aquatic impacts, is completed. It was performed so as to cause no permanent effects to aquatic life. Dredge spoils were disposed of in an existing spoils disposal site; no aquatic impacts will result from the disposal if runoff continues to be handled properly. No significant impacts or aquatic life are projected to result from coal-handling or storage, if effluent is handled properly.

No ecological effects are projected to result from operation of the Brandon Shores *and Crane* units on alternative fuels.

Energy Resource

Finalizing the prohibition orders for the Brandon Shore units would result in a reduction in petroleum use of approximately 53 thousand barrels per day. *Conversion of Crane will result in a reduction in oil use of about 11 thousand barrels per day.*

Noise

No signficant noise effects are projected for either the conversion of Brandon Shores *or the voluntary conversion of Crane.*

Socio-economic

No significant socio-economic effects are projected either for the conversion of Brandon Shores *or the voluntary conversion of Crane.*

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1.0 PURPOSE AND NEED FOR ACTION

1.1 BACKGROUND

In 1973, in response to the oil embargo, Congress passed the Energy Supply and Environmental Coordination Act of 1974 (ESECA) (P.L. 93-3190). This act provides the authority to prohibit certain existing powerplants from using natural gas or petroleum as their primary energy sources, and provides for the plants' conversion to coal. The Federal Energy Administration (FEA), which administrated ESECA, had the burden of proving whether the powerplant or major fuel-burning installation had, or could acquire, the capability to burn coal; whether the plant could obtain the necessary supplies of coal; and, in the case of a powerplant, whether the conversion could be effected without reducing reliability. The FEA is now a part of the Department of Energy, and the responsibility for completing orders initiated under ESECA has been transferred to the Division of Fuels Conversion of DOE's Economic Regulatory Administration (ERA).

To extend and expand the provisions of ESECA, which expired in December of 1978, the Powerplant and Industrial Fuel Use Act of 1978 (FUA) (P.L. 95-620) was passed by Congress in November 1978. Among other things, FUA enabled DOE to order existing powerplants and major fuel-burning installations to cease using petroleum as a primary energy source, contingent upon DOE's ability to show 1) that the unit has the technical capacity to burn an alternate fuel; 2) that an alternate fuel is available and its use is financially feasible; 3) that conversion to an alternate fuel would not cause a substantial reduction in rated plant capacity; and 4) that all applicable environmental standards can be met. FUA differs from ESECA in that alternate fuels other than coal (such as municipal wastes and wood) can be considered as fuel conversion candidates, and that it allows for the use of fuel mixtures.

The Omnibus Budget Reconciliation Act of 1981 (OBRA) (P.L. 97-35) amended FUA to provide that the owners and operators of electric powerplants must initiate the prohibition order process by voluntarily certifying to the above FUA findings. Utilities subject to proposed orders under FUA or ESECA at the time of the OBRA amendments were allowed to elect continued coverage under those laws. If no election was made, the proposed order lapsed.

Utilities which certify to the FUA findings and request Prohibition Orders (or elect continued coverage of outstanding orders) receive special treatment under the Clean Air Act (CAA) for the units so covered. A fuel switch to coal under these circumstances is not considered a major modification for CAA purposes, and the converted units will not be treated as new sources for New Source Performance Standards (NSPS) or Prevention of Significant Deterioration (PSD) purposes. However, any NSPS requirements which originally applied to the units would still be in effect. Also, any increase in emissions resulting from the fuel switch would consume PSD increment, even though no formal PSD permit proceeding would be required.

1.2 THE PROPOSED ACTION

The proposed action which is the subject of this Environmental Impact Statement is the issuance of final FUA Prohibition Orders to the Baltimore Gas and Electric Company (BG&E) for Brandon Shores Units 1 and 2. Proposed Prohibition Orders were issued for these units under FUA on October 9, 1979. BG&E elected continued coverage under FUA pursuant to the OBRA ammendments on November 9, 1981.

The Department of Energy has determined that issuance of a final prohibition for Brandon Shores would be a major Federal Action significantly affecting the quality of the human environment. This

EIS is being prepared in accordance with the requirements of the National Environmental Policy Act of 1969 (NEPA) 42 USC. 4321 et seq.).

1.3 NON-FEDERAL ACTION

This document also addresses certain non-Federal actions. BG&E is voluntarily converting its C.P. Crane Units 1 and 2 to coal (unit 1 using RDF as available), and certain BG&E activities related to this conversion are subjects of concern to state and local agencies. These activities, when combined with activities resulting from response to the proposed Federal Action, potentially have interactive or cumulative effects on the environment. Such activities are discussed in this EIS as required by Section 1506.2 and Sections 1501.7a(1) and (6) of the CEQ regulations.

This EIS also addresses the effects that might occur when the Crane and Wagner units, through the conversion of the Crane Units or continued operation of the Wagner Units, share or compete with Brandon Shores Units for air, water, and solid-waste disposal resources.

1.4 RELATIONSHIP OF PRESENT EIS TO PROGRAMMATIC EIS AND OTHER STUDIES

This EIS will address the site-specific environmental impact of the proposed action and reasonable alternative actions which could be expected to result from issuance of a final Prohibition Order. It has been prepared in accordance with the requirements of the National Environmental Policy Act and the following additional requirements: regulations promulgated by the Council on Environmental Quality (CEQ) implementing NEPA (40 CFR 1500-1508), and DOE NEPA Guidelines (DOE Order 5440.1A and 45 FR 62 p. 20694-20701, March 28, 1980).

The major purposes of this statement are to:

- ensure that appropriate consideration is given to environmental factors at all stages of DOE's decision-making process;
- reduce duplication between NEPA and state and local requirements by cooperation with state and local agencies to the fullest extent possible;
- provide information on the effect of the Federal Action so that it may be integrated into state and local planning processes; and
- identify and assess reasonable alternatives to the proposed action, including the no-action alternative, that will avoid or minimize adverse effects upon the human environment.

This site-specific environmental impact statement is the third tier in a three-tiered approach to enviromental impact assessment; an approach which conforms to the intent of the National Environmental Policy Act (NEPA) in general, and to the Council on Environmental Quality Regulations on implementing NEPA procedures in particular. Section 1508.28 of the CEQ Guidelines defines tiering "as the coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basinwide program statements or ultimately site-specific statements) incorporating by reference in the general discussion and concentrating solely on the issues specific to the statement subsequently prepared."

The first tier in the impact assessment process associated with fuel conversion is the programmatic analysis. In April 1979, DOE issued a Final Programmatic Environmental Impact Statement for the Fuel Use Act (DOE/EIS-0038) assessing the major environmental impacts resulting from the implementation of the Powerplant and Industrial Fuel Use Act. That impact statement addresses overall program impacts rather than site-specific impacts, and is predicated on the assumption that coal will be the primary fuel substituted for oil and natural gas in the short term (1990). Additional generic and historic information on the impacts associated with the use of coal and alternate fuels can be found in the Revised Programmatic Environmental Impact Statement for the Energy Supply and Environmental Coordination Act (FES 77-3) published by the Federal Energy Administration in May 1977.

The second tier of the impact analysis is the Northeast Regional Environmental Impact Statement (NEREIS) (DOE/EIS-0083). This document responds to the need to assess the potential for cumulative and interactive impacts among powerplants located in proximity to each other. This type of analysis is considered appropriate because more than half (42) of the powerplants subject to, or under consideration for, prohibition orders are located in ten states in the northeastern United States. The NEREIS and four technical documents which provide the data base for the regional analysis emphasize four major interrelated issues: 1) air quality, 2) solid waste disposal, 3) fuel supply and the transportation of fuel and solid waste, and 4) health effects. The technical documents are designed to provide a portion of the data base for the site-specific environmental analysis as well as to provide a broader perspective for assessing the potential impacts of proposed conversion actions. Detailed site-specific issues are not treated in the NEREIS; rather, generic issues that are cumulative or interactive on a regional basis are emphasized. When addressing issues in the site-specific documents where the use of generic information is most appropriate, the information is incorporated directly from the NEREIS.

The analysis in the Northeast Regional Environmental Impact Statement is based on an assessment of the impacts associated with five air pollution emission scenarios (see Section 2.5). This component of the analysis was conducted at the subregional level. The four subregions center around Boston, New York, Philadelphia, and Baltimore. In the Baltimore subregions, the analysis is based on the interaction of: 1)four potential conversion candidates, including the Brandon Shores plant, and *2) the interaction of BG&E's C.P. Crane and Brandon Shores Generating stations in a voluntary-conversion scenario.* This approach to air-quality analysis assumes that all the conversion candidates will in fact convert. It is a conservative approach and produces worst-case results since it is highly unlikely that all coal-capable plants in the subregion will actually choose to convert.

This EIS examines the second NEREIS scenario described. In this scenario, the NEREIS examines the regional effects of converting the facilities to coal in compliance with currently approved State Implementation Plans (SIPs). This EIS examines also the effects of several alternative responses of the utility to the proposed Federal action and evaluates these effects on a local as well as a regional basis.

The findings of the Northeast Regional Environmental Impact Statement are presented in summary form in Section 2.5 of this document.

1.5 PERMITS AND APPROVALS

A summary of the permits required to operate Brandon Shores Units 1 and 2 on coal is presented in Table 1.1. The Brandon Shores units are still under construction, and numerous permits and approvals have been and will be required for construction-related activities. Most of these are not specific to the units' operating fuel. Also, the original Brandon Shores Certificate of Public Convenience and Necessity (CPCN) (May 16, 1973) applied to a fossil-fuel-fired powerplant. This has been interpreted by affected parties as permitting operation on either coal or petroleum fuel. Certain aspects of operation on coal have been the subject of a modification of the CPCN issued December

14, 1981. These details refer to stack exit temperature and velocity,[a] fugitive-dust control, and noise regulation. Each of these is related to the use of coal by the units.

The other permits and approvals required for coal operation are related to coal delivery, coal storage and handling, and waste handling and disposal. These permits are summarized in Table 1.1 under these categories. With the exception of amending the present NPDES permit to include coal-pile runoff, all relevant permits and approvals have been received. The existing NPDES permit expired in March 1983, and BG&E is operating under EPA's continuance of existing permits. Application for a revised permit is in progress.

TABLE 1.1. Permits and Approvals Required to Operate Brandon Shores on Coal

Activity	Agency	Approval Date	Status of Activity
General			
Modification of Certificate of Public Convenience and Necessity - changes in stack gas temperature and exit velocity, fugitive dust control, and noise regulation related to coal use	Maryland Service Commission	12/14/81	Units under construction
Coal Delivery			
Dredging new barge channel	U.S. Army	09/03/81	Completed
	Maryland Port Administration	02/02/81	
	Natural Resources Permit	02/04/81	
	Water Quality Certificate	03/18/81	
Grade area for spoil disposal from dredging barge channel	Anne Arundel County	11/26/80	Completed
Relocate and install buoys to mark barge channel	U.S. Army (Corps of Engineers)	03/03/82	Completed
	U.S. Coast Guard	01/26/82	
Construct coal-unloading facilities over waterway	U.S. Army (Corps of Engineers)	12/08/81	Completed
	Maryland Port Administration	01/08/82	
	Anne Arundel County	01/12/82	
Coal Storage and Handling			
Grade area for coal pile and coal handling equipment	Anne Arundel County	05/05/81	Completed
Construct foundation for placement of upland coal-handling facilities	Anne Arundel County	01/12/82	Completed
Construct transfer buildings, crusher building, conveyers, stacker reclaimer	Anne Arundel County	04/16/82	Completed
Discharge of coal-pile runoff	Maryland State Health Department	(a)	Coal-pile-runoff facility constructed
Waste Handling and Disposal			
Construct fly ash silo, surge-setting tanks, chemical treatment building, pump building	Anne Arundel County	03/30/82	Completed
Grading for fly-ash hauling road	Anne Arundel County	09/28/81	Completed

(a) Application for revision of NPDES permit in progress.

(a) The orignial Brandon Shores design did not have stack-heat recuperators. Stack-heat recuperators use stack heat to preheat combustion air, providing a more efficient use of the energy in the fuel. The original intent was to operate Brandon Shores as an intermediate-load facility. In that mode, stack heat recuperators would not be cost-effective on coal. It is now planned that the units will be operated as base-load, for which stack-heat recuperators are cost-effective.

2.0 PROPOSED ACTION AND ALTERNATIVES

2.1 PROPOSED ACTION

DOE's proposed action is the finalization and issuance of a Prohibition Order that would prohibit the use of petroleum or natural gas as primary fuels in the BG&E Brandon Shores Generating Station Units 1 and 2. DOE is providing this EIS in order to evaluate the environmental effects that may result from the conversion of these two generating units from oil to an alternate fuel.

Section 1502.14 of the CEQ regulations defines the alternatives section to be the "heart of the environmental impact statement;" therefore, this section of this EIS presents "... The environmental impacts of the proposed action and the alternatives in comparative form, thus sharply defining the issues and providing a clean basis for choice among alternatives."

2.2 ALTERNATIVES TO THE PROPOSED ACTION

The choices available to DOE in the Prohibition Order Process are limited to either issuing a final order or declining to issue one. However, in developing the reasonable alternatives to be assessed for NEPA purposes, DOE focused attention on the various manners in which Brandon Shores units might burn coal in compliance with a Prohibition Order. This resulted in the fuel scenario alternatives discussed below.

2.3 FUEL SCENARIO ALTERNATIVES

2.3.1 Function

The fuel scenarios provide a means of evaluating fuels or fuel combinations that realistically could be used as alternatives to oil in the BG&E units. Although numerous options are available, relatively few fuels are viable alternatives from the combined standpoints of fuel availability, environmental standards and regulations, and ease of making engineering modifications to the stations and the subject units. The criteria considered in selecting fuel conversion scenarios are described in the following section.

2.3.2 Basis for Selection

Fuels for the fuels conversion scenarios were selected on the basis of emission limitations, DOE's internal analyses of engineering considerations, boiler fuel requirements, and fuel availability. Also taken into account were recommendations of the U.S. EPA and the State of Maryland. Other considerations included the following:

- The continued use of oil as the primary fuel for all four units at both generating stations was considered. This represents the baseline scenario for comparing the impacts of conversion to alternate fuels.

- Precedence was given to those fuels or fuel combinations that produce air emissions that comply with present emission standards. Several scenarios were adopted based on established emission limits that were suggested by the State of Maryland

- *The cyclone boilers at the Crane Generating Station require coal with a low ash fusion temperature. The availability of low-sulfur coal with this characteristic is quite limited. Therefore low-sulfur (compliance) coal may be impractical at this station. Additionally, the EPA has approved an application on the part of BG&E for a permanent SIP revision that would allow the burning of higher sulfur coal (46 FR 44448, September 4, 1981).*

- The conversion to relatively abundant, high-sulfur coal is considered along with the use of equipment such as flue-gas desulfurization (FGD) needed to keep air emissions within standards.

- *Although the local supply of refuse-derived fuel (RDF) is insufficient to satisfy the total fuel needs of all the units, this EIS also considers the conversion of Crane Unit 1 to a mixture of RDF and coal. One scenario addresses the situation resulting if the Crane Unit 1 is converted to use RDF and coal, and Unit 2 burns coal, while Brandon Shores uses design oil. This scenario represents the "no-action" scenario because it describes the situation that would result if the Prohibition Order is not perfected.*

The fuel scenarios considered in this analysis are summarized in Table 2.1. These scenarios are generally defined by atmospheric emissions. This reduces the effort involved in air-quality analyses because several fuels or fuel combinations can result in the same stack emissions (although other parameters such as exit velocity and exit temperature may change). This approach cannot be used, however, for assessing the impact of fuel conversion on water quality, solid-waste disposal, ecological, and economic factors. Specific fuels are identified for each scenario in order to provide a basis for estimating the kinds and amounts of liquid and solid wastes released to the environment, and the associated impacts of fuel conversion on media other than the atmosphere. For each of the

TABLE 2.1. Fuel Conversion Scenarios for Brandon Shores *and Crane* Generating Stations

				Alternative	
Generating Station	Base Case 1	No-Action 2	Utility Preference 3	Full FGD 4	Partial FGD 5
Brandon Shores					
Unit 1	SO_2: 0.8 lb/10^6 Btu TSP: 0.01 gr/SCFD Fuel: 0.76% S Oil Control: ESP	SO_2: 0.8 lb/10^6 Btu TSP: 0.01 gr/SCFD Fuel: 0.76% S Oil Control: ESP	SO_2: 1.2 lb/10^6 Btu TSP: 0.03 gr/SCFD Fuel: 0.72% S Coal Control: ESP	SO_2: 0.8 lb/10^6 Btu TSP: 0.03 gr/SCFD Fuel: 2.5% S Coal Control: ESP, 81% wet FGD	SO_2: 0.8 lb/10^6 Btu TSP: 0.03 gr/SCFD Fuel: 0.72% S Coal Control: ESP
Unit 2	Same as Unit 1	Same as Unit 1	Same as Unit 1	Same as Unit 1	SO_2: 0.8 lb/10^6 Btu TSP: 0.03 gr/SCFD Fuel: 2.5% S Coal Control: ESP, 81% wet FGD
Crane					
Unit 1	*SO_2: [illegible] lb/10^6 Btu TSP: 0.02 gr/SCFD Fuel: 1.0% S Oil*	*SO_2: 3.5 lb/10^6 Btu TSP: 0.03 gr/SCFD Fuel: 10% RDF/90% Coal 0.1% S/RDF/ 2.2% S Coal Control: Baghouse*	*SO_2: 3.5 lb/10^6 Btu TSP: 0.03 gr/SCFD Fuel: 10% RDF/90% Coal 0.1% S/RDF/ 2.2% S Coal Control: Baghouse*	*SO_2: 3.5 lb/10^6 Btu TSP: 0.03 gr/SCFD Fuel: 10% RDF/90% Coal 0.1% S/RDF/ 2.2% S Coal Control: Baghouse*	*SO_2: 3.5 lb/10^6 Btu TSP: 0.03 gr/SCFD Fuel: 10% RDF/90% Coal 0.1% S/RDF/ 2.2% S Coal Control: Baghouse*
Unit 2	*Same as Unit 1 TSP: 0.03 gr/SCFD Fuel: 2.2% S Coal Control: Baghouse*	*SO_2: 3.5 lb/10^6 Btu TSP: 0.03 gr/SCFD Fuel: 2.2% S Coal Control: Baghouse*	*SO_2: 3.5 lb/10^6 Btu TSP: 0.03 gr/SCFD Fuel: 2.2% S Coal Control: Baghouse*	*SO_2: 3.5 lb/10^6 Btu TSP: 0.03 gr/SCFD Fuel: 2.2% S Coal Control: Baghouse*	*SO_2: 3.5 lb/10^6 Btu*
Remarks	*1.0% S Oil is 16,667 Btu/lb.* Brandon Shores design oil is 18,940 Btu/lb, 0.10% ash, 0.05% moisture, 0.90 sp. gr.	0.76% S Oil is 17,500 Btu/lb. *RDF is 4500 Btu/lb. 2.15% S and 2.2% S Coal is 12,500 Btu/lb.*	0.72% S Coal is 12,000 Btu/lb. *RDF is 4500 Btu/lb. 2.15% S and 2.2% S Coal is 12,500 Btu/lb.*	2.5% S Coal is 12,000 Btu/lb. *RDF is 4500 Btu/lb. 2.15% S and 2.2% S Coal is 12,500 Btu/lb.*	0.72% S Coal is 12,000 Btu/lb. *RDF is 4500 Btu/lb. 2.15% S and 2.2% S Coal is 12,500 Btu/lb.*

coal-based scenarios, coal is assumed to be delivered by barge to the Brandon Shores Station *and by rail to the Crane Station.* The scenarios envision disposal of dredge spoils at the Marley Neck disposal site north of Brandon Shores. RDF delivery is assumed to be by truck. Offsite ash and/or sludge disposal is also by truck.

Units 1 and 2 at the Crane Generating Station are exempt from the Federal New Source Performance Standards (NSPS) because they were operating on coal prior to the effective date of these standards (in 1971). Following the granting by EPA of a temporary variance to allow a test burn of several coals and RDF, EPA granted BG&E's request for a permanent variance to allow SO_2 emissions from Units 1 and 2 up to 3.5 lb/10^6 Btu. This variance allows coal combustion in the cyclone-fired Crane boilers, and is thus reflected in the scenarios.

The Brandon Shores Generating Station is subject to either the 1971 NSPS or the State of Maryland emission limits, whichever are more stringent. For sulfur dioxide (SO_2) emissions, the Federal NSPS for oil (0.8 lb $SO_2/10^6$ Btu) and coal (1.2 lb $SO_2/10^6$ Btu) apply. For TSP, the more stringent State standards (0.01 grains/SCFD for oil, 0.03 grains/SCFD for coal) apply.

In the event that prohibition orders are finalized for either or both of the units at Brandon Shores and if the units convert to an alternate fuel, each is exempt from 1979 Federal NSPS regulations because any conversion to the use of an alternate fuel is not considered a "major modification".

2.3.3 Description of Scenarios

Five scenarios were selected for detailed analysis (Table 2.1).

Scenario 1 represents the base case alternative against which the impacts of conversion are compared. In this scenario, it is assumed that the four units burn oil to meet applicable emission limits. For the Brandon Shores station, this means that although oil has a low ash and particulate content, electrostatic precipitators must be used to meet Maryland State TSP limits. The assumption of oil use in the absence of a Prohibition Order, however, makes the analysis of the effects of a Prohibition Order more conservative. That is, this analysis tends to overestimate the effects of the Prohibition Order because a base case on oil involves smaller baseline emissions than a base case on coal.

Scenario 2 represents the situation if no Federal Action occurs (i.e., if the Prohibition Order is not perfected). This scenario is based on using oil to operate Brandon Shores *and converting Crane Unit 1 to use coal and RDF and Unit 2 to use coal.*

The combustion of RDF is worth examining because it has the potential for relieving problems that may occur with the disposal of municipal solid waste, and it allows the use of slightly higher-sulfur coals. Based on DOE's internal engineering analyses, a 10% RDF mix was judged to be consistent with the potential availability of the fuel in the Baltimore area. Potential problems with corrosion, degradation of ESP performance, storage, and derating of the units led to the establishment of a 10% upper limit on RDF.

Scenario 3 addresses the conversion of all four units to coal combustion such that no flue gas desulfurization (FGD) equipment would be needed. The units at Brandon Shores would burn coal in compliance with currently applicable air-quality standards. *The Crane units would burn coal and RDF and coal in compliance with a SIP revision allowing the use of coal compatible with the existing boile*[illegible] This scenario is that anticipated to occur if the Prohibition Order is finalized.

Scenario 4 envisions the conversion of the Brandon Shores unit to coal use such that the emission limits applicable to oil use would be met. This would require the use of an FGD system. *The Crane units would convert to coal and RDF and coal.* This scenario is that which would most probably occur should the Prohibition Order not be finalized and the utility choose to operate on coal subject to the 1979 NSPS.

Scenario 5 is a modified coal-conversion scenario in which the SO_2 emissions at Brandon Shores vary between units. This would involve using FGD on one unit. This scenario might be realized if problems occurred in meeting Prevention of Significant Deterioration (PSD) requirements without the use of FGD. This scenario was suggested by the State of Maryland[a] as a possible coal conversion alternative. *Crane Units 1 & 2 would convert to coal with RDF and coal, respectively.*

From the standpoint of potential environmental impacts, Scenario 1 (the baseline alternative) has the least potential for affecting air, water, and land resources. To the extent that coal (and RDF) displaces oil use in the other scenarios, however, the issuance of Prohibition Orders has a positive effect on the human environment. Among the conversion scenarios, Scenario 3 would be the most preferable scenario with regard to air quality and solid waste. A more detailed comparison of potential impacts is given in Section 2.4.

Several additional fuel conversion options were considered and dismissed because their analysis would not add substantially to the evaluation of environmental impacts of fuel conversion or to the selection of viable fuel alternatives. The impacts that would result from the conversion to these fuels would lie within the range of effects accruing under the foregoing scenarios. These options include natural gas; washed coal with partial FGD; and fuel mixtures of coal-oil, coal-natural gas, RDF-oil and RDF-natural gas. Consideration was also given to the use of either dry or regenerable FGD to control air emissions.

Rail delivery of coal to the Brandon Shores site is considered, but barge delivery is given primary consideration. The layout of the site effectively precludes unit train delivery of coal without breaking up the trains. Additionally, BG&E has completed dredging and has used the Marley Neck site for spoils disposal. Other potential spoils-disposal sites existed, including the Brandon Shores site. However, because the Marley Neck site had already been used for dredge spoil disposal and is equipped with suitable water-quality protection facilities, and because the site also has disposal capacity available to BG&E, it was deemed to be the most reasonable alternative available to BG&E.

2.4 COMPARISON OF ENVIRONMENTAL IMPACTS IN RELATION TO FUEL SCENARIOS

Table 2.2 contains a comparative summary of the environmental changes projected to be associated with the various fuel conversion scenarios relative to base case (oil burning) operating conditions at the two generating stations. Impacts identified in Table 2.2 are the cumulative impacts of each scenario. *Scenario 2 represents the conversion of Crane only.* Scenarios 3, 4, 5 represent the conversion of both Brandon Shores *and Crane* (see Table 2.1). To identify effects of conversion of Brandon Shores alone, subtract the effects of Scenario 2 from those of 3, 4 or 5, respectively. In some instances (dredging of the proposed barge channel, for example), the projected impacts do not vary among conversion scenarios, but are simply a result of coal use by the stations. The table is further described in this section.

(a) Letter from Stephen M. Long, Md. Powerplant Siting Program, and George Ferreri, Bureau of Air Quality Control, to Seven Ferguson, ERA, February 19, 1980.

TABLE 2.2. Comparison of Environmental Impact of Fuel Conversion Scenarios

Impact Area	Base Case 1	No-Action 2	Utility Preference 3	Alternative: Full FGD 4	Alternative: Partial FGD 5
	Fuel Conversion Scenario (Refer to Table 2.1)				
Air Quality					
Fugitive Dust Emissions					
Construction (Increase over base case)	None	160 lb/day released	1280 lb/day released	2640 lb/day released	1280 lb/day released
Operation (increase over base case)	None	574 lb/day released	2363 lb/day released	2394 lb/day released	2381 lb/day released
Possible Violations	None	For all conversion scenarios, ambient air quality would not be significantly affected.			
Stack Emissions					
SO_2	1.7 kg/s	2.9 kg/s	3.5 kg/s	3.3 kg/s	3.5 kg/s
NO_2	0.78 kg/s	1.5 kg/s	2.1 kg/s	2.1 kg/s	2.1 kg/s
CO	63.3 g/s	67.3 g/s	79.5 g/s	79.5 g/s	79.5 g/s
Hydrocarbons	11.9 g/s	14.8 g/s	23.8 g/s	23.8 g/s	23.8 g/s
Particulate Matter	85.8 g/s	94 g/s	94.0 g/s	94.0 g/s	94.0 g/s
Possible Violations	Base Case	For all conversion scenarios, no violations projected			
PSD Consumption					
Combined to All Stations (including overlaps)	Base Case No Consumption of increment	No consumption of increment for TSP. Approximately 25% consumption of available increment on an annual basis. Approximately 83% consumption of available SO_2 increment on a 3-hour basis.	No consumption of increment for TSP. Approximately 25% consumption of available SO_2 increment on an annual basis. Approximately 97% consumption of available SO_2 increment on a 3-hour basis.	No consumption of increment for TSP. Approximately 25% consumption of available SO_2 increment on an annual basis. Approximately 83% consumption on a 3-hour basis	No consumption of TSP increment. Approximately 25% consumption of available SO_2 annual PSD increment. 75% consumption of 24-hour increment, and 97% consumption of 3-hour increment.
Land Use and Solid Waste					
Coal Storage (78 days at 100% capacity)		*About [illegible] acres at Crane available on site*	About 32 acres for both stations, available on site	About 32 acres for both stations, available on site	About 32 acres for both stations, available on site
Limestone Storage (30-day supply)		None	None	About 1.4 acres at Brandon Shores *and Crane*, available on site	About 0.7 acre at Brandon Shores, available on site
RDF Storage (Daily Supply)		*Less than 0.1 acre for Crane, available on site*	*Less than 0.1 acre for Crane, available on site*	*Less than 0.1 acre for Crane, available on site*	*Less than 0.1 acre for Crane, available on site*

TABLE 2.2. (Continued)

Impact Area	Fuel Conversion Scenario (Refer to Table 2.1): Base Case 1	No-Action 2	Utility Preference 3	Alternative: Full FGD 4	Alternative: Partial FGD 5
Waste Disposal (fly ash, bottom ash, FGD sludge)					
Rate of Generation	267 ft^3/day	18,400 ft^3/day	60,800 ft^3/day	95,800^3/day	78,300 ft^3/day
Lifetime Land Commitment, 25-foot fill depth	2 acres	73 acres	400 acres	670 acres	540 acres
Dredge Spoils	No Impact	462,000 yd^3-disposal at Marley Neck Site	462,000 yd^3-disposal at Marley Neck Site	462,000 yd^3-disposal at Marley Neck Site	462,000 yd^3-disposal at Marley Neck Site
Water Quality					
Coal Storage					
Surface Water Quality	No Impact	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	These conversion scenarios, treated runoff from Brandon Shores discharged to Patapsco River; *treated runoff from Crane discharged to Seneca or Saltpeter Creek estuaries* Impacts from discharge of this treated runoff are insignificant.		
Ground-Water Quality	No Impact	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	These conversion scenarios, potential exists for contamination from leachate from *Brandon Shores or Crane* coal piles. Mitigation measures (impermeable barriers, underdrains) can minimize potential for contamination.		
Waste Disposal					
Surface-Water Quality	Base Case	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	Minimal potential for impact for these scenarios since contact time of runoff with water is short.		
Ground-Water Quality	Base Case	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	Potential for impact among these conversion scenarios is small, since Bishop/McKay disposal site appears to have a confining clay layer. Greatest potential for impact is with Scenario 4, since most waste is generated under this scenario.		
Dredging	No Impact	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	No projected effect on ambient quality of Patapsco River outside of an allowed mixing zone. Within the zone, pollutant concentrations may increase temporarily. *No effect from Crane*		
Dredge Spoils					
Surface-Water Quality	No impact	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	If overflow of sediment basin occurs, State standards for discharge of arsenic and mercury would be exceeded.		
Ground-Water Quality	No Impact	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	Insignificant potential for impact, since disposal site is currently used for disposal of Baltimore Harbor spoils		

TABLE 2.2. (Continued)

Impact Area	Fuel Conversion Scenario (Refer to Table 2.1)				
				Alternative	
	Base Case 1	No-Action 2	Utility Preference 3	Full FGD 4	Partial FGD 5
Ecology					
Terrestrial Ecology					
Atmospheric Emissions	Small potential for SO_2 damage to vegetation	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	Small potential for SO_2 damage to vegetation	Small potential for SO_2 damage to vegetation	Small potential for SO_2 damage to vegetation
Disruption of Habitat (Waste Disposal)	Up to 2 acres disrupted for 35 to 45 years	Up to 73 acres disrupted for 35 to 45 years	Up to 400 acres disrupted for 35 to 45 years	Up to 670 acres disrupted for 35 to 45 years	Up to 540 acres disrupted for 35 to 45 years
Threatened and Endangered Species	No impact	No impact	No impact	No impact	No impact
Aquatic Ecology					
Thermal Discharge	Base Case	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	Increase in capacity factor at Brandon Shores *and Crane (all conversion scenarios)* may cause minor temporal and spacial shifts in resident populations; *this is more probable for Crane than for Brandon Shores.*		
Impingement-Entrainment	Base Case	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	For all conversion scenarios, an increase in loss rates; this is insignificant when compared to the commercial catch of the area.		
Coal Storage	No impact	No impact from treated runoff	No impact from treated runoff	No impact from treated runoff	No impact from treated runoff
Waste Disposal	Base Case	No impact from treated effluent	No impact from treated effluent	No impact from treated effluent	No impact from treated effluent
Disruption of Habitat (Dredging)	No impact	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	For all conversion scenarios, benthic habitat would be disrupted (about 70 acres) during dredging operations. Recolonization would occur within 2 years.		
Resuspension of Toxic Contaminant in Sediments (Dredging)	No Impact	No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	For all conversion scenarios, potential exists for a transient toxicity hazard due to resuspension and resolubilization. This impact is naturally mitigated by dilution and resettling.		
Threatened and Endangered Species		No impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	No Impact	No Impact	No Impact
Noise					
Construction	Base Case	No Impact from Brandon Shores, *effects from Crane are the same as Scenarios 3, 4 and 5*	Increases may occur, but no violation of standards projected	Increases may occur, but no violation of standards projected.	Increases may occur, but no violation of standards projected.

TABLE 2.2. (Continued)

Impact Area	Base Case 1	No-Action 2	Utility Preference 3	Alternative: Full FGD 4	Alternative: Partial FGD 5
			Fuel Conversion Scenario (Refer to Table 2.1)		
Operation					
Daytime	Base Case	No impact from Brandon Shores, effects from Crane are the same as Scenarios 3, 4 and 5	For all conversion scenarios, Crane may exceed standards		
Nighttime	Base Case	No impact from Brandon Shores, effects from Crane are the same as Scenarios 3, 4 and 5	For all conversion scenarios, Crane and Brandon Shores may exceed standards.		
Socioeconomic					
Employment					
Construction	No Impact	Insignificant increase (30 to 60 jobs)	Insignificant increase (60 to 120 jobs)	Insignificant increase (60 to 120 jobs)	Insignificant increase (60 to 120 jobs)
Operation	Base Case	Insignificant increase (about 35 jobs)	Insignificant increase (about 65 jobs)	Insignificant increase (about 90 jobs)	Insignificant increase (about 90 jobs)
Community Impacts					
Transportation	Base Case	No impact from Brandon Shores, effects from Crane are the same as Scenarios 3, 4 and 5	For all scenarios, minor traffic increases will occur from fuel, solid waste, and FGD reagent transport. Scenario 4 will cause the largest increases in local traffic volume.		
Aesthetics		No increase in impact	No increase in impact	No increase in impact	No increase in impact
Archeological/Historical	Base Case		No increase in impact	No increase in impact	No increase in impact
No increase in impact					
Energy/FGD Reagent					
Oil Use Displacement	None	About 11,000 bbl/day. Continued use of 28,000 bbl/day	About 39,000 bbl/day	About 39,000 bbl/day	About 39,000 bbl/day
Coal Consumption (100% capacity)	None (~150,000 gal/hr oil use)	139/tons/hr	About 640 tons/hr	About 650 tons/hr	About 660 tons/hr
RDF Consumption (100% capacity)	None	about 43 tons/hr	about 43 tons/hr	about 43 tons/hr	about 43 tons/hr
Limestone Requirements (78 wt% $CaCO_3$)	None	None	None	1270 tons/day	635 tons/day

2.4.1 Air Quality

The air-quality impacts described in detail in Section 4.1 and Appendix H are compared by scenario in this section. National Ambient Air Quality Standards (NAAQS) and Prevention of Significant Deterioration (PSD) regulations provide a framework for comparison of impacts.

Estimates of maximum concentrations of atmospheric pollutants and projections of consumption of PSD increments are related (but different) measures of local air quality. The former estimates the total impact of all activities in the region (i.e., including ambient concentrations as well as the proposed actions), whereas the latter represents the change in air quality over previous operations. Also, the basis for computing maximum concentrations and PSD differs in several ways. (Appendix H describes these differences in more detail.)

An atmospheric dispersion model (CRSTER) was used to compute ground-level pollutant concentrations resulting from stack emissions. The model used was developed and approved for relevant applications by the U.S. Environmental Protection Agency.

The modeling strategy used in this EIS includes, by necessity, certain approximations that were made to err on the conservative side (i.e., to predict atmospheric concentrations of pollutants on the high side). An example of one such conservative approximation includes taking the highest ambient concentration of pollutant that was measured as background for all conditions. Correlating actual background concentrations with meteorological conditions would reduce the computed maximum concentrations.

Fugitive Dust

Large uncertainties in the fugitive-dust-emission source terms made detailed modeling of little practical use. A screening model was used to provide conservative estimates of the range of maximum increases in fugitive dust for the scenarios based on conventional coal-handling and -storage methods. Recent studies of the fugitive-dust air-quality impacts from coal conversions at Brandon Shores *and at Crane* provide more detailed estimates of potential impacts both for conventional and improved onsite fugitive-dust emission controls. A comparison of fugitive emissions with respect to the fuel scenarios (Table 2.3) shows that although the amount of material released during construction activities varies, emissions from routine operations using conventional coal-handling and

TABLE 2.3. Summary of Increases in Particulate Fugitive Emissions at Brandon Shores *and Crane*[(a)]

	Total Emission Rate[(a)]			
	Scenario			
	2	3	4	5
Brandon Shores				
Construction	1,120	2,480	1,120	1,840
Operation[(b)]	1,789	1,820	1,807	1,814
Crane				
Construction	*160*	*160*	*160*	*160*
Operation[(b)]	*579*	*574*	*574*	*574*

(a) Increase over the base case (oil-combustion) scenario (Scenario 1) in pounds of dust per day, based on data in Table H.18. These are estimates used as input to the screening model.

(b) New emissions, no existing coal-handling operations onsite.

-storage methods are nearly scenario-independent. Construction-related fugitive emissions are greatest for Scenario 4, in which both of the generating stations are converted to coal and both units at Brandon Shores use FGD.

NAAQS and PSD regulations apply to fugitive dust emissions generated during routine operation. Brandon Shores is projected to have the larger 24-hour TSP values; the estimated maximum 24-hour TSP values at Crane are less than one half of those at Brandon Shores. Only very small differences exist between the scenarios. These reflect differences in operations such as ash handling (see Appendix H).

Fugitive-dust emissions and resultant impacts for the conversion of Brandon Shores Units 1 and 2 (Environplan 1980a) and Crane Units 1 and 2 (Environplan 1980b) were modeled using the EPA Industrial Source Complex (ISC) model. These results show that conventional particulate-control methods would result in computed TSP values in excess of permissible values. The Environplan studies also computed the emissions expected if an improved level of fugitive emission controls was used; this study projected compliance both in the attainment and non-attainment areas in this region for both annual and 24-hour TSP values. The maximum fenceline impacts at Brandon Shores were less than the *de minimis* values.

Based on these results, the fugitive-dust emissions are projected to comply with TSP regulations for all scenarios at all sites, provided that adequate controls are adopted at each station; little difference exists between the scenarios in this regard. The overlap of fugitive emissions does not contribute significantly to TSP concentrations. Even in the case of the adjacent Brandon Shores and Wagner stations, overlap of new fugitive emissions from Brandon Shores with those from existing operations at Wagner is projected to be small. In addition, the fugitive TSP emissions originating from current operations at Wagner could be reduced by changing fugitive-emission control operations and/or equipment sufficiently to offset any combined increases resulting from conversion of Brandon Shores.

Fugitive emissions resulting from conversion of Unit 1 at Crane to RDF/coal would be minor. The RDF in the form of fluff or pellets would be transported in covered trucks to minimize fugitive emissions during shipment. Most of the fugitive emissions in the RDF-related scenarios would result from the construction work needed to convert the boilers to RDF-firing capability.

Stack Emissions

Sulfur dioxide (SO_2), total suspended particulates (TSP), nitrogen dioxide (NO_2), and small amounts of carbon monoxide (CO) and hydrocarbons (HC) are combustion products of interest from an air-quality perspective. The discussion of air-quality impacts by scenario includes both separate station and combined-station values.

Although the values reported here were obtained by detailed modeling using an EPA-approved model, values meeting NAAQS in these tables do not necessarily imply that air-quality standards would be met if the units convert according to a particular scenario. Additional assumptions or models could result in different results. A uniform modeling approach is used here to illustrate the relative air-quality impacts. The NAAQS are provided as benchmarks against which to measure the impacts.

The total stack emissions from each conversion scenario for SO_2, NO_2, CO, hydrocarbons, and particulates (Table 2.4) are all equal to or greater thar the baseline scenario (Scenario 1). All conversion scenarios have predicted concentrations of air pollutants values which fall in a narrow range all values of which lie below applicable NAAQS.

TABLE 2.4. Comparison of Total Stack Emissions by Scenario from the Brandon Shores and Crane Generating Stations

	Emission Rate (g/s) (except where noted)				
	Scenario				
Emissions	1	2	3	4	5
SO_2	1.8 kg/s	2.9 kg/s	3.5 kg/s	2.9 kg/s	3.5 kg/s
NO_2	0.78 kg/s	1.5 kg/s	2.1 kg/s	2.1 kg/s	2.1 kg/s
CO	63.3	67.3	79.5	79.5	79.5
Hydrocarbons	11.9	14.8	23.8	23.8	23.8
Particulates	85.8	94.0	94.0	94.0	94.0

The relative compliance of the scenarios with respect to stack emissions are summarized in Tables 2.5, 2.6 and 2.7. The results for each station for each scenario are ranked for each pollutant-time period on a scale of 1 to 6; 1, 2, and 3 are acceptable (i.e., resulting in pollutant concentrations smaller than NAAQS) and 4 and 5 fail to meet the NAAQS in this computation. No violations of applicable standards were predicted.

Increases in NO_x emissions above those of the "no-action" scenario are predicted for all conversion scenarios. Annual maximum NO_x concentrations show little variation among scenarios and are projected to be in compliance with the standards for all scenarios. The increased emissions of NO_x may lead to increased formation of photochemical oxidants and the transformation of NO_x to acidic compounds. This could result in possible long-range impacts, perhaps to human health. Ozone and other photochemical oxidants are formed by photochemical reactions among emitted pollutants. For instance, hydrocarbons and NO_x are precursors for ozone formation.

All scenarios except the baseline scenario result in increased emissions of hydrocarbons and carbon monoxide. It is not possible to distinguish among scenarios on the basis of increases in atmospheric carbon monoxide and hydrocarbon concentration. Based on extrapolations of the predicted maximum concentrations of the other criteria pollutants, the NAAQS for these criteria pollutants in any scenario would not be violated.

Prevention of Significant Deterioration (PSD) Increment Consumption

PSD increment consumptions were computed using Good Engineering Practice (GEP) stack height (187 m) at Brandon Shores. Table 2.8 shows a summary of these results by scenario. Because the overlap in plumes between Brandon Shores and Crane is not significant, the consumption of PSD by a combined conversion would be the same as the individual conversions. Of the conversion scenarios, only Scenario 4 does not consume nearly all of the available SO_2 increment. Scenarios 2, 4, and 5 are nearly indistinguishable and consume marginally less than 100% of the available 3-hour increment for SO_2. All of the conversion scenarios show appreciable consumption of the 3-hour and 24-hour SO_2 increments. Only Scenario 4 has extremes of 3-hour SO_2 increment consumption. Scenario 3 consumes the least increment.

TABLE 2.5. Summary of Maximum Computed Pollutant Concentrations of SO_2 and TSP for Scenarios 1, 2 and 3[a]

		SO_2					TSP			
Scenario	Station[b]	Annual	Highest 24-hour	Second High 24-hour	Highest 3-hour	Second High 3-hour	Annual	Highest 24-hour	Second High 24-hour	Highest 24-hour Change in Non-Attainment Area
1	B	29	164	153	538	496	69	217	216	(c)
	C	22	182	161	683	456	57	148	147	(c)
2	B	30	218	200	1018	874	69	218	217	(c)
	C	27	339	237	1547	883	57	148	147	(c)
3	B	30	217	186	930	731	69	219	218	(c)
	C	24	228	186	828	602	57	150	149	(c)

(a) Entries are in $\mu g/m^3$. See Section 4.1 and Appendix H for origins of these numbers.
(b) B = Brandon Shores Units 1 and 2; C = Crane Units 1 and 2.
(c) Computed change is less than *de minimis* values.

TABLE 2.6. Summary of Maximum Computed Pollutant Concentrations of SO_2 and TSP for Scenarios 4, and 5[a]

		SO_2					TSP			
Scenario	Station[b]	Annual	Highest 24-hour	Second High 24-hour	Highest 3-hour	Second High 3-hour	Annual	Highest 24-hour	Second High 24-hour	Highest 24-hour Change in Non-Attainment Area
4	B	30	218	200	1018	874	69(c)	218	217	(c)
	C	27	339	237	1547	883	57(c)	148	147	(c)
5	B	30	209	193	943	803	69(c)	218	218	(c)
	C	25	218	195	958	702	57(c)	150	149	(c)

(a) Entries are in $\mu g/m^3$. See Section 4.1 and Appendix H for origins of these numbers.
(b) B = Brandon Shores Units 1 and 2; C = Crane Units 1 and 2.
(c) Computed change is less than *de minimis* values.

TABLE 2.7. Comparisons of Compliance with Standards for SO2, TSP, and NO_x[a]

Station and Standard	Scenario 2	3	4	5
Brandon Shores	1	2	2	2
SO_2-Annual	2	2	2	2
24-Hour	2	2	2	2
3-Hour	2	2	2	2
TSP-Annual	1	1	1	1
24-Hour	1	1	1	1
NO_x-Annual	2	2	2	2
Crane				
SO_2-Annual	2	2	2	2
24-Hour	2	2	2	2
3-Hour	2	2	2	2
TSP-Annual	1	1	1	1
NO_x-Annual	2	2	2	2

Rating Scale Used in Table:

1 = Acceptable: computed value is less than de *minimis*

2 = Acceptable: computed concentrations do not exceed NAAQS

(a) Based on results in Tables 4.6 to 4.9 and H.13.

TABLE 2.8. Summary of PSD Consumption by Scenarios[a]

Station	Scenario 2	3	4	5	Available PSD Increment
Combined[b]					
SO_2-Annual	5	5	2	5	20
24-Hour	68	63	37	63	91
3-Hour	426	496	265	496	512
Brandon Shores					
SO_2-Annual	0	2	2	2	20
24-Hour	0	63	47	63	91
3-Hour	0	496	353	496	512
TSP-Annual	0	0	0	0	19[c]
24-Hour	0	0	0	0	37[c]
Crane					
SO_2-Annual	5	5	2[b]	5	20
24-Hour	68	68	37[b]	68	91
3-Hour	426	426[b]	265[b]	426	512
TSP-Annual	0	0	0	0	19[c]
24-Hour	0	0	0	0	37[c]

(a) Entries in $\mu g/m^3$; see Section 4.1 and Appendix H for additional details. Calculations with the exception of (b) are based on 1964-1968 data.

(b) Based on 1964 data only.

(c) Less than this is available in areas adjacent to TSP non-attainment areas.

2.4.2 Land Use and Solid Waste

Coal, Limestone, and RDF Storage

The conversion of Brandon Shores to coal *and Crane to coal and coal/RDF* mixture under Scenarios 3, 4, and 5, *or only converting Crane to coal and coal/RDF under Scenario 2* would require the establishment or reactivation of coal piles at these sites. The sizes of the coal piles at the stations would not vary substantially among the scenarios. The piles would cover about 13 acres at Brandon Shores *and 3.2 acres at Crane*. The coal-pile runoff treatment facilities would be located on the stations' grounds; additional land would not be required. *The land previously used for coal storage at Crane would again be used for this purpose.* A new coal pile could be established at Brandon Shores.

Under Scenarios 4 and 5, limestone would be stored onsite at Brandon Shores. For Scenario 4, about 1.4 acres (at a 20-foot height of 78 wt% $CaCO_3$ limestone) would be required for limestone storage at Brandon Shores. For Scenario 5, about 0.7 acres would be required for Brandon Shores. No offsite land would be required for this amount of storage capacity.

Refuse-derived fuel would be shipped daily to Crane since RDF tends to settle and become compacted when stored. The amounts of RDF required under Scenarios 2, 3, 4, and 5 could be stored onsite at Crane, with no offsite land required.

Combustion Ash and FGD-Sludge Storage and Disposal

The quantities of fly ash, bottom ash, and FGD sludge produced depend on the type of fuel burned, the configuration of the boiler, the particulate and sulfur dioxide emission-control technology used, the degree of sulfur dioxide and particulate-removal, and the method of treatment of the wastes. Ash contents of various fuels were taken to be 15% for coal, *10% for refuse-derived fuel (RDF)*, and 0.10% for oil. For purposes of estimating the impacts of solid waste, particulate-removal equipment was taken to be 100% effective. In those scenarios incorporating FGD (Scenarios 4 and 5), a wet-limestone FGD system was incorporated into the scenarios. Wet-limestone systems are the most technically feasible FGD systems and provide a worst-case situation with respect to sludge generation.

The quantity of solid waste produced (Table 2.9) when coal is burned by all four units is much greater than when oil is burned (Scenario 1). When coal is burned, about 32,000 ft^3/day of fly ash and 29,000 ft^3/day of bottom ash is produced at full load for all units. About 17,000 ft^3/day of oxidized, high-calcium limestone FGD sludge would be produced under Scenario 5 and about

TABLE 2.9. Estimated Production of Solid Waste[(a)] at BG&E Stations Under Different Fuel Use Scenarios, Ft^3/Day

Fuel Use Scenario	1	2	3	4	5
Brandon Shores 1	90	90	21,300	38,800	21,300
Brandon Shores 2	90	90	21,300	38,800	38,800
Crane 1	44	9,200	9,200	9,200	9,200
Crane 2	43	9,000	9,000	9,000	9,000
TOTAL	267	18,400	60,800	95,800	78,300

(a) Solid waste figures are the sum of fly ash from Table 4.20, bottom ash from Table 4.21, and high calcium, oxidized FGD sludge from Table 4.22.

34,000 ft³/day under Scenario 4. Thus, the greatest amount of solid waste is produced under Scenario 4. At full capacity, this waste would occupy approximately 6 acres/yr to a depth of 25 feet in Scenario 2; 32 acres/yr in Scenario 3; 26 acres/yr in Scenario 4; and 27 acres/yr in Scenario 5.

BG&E has investigated a wooded area across Fort Smallwood Road from the Brandon Shores generating station—the Bishop and McKay properties—which will be used for disposal of solid waste from Brandon Shores and Wagner. Selection of this site would minimize environmental impacts from transportation. Only a small portion (about 2%) of the site is flood plain or wetland and would not be used for waste disposal as the State of Maryland is committed to protecting this resource. The soil is stable and is underlain by a clay layer, which appears to be continuous. The disposal area would have to be designed to prevent contamination of surface water by runoff and to prevent contamination of ground water by leachate. The Bishop and McKay site could contain 7 to 10 years production of the combined solid waste from the Brandon Shores and Wagner BG&E units. Additional disposal area would be required for the remaining life of these stations. *BG&E has designated a site at Rossville for the disposal of C.P. Crane waste.*

Dredge-Spoil Storage and Disposal

Transporting coal by barge to the Brandon Shores generating station necessitates dredging of the Patapsco River estuary, to clear a channel to the coal-unloading station. BG&E estimates that approximately 462,000 cubic yards of dredge spoils were removed and placed in a disposal site. The soils were disposed of at an 80-acre site on Marley Neck, one mile north of the generating station. The site, which has been used previously to dispose of Baltimore Harbor dredge spoils, has containment dikes on the east, north, and south sides, all of which are currently being enlarged. When dike construction is completed, the Marley Neck site will have a total available capacity of 1.1 million cubic yards. The possible impacts associated with dredge spoil storage and disposal are common to Scenarios 3, 4, and 5.

The overall land-use impacts of dredge spoil disposal at Marley Neck are projected to be negligible. A wetland area does exist to the west of the site. However, disposal of the BG&E spoils did not require the use of this wetland. Most of the surrounding land is zoned for heavy industrial use. The ultimate use of the disposal area depends on the structural stability and chemical quality of the dredge spoils. The site may ultimately be used for construction of a port facility by Chessie Resources, Inc., which is the parent company of the owner of the site, Marley Neck Patapsco Company.[a]

2.4.3 Water Quality

Runoff and Leachate from Stored Coal

The quantity of coal-pile runoff generated depends on the area of the coal pile and the amount and duration of precipitation. Yearly quantities of coal-pile runoff projected for Brandon Shores *and Crane* are given in Table 2.10. Since the coal piles for the stations do not vary in size among the conversion scenarios, these figures are applicable to all the scenarios.

Because coal-pile runoff typically has a low pH and contains large amounts of trace metals, some treatment is usually required to meet effluent limitations specified by the National Pollution Discharge Elimination System (NPDES) regulations. According to the EPA regulations (40 CFR 423), effluent from precipitation greater than the 24-hour, 10-year rainfall event may be discharged without treatment. EPA regulations are summarized in Table 2.11.

(a) Letter from Chessie Resources, Inc., to William K. Hellman dated July 17, 1979. Letter is reproduced in USDOT/MDT (1979).

TABLE 2.10. Estimated Yearly Volumes of Coal-Pile Runoff

Plant	Runoff, gal
Brandon Shores 1 and 2	10,300,000
Crane 1 and 2	2,500,000

TABLE 2.11. Effluent Guidelines on Discharge of Treated Coal-Pile Runoff[(a)]

Parameter	Concentration
pH (units)	6.0 - 9.0
TSS (ppm)	50

(a) Source: 40 CFR 423.

Treated coal-pile runoff is generally of good quality, meaning that it would present minimal water-quality impacts if discharged into a waterbody. In a worst-case situation, water percolating through the coal pile into the underlying soil would have the same high acidity and metals content as the untreated surface runoff. This infiltrating coal-pile runoff could contaminate underlying ground water. The presence of impermeable clay strata would effectively isolate coal-pile runoff from underlying ground water.

Analysis of the soil profiles beneath the expected location of the Brandon Shores and Crane coal piles shows that relatively permeable sandy material would separate the coal piles from the water table. Therefore, BG&E has committed to install impermeable liners beneath the Brandon Shores and Crane coal piles to prevent possible ground-water contamination.

Scenarios 4, and 5 call for the conversion of the BG&E generating stations to relatively high-sulfur coal, and would generally result in untreated coal-pile runoff of the poorest quality.

A poorer quality, untreated runoff would generally increase any potential ground-water contamination under the coal pile and would generally result in the production of more sludge in coal-pile treatment facilities. However, the quality of treated runoff would remain unchanged.

Runoff and Leachates from Stored Ash and Flue-Gas Desulfurization (FGD) Sludge

Pollutants contained in ash (and FGD sludge in Scenarios 4 and 5) may be released to the environment through runoff or by leaching from solid-waste ponds or landfills. The major environmental concern is trace metal constituents of the ash and sludge. Trace-metal concentrations in runoff are projected to be negligible because of the minimal water-contact time (Coltharp et al. 1979); trace metal concentrations in leachate could be much higher. Ranges of trace metal concentrations in ash and sludge liquids are compared in Table 2.12 with water-quality standards. Although, trace elements in leachate could exceed Federal Drinking Water Standards, none of the trace elements exceed the Resource Conservation and Recovery Act (RCRA) standards for leachates from solid or hazardous wastes. The RCRA standards for leachate from solid waste are less stringent than the

TABLE 2.12. Comparison of Ranges of Elemental Concentrations in Various Liquid Wastes with Water-Quality Standards (all values in ppm)

Element	Flyash Pond	Bottom Ash Pond	Sludge Leachate	Treated Sludge Leachate	EPA Interim Primary Drinking Water Standards[b]	RCRA[a] Standards
Arsenic (As)	0.005 - 0.023	0.002 - 0.015	0.008 - 0.30	0.008 - 0.05[c]	0.05	5.0
Barium (Ba)	0.2 - 0.40	0.1 - 3.0	0.002 - 2.00	0.3 - 2[c]	1.0	100.0
Boron (B)	1.00 - 24.6	1.00 - 24.60	0.22 - 40.00	0.5 - 1.3[d]	0.75[e]	—(i)
Cadmium (Cd)	0.023 - 0.052	0.001 - 0.085	0.0005 - 0.047	0.01 - 0.03	0.010	1.0
Chromium (Cr)	0.012 - 0.17	0.005 - 0.023	0.001 - 0.25	0.02 - 0.05	0.05	5.0
Copper (Cu)	0.16 - 0.45	0.01 - 0.14	0.002 - 0.56	0.02 - 0.10	1[f]	—
Fluorine (F)	1.00	1 - 14.85	0.005 - 2[g]	0.05 - 1.75[d]	1.4 - 2.4	—
Lead (Pb)	0.01 - 0.20	0.01 - 0.08	0.003 - 0.039	0.05	0.05	5.0
Mercury (Hg)	0.002 - 0.0006	0.0002 - 0.006	0.0004 - 0.07	0.0015 - 0.006	0.002	0.2
Nickel (Ni)	0.06 - 0.13	0.15 - 0.20	0.015 - 0.05	0.15	—	—
Selenium (Se)	0.001 - 0.004	0.001 - 0.05	0.0005 - 0.54	0.04 - 0.09[d]	0.01	1.0
Silver (Ag)	0.01 - 0.01	0.05 -	0.036 - 0.038[d]	0.010 - 0.022[d]	0.05	5.0
Vanadium (V)	NA[h]	0.02	0.1 - 0.20	0.08 - 0.29[d]	10.0[e]	—
Zinc (Zn)	1.1 - 2.7	0.02 - 0.16	0.01 - 4.20	0.01 -0.02	5[f]	—

Source: Hart and Delaney 1978, except where noted.
(a) RCRA standards are defined to be 100 times greater than the primary drinking water standards.
(b) Knight et al. 1980.
(c) Holland et al 1975 (p. 21).
(d) Coltharp et al. 1979 (p. 6-78).
(e) Irrigation Standards.
(f) Proposed Secondary Drinking Water Standards.
(g) Jones and Schwitzgebel 1978 (p. 12, Shawnee and Four Corners sludge).
(h) NA = Not available.
(i) — = Not applicable.

Drinking Water Standards because dilution and soil attenuation in a properly designed and operated landfill should reduce trace element concentrations.

Variations in the coal, the waste, and the landfill soils and hydrogeology make it impossible to predict the exact composition and quantities of the leachate. Holland et al. (1975) found that trace metal constituents of ash and FGD sludge were attenuated by soil systems. Boron, chromium, fluoride, and selenium were most mobile and therefore were most likely to cause ground-water contamination. Environmental impacts should be minimized by selection and engineering design of the disposal site.

The maximum amount of solid waste (95,800 ft^3/day) is produced under Scenario 4 (Table 2.9). This scenario would have the greatest potential for impacts on surface and ground water. BG&E is planning to use a wooded area across Fort Smallwood Road from the Brandon Shores Generating Station as a solid-waste disposal site. The site is underlain by a clay layer, which appears to be continuous. If the layer is continuous, it would protect ground water. Otherwise, a clay or synthetic liner would have to be added. Runoff from the site flows into the Patapsco River estuary via Bishop and Cox Creeks. The runoff would have to be diverted from solid-waste disposal areas.

Dredging and Dredge Spoils Disposal

With any of the conversion scenarios (Scenarios 3, 4, and 5) for Brandon Shores generating station, the transport of coal to the station by barge would require the dredging of a channel from the existing coal-unloading facility at Wagner generating station. Approximately 462,000 yd^3 of dredged sediment was removed during the seven-to-nine-month dredging operation (completed in March 1982) and subsequently placed in an upland disposal site on Marley Neck. There is no discernible difference in impacts between scenarios involving conversion. All scenarios involving conversion of Brandon Shores result in impacts relative to the no-action scenario and the baseline scenarios. For the baseline scenario (Scenario 1) and the no-action scenario (Scenario 2), no dredging is required.

Dredging Impacts

Clamshell dredging was the method preferred by the utility for dredging the barge channel. This technique typically produces a smaller volume of dredge spoil than the hydraulic dredging technique, because less water is removed along with the sediments. However, the clamshell process creates greater amounts of turbidity in the area being dredged than does the hydraulic dredging process.

Within the turbid plume created by dredging operations, the concentration of suspended solids is estimated to exceed 250 mg/l for a distance of up to 240 m from the dredging operation, and to exceed 80 mg/l for a distance of 700 m (EA 1980a). The estimated dimensions of turbid water plume containing 80 mg/l suspended solids do not exceed EPA standards which state that no more than 10% of the cross-sectional area of an estuary can be included in the turbidity plume and an area contiguous to the plume (mixing zone) where water quality standards are exceeded (EPA 1976).

Within the turbid plume of suspended sediments, pollutant concentrations may increase temporarily over the ambient levels. This increase is a result of both the suspension of pollutants present in the sediment, and the dissolution of sediment-bound contaminants. The dissolved oxygen content of the water within the plume may also temporarily decline as a result of reaction with sulfur, iron, or manganese compounds in the suspended sediments.

The cadmium and mercury concentrations at the edge of the mixing zone, 2300 ft (700 meters) from the dredging operation, could exceed EPA water quality criteria for both fresh and marine water. However, the predicted concentrations are similar to the present ambient quality of the Patapsco River near Brandon Shores. With the addition of sediment from dredging, the dissolved oxygen content of the river water is still projected to meet EPA water quality criteria for both fresh and marine waters. Therefore, the dredging of the barge channel is not projected to have affected the ambient quality of the Patapsco River estuary outside of the allowed mixing zone.

Dredge-Spoils Disposal Impacts

Dredge spoils have been disposed of at an upland disposal area on Marley Neck, located about 1 mile from the Brandon Shores station. The site, which covers 80 acres and has a total capacity of 1.5 million yd^3, has a 1.8-acre sedimentation basin to hold excess water from the spoils.

If overflow of the sedimentation basin were to occur, the discharged water would contain concentrations of arsenic and mercury that exceed State of Maryland water-quality standards for spoil-containment area discharge. The overflow from this basin into a spillway leading to the Patapsco River would occur "only after abnormally high amounts of precipitation from major storms."[a]

(a) Letter to Jon Romeo, ACOE, from EU Dalton, Aakenheil and Assoc., dated January 10, 1980.

Contamination of ground water could occur at the disposal site if water contained in the spoils infiltrates through the underlying soil and comes into contact with ground water. The infiltrating water will meet EPA Interim Primary Drinking Water Standards (Section 4.2.3). Therefore, the groundwater quality will not be degraded to below these standards. The site has been used in the past for depositing dredge spoils, and it is probable that the concentrations of chloride, sulfate, and total dissolved solids are already high in any ground water at the site. It is also probable that most water that infiltrates into the underlying soil at the site flows back into the Patapsco River, which borders the site to the east and the south. As the waters of the Patapsco River already have high ambient concentrations of these constituents, water infiltrating into the underlying soil causes only minimal changes in water quality.

Periodic maintenance dredging of the proposed barge channel at Brandon Shores typically would occur every 4 to 6 years and would cause water quality impacts similar to those which occurred during the original dredging operations. However, because the dredging operation would be shorter in duration and involve smaller amounts of spoils, the associated impacts would be correspondingly smaller.

2.4.4 Ecology

Terrestrial Ecology

Conversion to an alternate fuel at the two BG&E generating stations would result in two types of impact on terrestrial ecosystems: adverse effects of SO_2 emissions on vegetation, and loss or disruption of habitat due to the disposal of solid-waste materials. Impacts such as fugitive dust (caused by construction or fuel and solid-waste handling), noise (resulting from construction, transportation or plant operation), and storage of fuel or limestone are of minor concern because either the duration or magnitude of potential impacts on terrestrial ecosystems from these components would be minimal.

Vegetation is the most sensitive component of terrestrial ecosystems to SO_2 emissions. Potential impacts on vegetation were evaluated with respect to the contribution that generating station emissions would have on ground level concentrations of SO_2. Species of plants that are most sensitive to SO_2 are affected within a concentration range of 540-3,930 $\mu g/m^3$, based on a 3-hour exposure period. This concentration is smaller than the predicted lower limit of sensitivity for vegetation classified as intermediately sensitive by Heck and Brandt (1977). All coal-based fuel scenarios for both generating stations are capable of producing ground-level concentrations of SO_2 that can injure highly sensitive vegetation. It is important to realize that these predicted maximum values are isolated events and that the frequency of occurrence is very rare. Generally, much lower concentrations of SO_2 would predominate under coal-fired operations. Chronic effects of SO_2 on vegetation may occur only when periods of stagnation during warm Summer months cause the 24-hour average SO_2 concentrations to exceed 130 g/m^3 for several consecutive days. It is not possible to quantify the predicted extent of foliar damage by SO_2 from coal conversion. Conservatively based assumptions and measurements used in the atmospheric modeling suggest that these estimates of SO_2 concentration may be high and that the estimated effects on vegetation exposure are overstated. The potential for plant damage would be greatest during peak periods in the Summer when high electrical demand coincides with high susceptability of plants to SO_2.

Loss or disruption of natural habitat would be the other potential terrestrial impact. Brandon Shores would generate the majority of solid waste under scenarios for which it converts. Estimates of the lifetime commitment of land for the disposal of solid wastes from Brandon Shores ranges from 400 acres (Scenario 3) to 670 acres (Scenario 4) (Table 4.26). A 282-acre site (Bishop and McKay property; Dames and Moore 1980) has been identified for the disposal of solid wastes. The undeveloped site is part of a larger tract of land in the southern Baltimore region. This site would be disturbed for a period of 7 to 10 years, depending on the rate of solid-waste disposal. If a market for fly ash could be found, the Bishop and McKay site could possibly handle all the wastes generated by Brandon Shores and Wagner. *Crane wastes are to be disposed of at a site in Rossville.*

Dredge spoils have been disposed of at an existing spoil disposal site; consequently, no additional commitment of land resulted from this activity.

No single scenario stands out with respect to its potential to affect terrestrial ecosystems. Scenario 4, which would require the largest commitment of land for solid waste disposal, has the smallest potential for impact in terms of atmospheric emissions of SO_2, because it specifies FGD for both units at Brandon Shores. Scenario 3 has the greatest potential for impact with respect to SO_2 emissions, but requires more moderate land commitments for solid waste.

Aquatic Ecology

The most significant potential impact to aquatic ecosystems was the physical disruption of benthic habitat that occurred when the proposed barge channel was constructed. The disturbed area involved approximately 70 acres, 25 of which represent the existing Wagner barge channel. Benthic populations of organisms were reestablished within 3 to 18 months of the termination of dredging activities; therefore, these impacts were temporary. Resuspension and the potential for dissolving of toxic components in the resuspended sediments constitutes a transient toxicity hazard to aquatic organisms. This temporary hazard occurs under all the coal-use scenarios, and would be naturally mitigated by dilution and settling of the sediment as the dredge plume moves downstream.

Toxicological hazards associated with coal-pile runoff and solid-waste leachates may be controlled by proper management and design of waste disposal sites. Coal-pile runoff will be treated prior to discharge and is not projected to present any significant ecological hazard.

Threatened and Endangered Species

No threatened or endangered species are found at the generating station sites, at the disposal sites for solid wastes, or in the areas adjacent to sites identified for the disposal of dredge spoils or solid wastes. Only two such species are found within a 5-mile radius of any of the BG&E generating stations; the peregrine falcon, and the bald eagle. Consequently, threatened or endangered species would not be directly affected by any conversion scenarios at either of these generating stations.

2.4.5 Noise

State regulations for noise levels resulting from construction activities (70 dBA) are considerably higher than the daytime standard of 60 dBA. Intrusive noise resulting from construction may cause complaints even if the noise levels meet State standards.

Noise levels associated with the coal-fired operation of thermal powerplants are higher than those of oil- or gas-fired operations because coalhandling equipment is inherently noisy. Noise predictions for Brandon Shores were made by an independent consultant (Cwiklewski 1980). Neither daytime nor nighttime operation of the generating station would result in violations of State standards.

A computer code for predicting noise emissions from generating stations developed at Argonne National Laboratory (Dunn et al. 1981) was used for analysis of noise at Crane. At its present stage of development, the model does not include barrier or terrain effects; consequently, predictions made with this model should be viewed as conservative (i.e., erring on the high *side). The model was used to predict noise levels under coal-fired operations (Scenarios 2, 3, 4, and 5) at the Crane Generating Station. A daytime mode of operation that included the simultaneous operation of all sources of coal-handling equipment was modeled to represent a "worst case" example. A prediction of nighttime operations was made in which all coal-delivery sources of noise were deleted. Predicted noise levels at selected receivers (i.e. residences) or generating station boundaries suggest that both daytime and nighttime standards could be violated at Crane. Actual noise levels at Crane may be substantially lower because of the presence of tracts of forest that separate the key sources of noise from the boundary or residential receptors. This modeling exercise demonstrates that conversion of Crane to a coal-fired mode of operation has the potential to produce noise levels in violation of current State standards.*

Whether or not complaints would result from conversion of the four units is speculative and is not quantifiable.

2.4.6 Socioeconomic Impacts

The conversion of the four BG&E units to alternate fuels is not projected to create significant perturbations on housing, governmental service, or employment activity at the local community level under any conversion scenario. The principal reasons for this are: 1) the majority of impacts during construction and operation, including those related to employment, are associated with prior activities unrelated to Prohibition Orders, and 2) conversion activities are small compared to the economic and employment base for the region.

Local traffic patterns would be slightly impacted if coal were brought into the stations by rail. These impacts are reduced if barge delivery is used. Transporting RDF and solid waste by truck would add a small incremental increase to local traffic volume, but is not projected to cause any real impact in the area.

Because the units being converted already exist, no impact to archeological or historic sites is projected.

2.4.7 Energy Resources

The intent of the FUA is to reduce or eliminate the use of petroleum fuels in certain generating station units. Conversion of the four units under consideration would displace fuel oil in the approximate amounts listed in Table 2.13 (ERA 1980b).

The consumption of alternate fuels would increase proportionately to heat content of the fuel if alternate fuels displace oil. If coal were used solely as the alternate fuel at all of the units, an estimated 3,400,000 tons/yr would be needed (ERA 1980b). The projected demands for coal by unit are

TABLE 2.13. Potential Oil Use Displaced by Conversion[(a)]

Plant	Units	Barrels/day
Brandon Shores	1	13,400
	2	13,600
Crane	1	5,320
	2	5,850
TOTAL		38,170

(a) Source: ERA 1980b.

indicated in Table 2.14. The actual amount of coal required to supply the boilers would depend on the fuel-conversion strategy followed, the heat value and ash content of the coal, and the costs of supplying power for the coal-handling and pollution-control equipment. The consumption of coal varies slightly with the conversion scenario considered (Table 2.2), from a high of about 600 tons/hour (Scenario 4) to a low of about 640 tons/hour (Scenario 3).

The use of a 90% coal, 10% RDF (Scenario 4) mixture at Crane would result in RDF requirements of about 190,000 tons/yr.

Additional considerations must include the energy cost of transportation of fuels and FGD reagents to the sites and transportation of solid wastes to disposal sites. Coal will be delivered to the stations by barge, with rail as a back-up delivery mode. Limestone (Scenarios 4 and 5) would be trucked to Brandon Shores. *Refuse-derived fuel would also be brought in by truck; because there is no practical way to stockpile RDF, it would have to be supplied daily to the unit using this fuel.* These uses of energy are insignificant compared to the amount of energy (coal) that would be consumed to generate steam in the units, but they may add a small amount to the cost of generating electricity.

Energy consumption levels would increase while the fuel conversion construction activities are occurring, but these increases would be short-term. Truck transport and delivery of materials and the use of heavy equipment would account for much of the added fuel expenditures.

2.5 SUMMARY OF CUMULATIVE ENVIRONMENTAL EFFECTS

To assess the potential cumulative effects, this study refers to the Draft (DOE/EIS-0083-D) and Final (DOE/EIS-0083-F) Northeast Regional Environmental Impact Statement (NEREIS). The Draft NEREIS evaluated the environmental effects that could result if, under the FUA (see Section 1.1) 42 selected powerplants in the northeastern United States ceased to burn oil and natural gas, and converted to coal. The Final NEREIS addresses comments received during and after a formal 90-day public comment period.

2.5.1 NEREIS Study

The 42 powerplants included in the study (see Table 2.15) are located in a ten-state region extending from Maryland to Maine.[a] The sites were selected from an original list of 117 coal-capable plants developed by the President's Coal Commission. The original list was reduced by the U.S. Department of Energy (USDOE) using the criteria of eliminating 1) most units over 25 years of age and 2) stations with an aggretate capacity of less than 100 megawatts (MW). The age and size criteria focused attention on those powerplants that had the greatest potential for oil displacement and economic benefits, and on those units having the longest remaining useful life.

TABLE 2.14. Potential Demand for Coal

Plant	Units	Tons/year
Brandon Shores	1	1,200,000
	2	1,200,000
Crane	1	485,000
	2	534,000
TOTAL		3,419,000

(a) Source: ERA 1980b.

TABLE 2.15. Facilities Included in the Northeast Regional Environmental Impact Statement

42-Station Conversion Scenarios[a]		27-Station (Voluntary) Conversion Scenario[b]	
State/Facility	Unit	State/Facility	Unit
Connecticut		**Connecticut**	
Bridgeport Harbor	3	Bridgeport Harbor	3
Devon	7,8	Devon	7,8
Middletown	1,2,3		
Montville	5		
Norwalk Harbor	1,2	Norwalk Harbor	1,2
Delaware		**Delaware**	
Edge Moor	1,2,3,4	Edge Moor	3,4
Maine		**Maine**	
Mason	1,2,3,4,5	Mason	3,4,5
Maryland		**Maryland**	
Brandon Shores	1,2	Brandon Shores	1,2
Crane	1,2	Crane	1,2
Riverside	4,5		
Herbert A. Wagner	1,3		
Massachusetts		**Massachusetts**	
Canal	1		
Mt. Tom	1	Mt. Tom	1
Mystic	4,5,6	Mystic	4,5,6
New Boston	1,2	New Boston	1
Salem Harbor	1,2,3	Salem Harbor	1,2,3
Somerset	6	Somerset	5,6
West Springfield	3	West Springfield	1,2,3
New Hampshire		**New Hampshire**	
Schiller	4,5,6	Schiller	4,5,6
New Jersey		**New Jersey**	
Bergen	1,2	Bergen	2
Burlington	7	Burlington	7
Deepwater	7,8,9	Deepwater	7,8,9
Hudson	1		
Kearny	7,8		
Sayreville	4,5	Sayreville	4,5
Sewaren	1,2,3,4		
New York		**New York**	
Albany	1,2,3,4	Albany	1,2,3,4
Arthur Kill	2,3	Arthur Kill	2,3
Danskammer Point	1,2,3,4	Danskammer Point	3,4
E. F. Barrett	1,2	E. F. Barrett	1,2
Far Rockaway	4		
Glenwood	4,5		
Lovett	3,4,5	Lovett	3,4,5
Northport	1,2,3,4		
Oswego	1,2,3,4		
Port Jefferson	1,2,3,4	Port Jefferson	3,4
Ravenswood	3	Ravenswood	3
Pennsylvania		**Pennsylvania**	
Cromby	2	Cromby	2
Schuylkill	1		
Southwark	1,3		
Springdale	7,8		
Rhode Island		**Rhode Island**	
South Street	12	South Street	12
TOTAL STATIONS	42	TOTAL STATIONS	27
TOTAL UNITS	94	TOTAL UNITS	55

(a) See Figure 2.1.
(b) See Figure 2.3

The proximity of these coal-capable powerplants to each other (see Figure 2.1) suggests a potential for the impacts from coal combustion to interact, creating larger or different types of effects than would generally be associated with any individual plant. Also, the physical extent of these collective impacts might reach beyond the area surrounding the individual plants into a larger geographic region. The following types of impacts are defined in the NEREIS:

- **Site-specific impacts** are impacts confined to the immediate area, generally within 50 km of a particular site, (e.g., impacts associated with the conversion of a single powerplant).
- **Interactive impacts** result from the combination or interaction of individual impacts from two or more powerplant conversions, and may differ from the individual impacts.

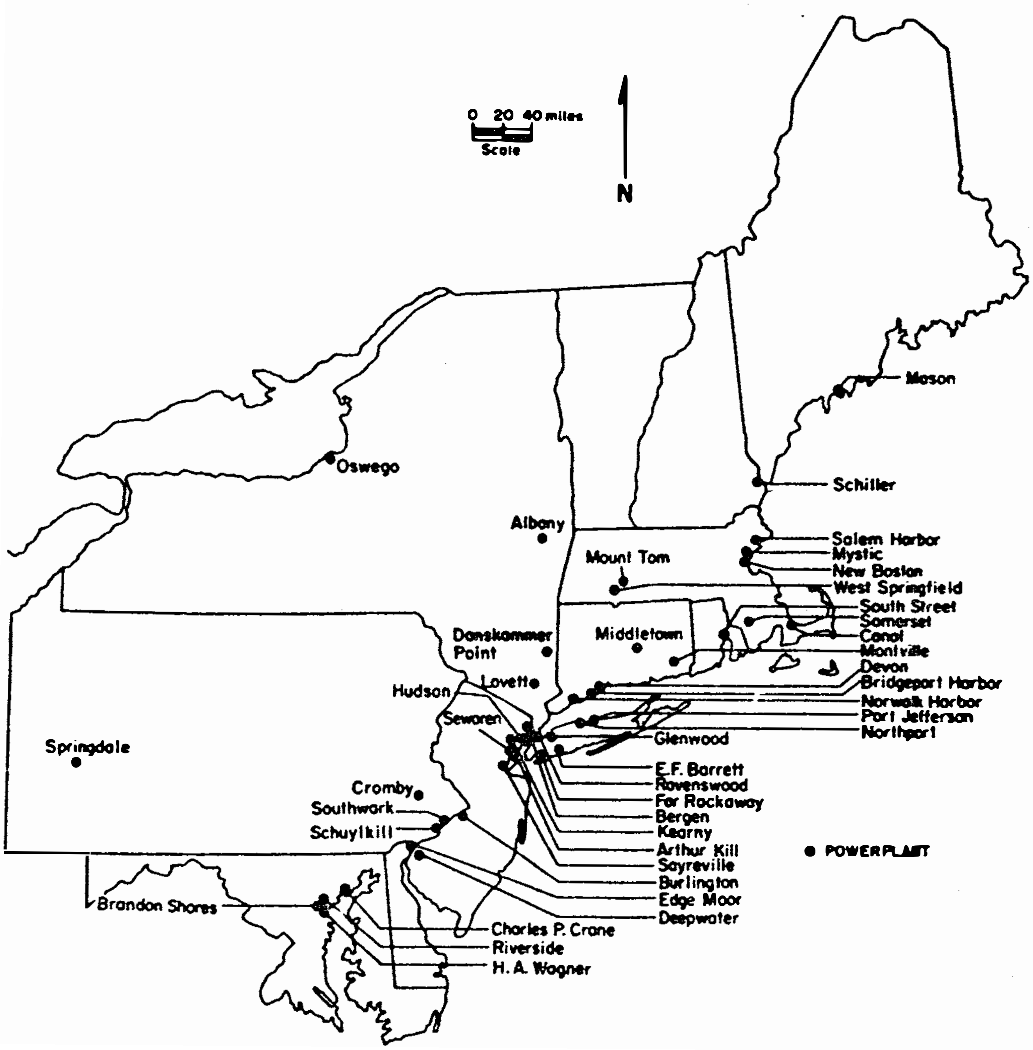


Figure 2.1. Facilities Included in the Northeast Regional Environmental Impact Statement Under the 42-Station Conversion Scenarios

- **Regional impacts** are interactive impacts which extend beyond the areas surrounding the individual plants into a larger region.
- **Cumulative impacts** are impacts that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such action.

An effective strategy for coal conversion involving multiple facilities requires information on these larger-scale cumulative and interactive effects so that decisions on site feasibility can be made and appropriate mitigative strategies adopted.

The Northeast Regional Environmental Impact Study undertaken by USDOE focuses on the potential effects of multiple coal conversions in a farily discrete geographic region, on 1) air quality, 2) solid-waste disposal, 3) fuel supply and transportation, and 4) health effects. These technical areas were identified as those in which cumulative effects are most likely to occur. A separate technical task force report was prepared for each of these technical areas (see following references: FEA 1977; Friesz 1981; Kornegay 1982; Saguisan 1981a; Saguisan 1981b; DOE 1979; Walsh et al. 1981), and provides information on the extent and magnitude of the impacts predicted from the increase in demand for coal in the northeastern United States as a result of the conversions. Information from these reports was incorporated in the analysis for the NEREIS.

The depth and breadth of coverage in the technical reports and the NEREIS are sufficient to provide a data base for site-specific environmental analyses as well as providing a broader perspective for assessing the impacts of the proposed action. Detailed site-specific issues are not treated in the NEREIS; instead, generic issues that are cumulative or interactive on a regional basis are emphasized.

2.5.2 Approach to Analysis

The NEREIS was designed to provide decision-makers with information on the types and magnitude of environmental impacts associated with a range of coal conversion strategies.[a] To provide this type of information, the approach to environmental impact analysis in the draft NEREIS focused on the assessment of four alternative conversion scenarios. These scenarios are defined in terms of the air-pollution emission limitations that could be imposed on a facility by a state or Federal agency as a condition for conversion. The use of air-quality levels as criteria for determining the feasibility of any proposed conversions is in consonance with the FUA stipulation that all facilities undergoing conversion meet all applicable enviromental requirements.

The four air-quality scenarios in the draft NEREIS are: 1) the emissions from burning coal at the rate specified for oil in the current State Implementation Plan (Oil SIP); 2) the emissions from burning coal at the current coal SIP (Coal SIP); 3) the emissions from burning coal at the 1971 New Source Performance Standards (1971 NSPS); and 4) the emission limitations proposed by certain utilities and state agencies for their powerplants, with all other powerplants modeled at the coal SIP (Modified Coal SIP). The application of an air-quality scenario to all 42 units represents a worst-case estimation of the air-quality impacts associated with that scenario.

(a) In the analysis for the NEREIS, the only FUA-related fuel that is considered is coal. The assumption is that of the alternate fuels available to a utility, coal, even with adequate environmental controls, provides in comparison a worst-case situation for the purposes of environmental impact analysis.

The draft NEREIS is organized by three interrelated elements: 1) the coal fuel cycle; 2) substantive environmental impact areas such as air quality, water quality, and biotic resources; and 3) geographically defined impact assessment regions. This type of organization provides information on the magnitude and size of an impact as well as on its geographic incidence.

The first element of the framework, the coal fuel cycle, can be disaggregated into five major components: mining, coal cleaning and processing, transportation, combustion, and waste disposal. The second element in the framework, the substantive environmental impact areas, are acted upon by the components of the fuel cycle, potentially producing cumulative and interactive environmental impacts. The substantive environmental impact areas included in this analysis are air quality, water quality, land use, biotic resources, socioeconomics, and public health.

The potential impacts of the fuel cycle components on each of these substantive areas, both in terms of type and degree, depend on the existing conditions (baseline environment) in the physical area where the interaction occurs. In the NEREIS, the potential impacts of the proposed action are assessed as they could occur in four conceptually distinct but geographically overlapping regions, each one associated with one or more components of the coal fuel cycle. The assessment regions are: the Supply Region, the Transportation Networks Region, the Combustion Region, and the Deposition Region. The relationship between the component of the coal fuel cycle and the assessment regions is represented in Figure 2.2.

In December 1981, public hearings were held in Boston, New York City, and Philadephia to receive comments on the draft NEREIS from interested parties. In addition, written comments on the draft NEREIS were received from interested parties through February 1982. Based on all comments that were received, revisions to the draft NEREIS were undertaken.

The following issues were identified:

- Validity of the original number of conversions (42 powerplants).
- Changes in stack parameters and emission limitations that would occur upon conversion of some stations.
- Validity of assumptions in the long-range transport model, ASTRAP.
- Severity of acid deposition impacts on agriculture, water quality, and cultural resources.
- Availability and feasibility of waste-disposal sites, particularly ocean disposal of ash.
- Potential for marketing coal ash as a reusable product.
- Predicted impact of incremental changes in air quality from coal conversion upon public health.
- Availability of low-sulfur coal from Appalachia.
- Potential for additional opportunities for conservation and utilization of alternative energy technologies in the Northeast.

The responses of the final NEREIS to issues raised during the public comment period were of two types: clarification and updating of the analysis done in the draft NEREIS; and analysis of additional scenarios.

The basis for most of the additional analysis was the concern about the number of stations or units included in the study, as well as the accuracy of the site information used in the analysis. To rectify this problem, a survey of all the utilities included in the draft study was undertaken to determine which powerplants were still being considered for coal conversion, the correct operating parame-

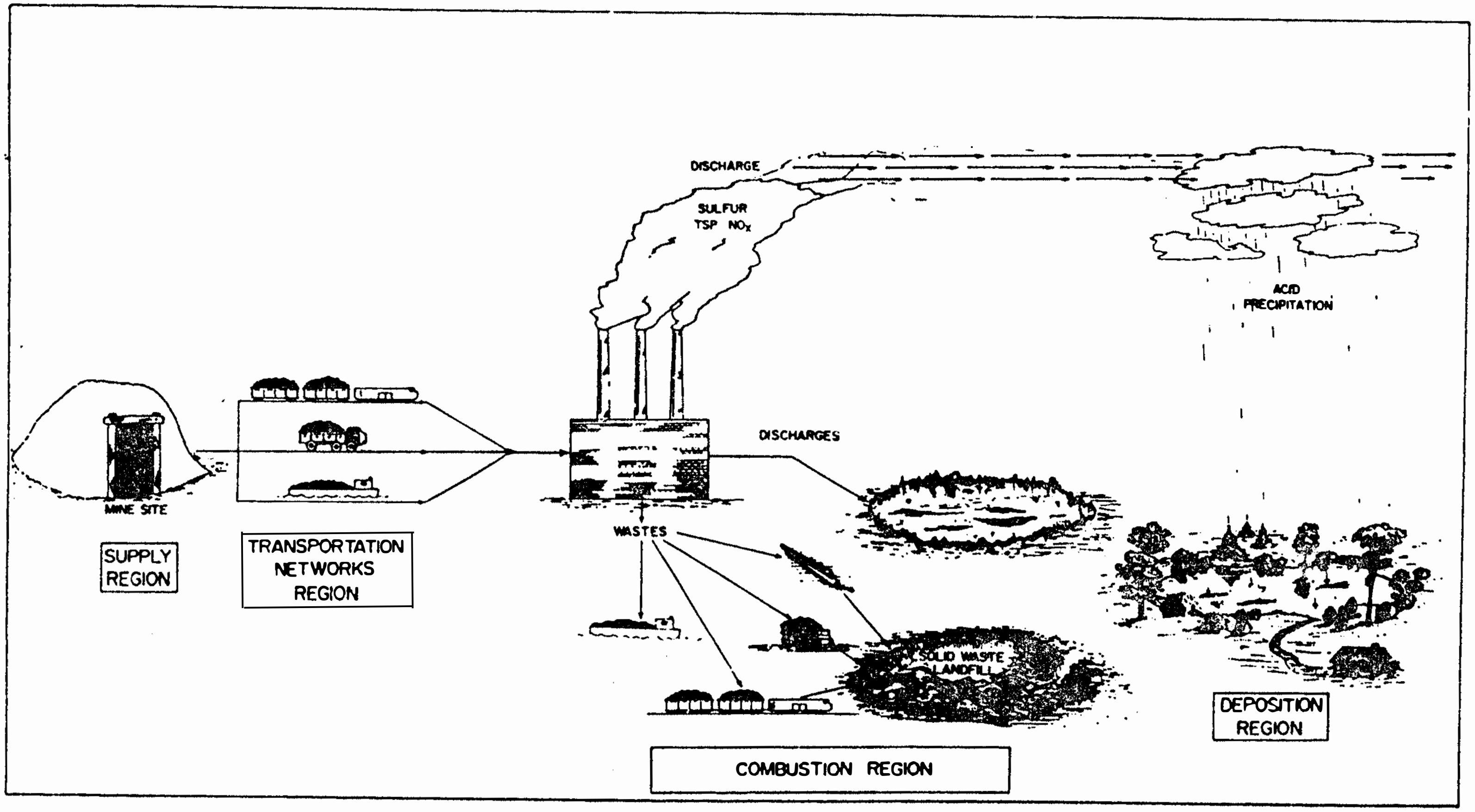


Figure 2.2. Relationship of Coal Fuel-Cycle Components and Environmental Assessment Regions

ters for the facilitlies, and the current approved SIP limits. Based on the survey, the 27 stations listed in Table 2.15 and shown in Figure 2.3 were included in the expanded analysis as a separate subset.

The 27-station scenario was designated as the "Voluntary Conversion Scenario," and represents a more likely maximum conversion case, to be contrasted with the 42-station worst-case scenario in the draft NEREIS air-quality analysis; it also provided an additional set of air quality scenarios. The results of the additional air-quality modeling were assessed to determine potential environmental impacts. A summary of the environmental effects of the Voluntary Conversion Scenario is presented in Table 2.16.

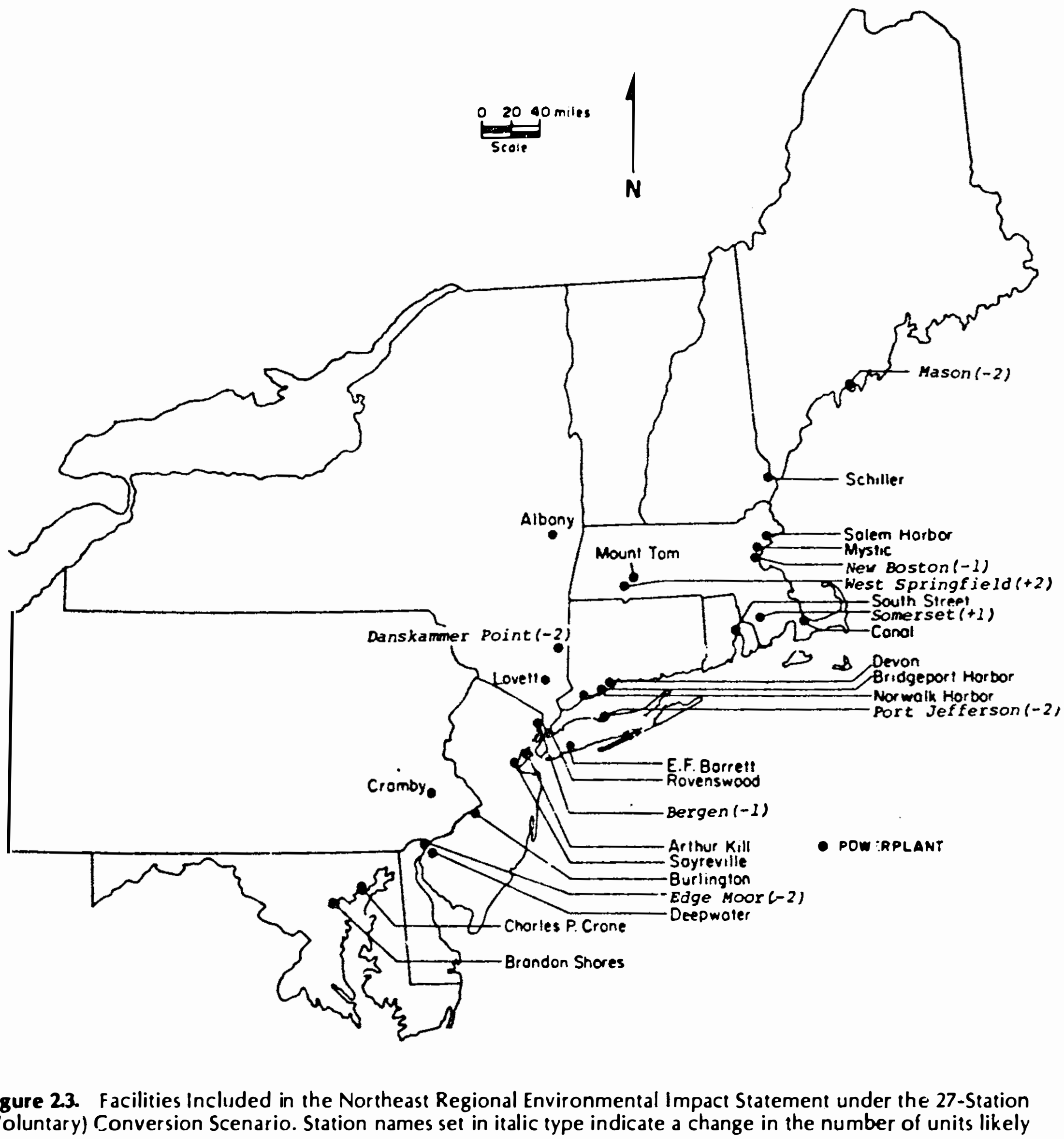


Figure 2.3. Facilities Included in the Northeast Regional Environmental Impact Statement under the 27-Station (Voluntary) Conversion Scenario. Station names set in italic type indicate a change in the number of units likely to convert.

TABLE 2.16. Summary of Environmental Impacts[a]

	Supply Region	Transportation Networks Region	Combustion Region	Deposition Region
Air Quality	**No regional cumulative impacts are anticipated. There is potential for site-specific increases in TSP associated with increases in mining activity.**	**No regional cumulative impacts are anticipated. Impacts associated with increased train movements may occur adjacent to the transportation links.**	**Dispersion modeling predicts that the conversions will not result in violations of air quality standards or PSD increment on the regional scale as a consequence of any of the conversion scenarios.**	Under the Voluntary Conversion Scenario, the increase in sulfur deposition is 3 to 4% in the New York City area and 1 to 2% in the Maritime Provinces.
Water Quality	**No regional cumulative impacts are anticipated if the Surface Mining Control and Reclamation Act is adequately enforced.**	**No regional cumulative impacts are anticipated. Site-specific impacts may result from spills, leaching, and leakage from coal, limestone and waste, particularly at loading and unloading points.**	**No regional cumulative impacts are anticipated. Site-specific impacts could result from the thermal and chemical discharge of individual powerplants into adjacent surface waters.**	For the Voluntary Conversion Scenario, the sulfur deposition of up to 4% represents a pH change of <0.02.
Land Use	**No regional cumulative impacts are anticipated. Some site-specific increases in the land area disturbed by surface mining.**	**No regional cumulative impacts are anticipated, as no new railway line construction is required. Site-specific impacts are possible at expanded port facilities.**	The additional solid waste generated by coal combustion and the use of pollution control technology may tax waste disposal capacity in several states in the Northeast (DEIS Sec. 5.3). Under the Voluntary Conversion Scenario, the volume of combustion wastes is about 35% of that produced under the DEIS Coal SIP Scenario.	**No regional cumulative impacts are anticipated from the predicted small increases in sulfur deposition.**
Biotic Resources	**No regional cumulative impacts are anticipated. Site-specific impacts on biotic resources might result from habitat loss associated with mining and coal processing.**	**No regional cumulative impacts are anticipated from the increase in coal transport.**	**No regional cumulative impacts are anticipated. Site-specific impacts including loss of habitat might result from increase in activity at limestone mines and quarries.**	Based upon available data, the contribution of the proposed action would not appear to adversely affect agricultural production on the region.
Socio-economics	**No regional cumulative impacts are anticipated. The increase in coal production associated with the conversion program is within normal levels of activity and is not expected to produce adverse impacts. Increases in mining activity may have positive socioeconomic impacts.**	Transportation network modeling indicates the potential for bottlenecks in the port areas if plans for expanding these facilities are not implemented.	There is a potential for the consumption of PSD increment by the converted powerplants. This could limit industrial growth in a number of highly industrialized counties. The extent of this impact could not be quantified.	Economic impacts associated with the predicted increase in sulfur deposition could not be quantified.

TABLE 2.16. (Contd)

	Supply Region	Transportation Networks Region	Combustion Region	Deposition Region
Health Effects (see Appendix E)	An increase of 4% in fatalities in 1991 is associated with increased mining activity. The corresponding increases in injuries and disabilities are 3% and up to 9%, respectively.	The potential increase in fatalities and injuries associated with increased railroad traffic by 1991 is about 2% above the base case of 111 occupational and 1430 public fatalities, and 47,900 occupational and 6450 public injuries.	The worst-case in the 24-hour pollution concentrations of SO_2, TSP ozone, NO_2, and respirable particulates (recurrence interval of 5 yr) under the Coal SIP Scenario may aggravate respiratory diseases. Other slight, transitory effects will occur. The health risk for the Voluntary Conversion Scenario will be less.	A 2% increase in monthly levels of atmospheric sulfate may contribute to a slight increase in public susceptibility to bacterial infection in areas where high concentrations of other pollutants are present.

(a) Boldface table entries indicate a potential for regional cumulative impacts, or insufficient information to conclude that there is no potential for such impacts. Lightface entries indicate that no regional cumulative impacts are expected.

3.0 DESCRIPTION OF THE AFFECTED ENVIRONMENT AND FACILITIES

Baltimore Gas and Electric Company operates nine generating stations in the Baltimore area with a total capacity in 1979 of 4,307,000 kW (BG&E 1979). The Brandon Shores station, currently under construction, will increase this total to 5,547,000 kW. The Brandon Shores station was issued proposed Prohibition Orders on Units 1 and 2 by the ERA under jurisdiction of the Fuel Use Act. Two units each at BG&E Crane, Riverside, and Wagner Generating Stations were issued Prohibition Orders under authority of the Energy Supply and Environmental Coordination Act (ESECA). Under the authority of OBRA, ERA permitted utilities to elect continued coverage under outstanding FUA and ESECA orders. BG&E exercised its option to continue coverage for Brandon Shores and not to continue coverage for the Crane, Riverside and Wagner units. Accordingly, the prohibition orders for the units at the latter three stations were rescinded by ERA. The Brandon Shores Prohibition Order continues in effect. The finalization of the Prohibition Order is a proposed Federal Action and is the subject of this EIS.

BG&E is voluntarily converting Crane Units 1 and 2. During the scoping period, state and local agencies expressed concern about the combined effects of BG&E activities. Therefore, aspects of both Brandon Shores and Crane operations, particularly where cumulative and interactive impacts may occur, are detailed in this section. Selected aspects of the Wagner Station which is adjacent to the Brandon Shores facilities are discussed where possibilites for cumulative or interactive impacts exist.

3.1 GENERATING STATION DESCRIPTIONS

The Brandon Shores and Crane generating stations are located within ten miles of Baltimore City and border surface waters that flow into Chesapeake Bay (Figure 3.1). Because of their proximity to Baltimore City and to each other (about 14 miles separate the Brandon Shores and Crane stations), these stations generally share the same climate, airshed, and population base. According to DOE's supporting analysis, BG&E may also obtain coal for Brandon Shores and Crane from the same general area of Alabama, eastern Kentucky, Tennessee, Virginia, and West Virginia.

3.1.1 Brandon Shores Generating Station

When BG&E authorized construction of the Brandon Shores Generating Station, it was planned that the two 628-MW units would be fired with No. 6 residual fuel oil. The original design, however, did provide for the future conversion to coal.

Since receiving its proposed Prohibition Order, BG&E has decided to start both units on coal. It is now planned that Unit 1 will come on-line in mid-1984 and Unit 2 in early 1988. As coal-fired units, they would operate as baseload units with daily cycling capability. With the addition of air preheaters, the dry bottom, drum-type boilers are rated at 620 MW when using compliance coal or 610 MW if flue gas desulfurization is required. It is anticipated that electrostatic precipitators would be used to reduce particulate emissions. Each unit will have a 700-foot stack.

If coal is burned, each unit would consume about 1,200,000 tons/yr (ERA 1980b). The coal is to be delivered by barge. This required the installation of an unloading pier and necessitated dredging a channel. Dredge spoils required disposal at a suitable site. Depending on the size of the barge used, one barge load would be sufficient to supply both units for 24 to 42 hours at full load operation. Space for a coal pile is available either to the northwest or southwest of the boiler buildings.

If noncompliance (higher sulfur) coal is selected as the fuel, a nonregenerable limestone FGD process may be chosen because limestone is readily available and relatively inexpensive. Limestone could be delivered by rail or truck.

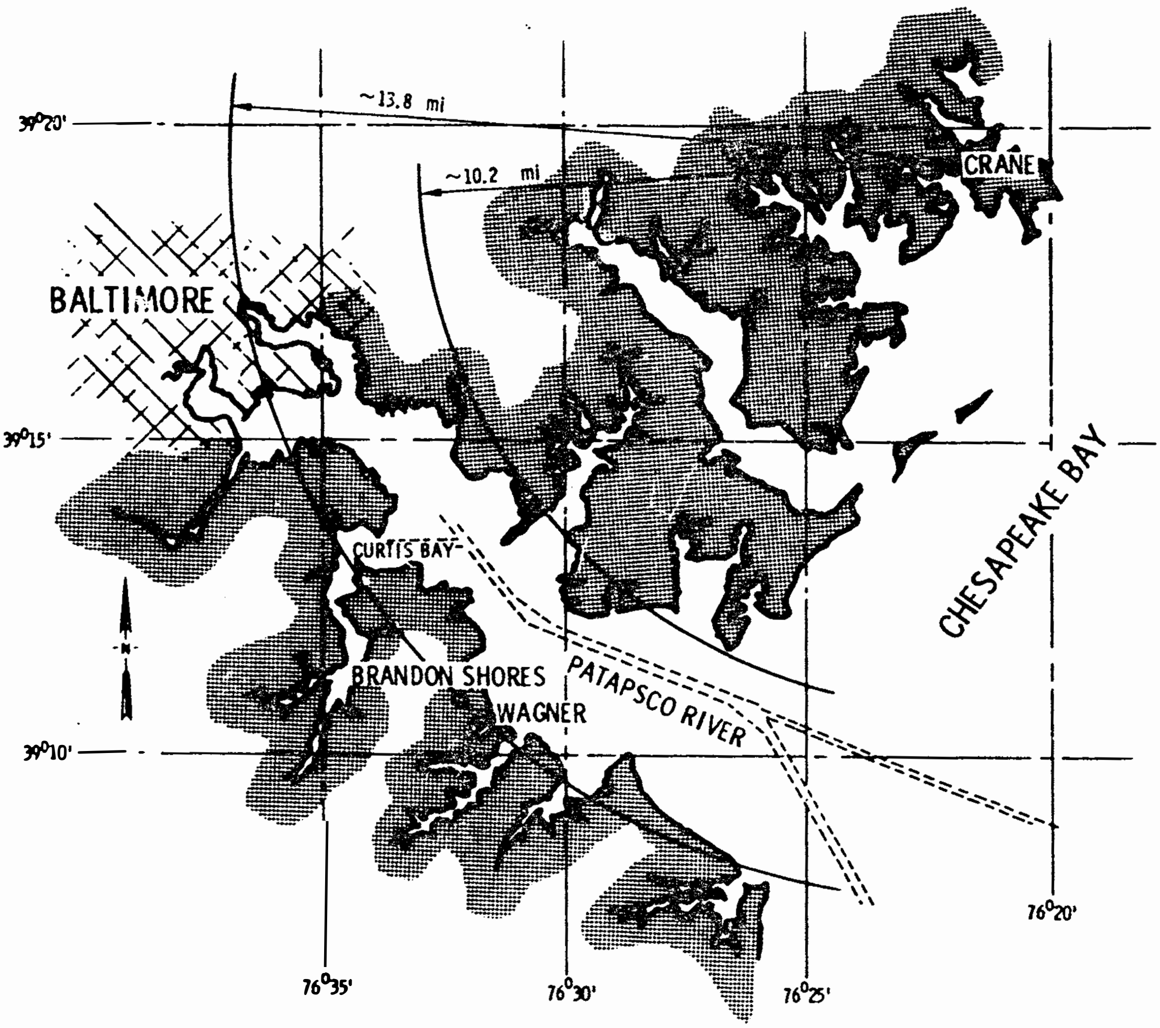


Figure 3.1. Location of Brandon Shores, Crane and Wagner Generating Stations

Wastes such as fly ash, bottom ash, and FGD sludge probably would be disposed of at an off-site landfill (Section 4.2.2). Coal-pile runoff will be treated in a system common to both units.

The station will be serviced by parallel path, wet-dry cooling towers. Patapsco River water drawn from the once-through cooling-water discharge canal of the adjacent Wagner Generating Station will be used as make-up water. Cooling tower blowdown water will be temporarily held in a retention pond and then returned to the canal for discharge back into the river.

3.1.2 Crane Generating Station

The Charles P. Crane Generating Station has two cyclone boilers with design capacities of 190 and 209 MW and a gas turbine rated at about 14.9 MW (Holland et al. 1975). Unit 1 last used coal in 1972, and Unit 2 last used coal nominally in 1970, although a test burn on coal was recently conducted. Both are now fired with No. 6 residual oil. Unit 1 is a baseload boiler; Unit 2 operates during the day in a cycling mode.

With a capacity factor of 62%, Unit 1 consumed 1,835,000 barrels of oil during 1978. Unit 2 burned 1,530,000 barrels that same year with a 58% capacity factor. When converted to coal, each unit will use an estimated 75 tons/hr [(a)] or 485,000 tons/yr for Unit 1 and 534,000 tons/yr for Unit 2 (ERA 1980b). According to DOE's analyses, delivery of coal to the Crane station would probably be by rail. A 3.6-acre unlined coal-storage area is located onsite with a capacity of 120,000 tons. An estimated 3800 barrels/day of oil would be displaced by the conversion of both units to an alternate fuel (ERA 1980b).

Coal used in cyclone boilers must have a low ash-fusion temperature to produce the proper slag viscosity. This type of coal typically has a high sulfur content.

The Crane units have electrostatic precipitators (ESP) for the removal of particulate stack emissions. The ESPs have been tested at an 85% removal efficiency. The two stacks are each 353 feet in height.

The generating station uses a once-through cooling system, taking water from Seneca Creek and discharging it into a channel leading to Saltpeter Creek.

3.2 CLIMATE

The Brandon Shores *and Crane* stations, both located near Baltimore, Maryland, are assumed to have similar climatic characteristics. Data obtained from the National Weather Station in Baltimore describe these characteristics (NOAA 1978).

3.2.1 Geographical Effect

The Atlantic Ocean and Chesapeake Bay to the east and the Appalachian Mountains to the west of the region tend to make the climate milder than in inland areas of the same latitude. The proximity of the ocean contributes to the occurrence of storms in the area, especially during the summer months. These storms may produce high tides and waves that cause damage along waterfronts.

Warm air from the south, along with the nearness of large water bodies, contributes to the high relative humidity experienced in the region during much of the year. Summer days are generally hot and humid, although they are frequently followed by thunderstorms or cool breezes in the evening and at night.

3.2.2 General Climate

A summary of local climate including temperature, precipitation, snowfall, and relative humidity is given in Table 3.1, based on surface observations at Baltimore from 1950 to 1978.

3.2.3 Wind Characteristics

The average annual wind speed in the Baltimore region (Table 3.2) is 9.4 miles/hr (15.1 km/hr). February, March, and April are the windiest months with mean wind speeds of 11 miles/hr 13.0 km/hr). The lowest mean wind speeds occur in July, August, and September and average 8.1 miles/hr (5.0 km/hr). Most of the year, the prevailing wind direction is from the west and northwest. In September, however, the prevailing wind direction is from the south.

Meteorological data for the pollutant dispersion computations are based on Baltimore surface observations from the National Climatic Center for the years 1965 to 1969. The wind rose for these data is plotted in Figure 3.2. Joint wind speed, direction, and stability tables are given in Table H.1 in Appendix H.

(a) Letter from R. W. Lowe, BG&E, to R. E. Barrett, Battelle Columbus Laboratories, March 13, 1980.

TABLE 3.1. Baltimore Climate Data (Based on years 1950 through 1978 unless otherwise noted)

Temperatures	°F	°C
Annual Average	55.0[(a)]	12.8
Annual Daily Maximum	65.1[(a)]	18.4
Annual Daily Minimum	44.8[(a)]	7.1
Record High	102.0 (July 1966)	38.9
Record Low	-7.0 (January 1963)	-21.7
Precipitation	**in.**	**cm**
Annual Average	40.46[(a)]	102.8
Maximum Monthly	18.35 (August 1955)	46.61
Minimum Monthly	trace (October 1963)	
24-hour Maximum	7.82 (August 1955)	19.9
Snow, Ice Pellets		
Annual Average	21.6	54.9
Maximum Monthly	21.6 (March 1960)	54.9
24-hour Maximum	15.5 (February 1958)	39.4
Maximum Annual	48 (1960)	121.9

(a) Based on Years 1941 through 1970

3.2.4 Ambient Air Quality

Ambient air quality in the vicinity of the Brandon Shores and Crane stations was described using data from the State of Maryland's ambient air quality monitoring network. Both Brandon Shores and Crane are located within the Metropolitan Baltimore air quality control region (AQCR), which includes Baltimore City, Anne Arundel, Howard, Carroll, Baltimore, and Harford Counties. The Metropolitan Baltimore AQCR is located within EPA Federal Region III (Figure 3.3). However, attainment and non-attainment areas are defined within the AQCR.

The concentration of man-made pollutants in the lower atmosphere will vary greatly over both time and space in a populated, industrialized area such as Metropolitan Baltimore. The concentration of a pollutant at any time and place is dependent on a complex interrelationship of such variables as: windspeed; wind direction; the source type, size, and location; regional-scale (hundreds of kilometers) and mesoscale (tens of kilometers) meteorology; chemical reactivity of the air; atmospheric stability or turbulence; and pollutant removal mechanisms. It is therefore necessary to identify certain pertinent statistics before describing ambient air quality.

TABLE 3.2. Baltimore Monthly Wind Speeds and Directions[a]

Month	Mean Wind Speed miles/hr (km/hr)	Prevailing Direction
January	9.9 (15.9)	WNW
February	10.6 (17.1)	NW
March	11.1 (17.9)	WNW
April	10.9 (17.5)	WNW
May	9.5 (15.3)	W
June	8.7 (14.0)	WNW
July	8.1 (13.0)	W
August	8.1 (13.0)	W
September	8.2 (13.2)	S
October	8.9 (14.3)	NW
November	9.4 (15.1)	WNW
December	9.4 (15.1)	WNW
Year	9.4 (15.1)	W

(a) Based on Years 1950-1978 1 mile/hr = 1.6 km/hr

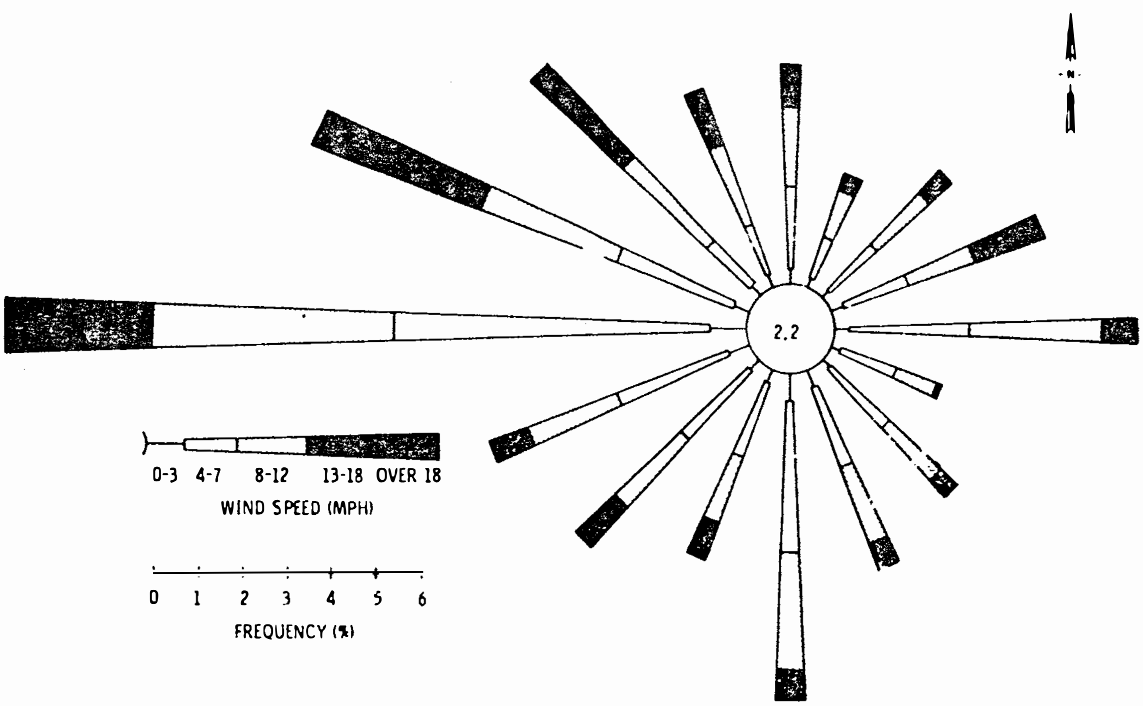


Figure 3.2. Annual Wind Rose for Years Used in the Air Quality Analysis (1965-1969) Baltimore Area

Figure 3.3. Location of Metropolitan Baltimore Air Quality Control Region Within EPA Federal Region III[a]

(a) Region III includes Pennsylvania, Maryland, Delaware, West Virginia, Virginia.

Under the Clean Air Act Amendments of 1970, the Federal government established National Ambient Air Quality Standards (NAAQS). These standards were designed to protect the public health (primary standards) and to protect the public welfare (secondary standards) from any known or anticipated adverse effects of an air pollutant (40 CFR 50.1). These standards are time-averaged statistics and maximum values that may not be exceeded at any location more than a certain number of times per year. Each state can adopt the NAAQS or promulgate standards of its own. A state's standards, however, cannot be less stringent than the Federal standards. Maryland's ambient air-quality standards are the same as the Federal standards and establish limits for total suspended particulate matter (TSP), sulfur dioxide (SO_2), lead (Pb), nitrogen dioxide (NO_2), ozone (0_3), hydrocarbons (HC), fluoride (Fl^-), and carbon monoxide (CO) (Table 3.3).

The following description of the existing ambient air quality in the Metropolitan Baltimore AQCR includes an overview of the current air-quality monitoring network, a tabulation of the maximum air pollutant levels measured in 1978 for time-averaging periods corresponding to the NAAQS; an analysis of 1979 air monitoring data, and a qualitative summary of the air quality by pollutant.

The 1979 air quality monitoring network within the Metropolitan Baltimore AQCR is made up of 36 monitoring stations (Figures 3.4 and 3.5). Fifteen of the stations are located within the city of Baltimore and the remainder are distributed as follows: Anne Arundel County (7), Baltimore County (11), Carroll County (1), Harford County (1), and Howard County (1).

TABLE 3.3. State of Maryland and National Ambient Air-Quality Standards (NAAQS)

	Primary	Secondary
	— (g/m³) —	
Sulfur Oxides(a)		
Annual Arithmetic Mean,	80	—(f)
24-hour Maximum,(b)	365	—
3-hour Maximum,(b)		1,300
Suspended Particulate Matter(a)		
Annual Geometric Mean,	75	60(b)
24-hour Maximum,(b)	260	150
Lead(a)		
3-month average,	1.5	—
Carbon Monoxide(a)		
8-hour Maximum,(b)	10,000	10,000
1-hour Maximum,(b)	40,000	40,000
Hydrocarbons(a)		
3-hour (6 to 9 AM) Maximum,(a)	160(c)	160(c)
Nitrogen Dioxide		
Annual Arithmetic Mean	100	100
Ozone(a)		
1-hour Maximum,(d)	235	235
Fluoride(e)		
24 hour	—	1.2
72 hour	—	0.4

(a) Code of Federal Regulations (40 CFR 50.1), Federal and State of Maryland air-quality standards are the same).
(b) Not to be exceeded more than once per year.
(c) Guideline.
(d) Not to be exceeded on more than one day per year (averaged over 3 years).
(e) State of Maryland Standards, 10.18.01 Regulations Governing the Control of Air Pollution in the State of Maryland, Corrected Comar Version 11-2078, Maryland State Department of Health and Mental Hygiene, Baltimore, Maryland.
(f) — = not applicable.

Total suspended particulates were monitored at 32 stations. In addition, NO_2 was monitored at 28 stations, SO_2 at 26 stations, CO at 8 stations, Pb at 11 stations, O_3 at 10 stations, and hydrocarbons at 6 stations. The 1978 monitoring network differed slightly from the 1979 system. The Hereford, Padonia and Fairfield stations were not operational until 1979. Two other stations—the Patapsco TSP station (#11) (Figure 3.5), and the Towson trailer station (#17) (Figure 3.4)—were in operation in 1978, but were not included in the measurements for 1979.

During 1978, the primary or secondary NAAQS were exceeded within the Metropolitan Baltimore AQCR for TSP, CO, Pb, and O_3 (DHMH 1979). Carbon monoxide and lead limits were exceeded in Baltimore City at Stations #1 and #3, respectively. The maximum recorded 1-hour and 8-hour CO levels were 26 mg/m³ and 14 mg/m³, respectively. The maximum recorded Pb level was 1.54 g/m³ for a 3-month average. Ozone standards were exceeded at eight out of ten stations. Station #6 in Anne Arundel County had the highest recorded 1-hour value of O_3 (412 g/m³).

1. Glen Burnie
2. Harmons
3. Harwood
4. Linthicum
5. Odenton
6. Riviera Beach-closest to Brandon Shores
7. St. Johns College
8. Catonsville
9. Chesapeake Terrace Elementary
10. Cockeysville Police
11. Edgemere Fire Station
12. Essex
13. Garrison
14. Lansdown
15. Middle River-Martin
16. Soller's Point
18. Westminster
19. Bel Air
20. Simpsonville

New Stations: Hereford and Padonia

Note: Station 17 - not operating

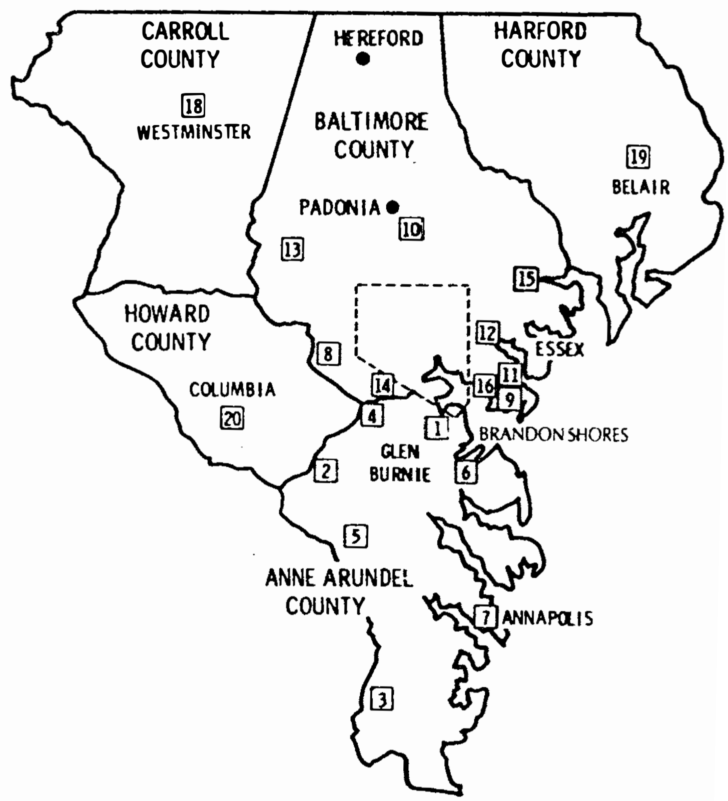


Figure 3.4. Operating Stations in the 1979 Ambient Air Quality Monitoring Network Area III (Except Baltimore City)

The primary TSP standard was exceeded at six of the 31 stations (the maximum recorded 24-hour value was 355 g/m³) and the secondary standard for TSP was exceeded at 17 of 31 monitoring stations. All six of these sampling stations where primary standards were exceeded are within the City of Baltimore. Brandon Shores and *Crane* are located outside of the primary and secondary TSP nonattainment areas (Figure 3.6).

Maximum air concentrations were recorded throughout 1978 for the various pollutants (Table 3.4). The averaging times given in this table correspond to the NAAQS averaging times for each pollutant. Specific monitoring stations at which the NAAQS were exceeded are given in Table 3.5.

1. AIRMON 1 Lombard & Penn
2. AIRMON 2 Calvert & 22nd
3. Fire Department Headquarters
4. Fire Department No. 10
5. Fire Department No. 22
6. Fire House No. 50
7. Fire House No. 57

9. Northeast Police Station
10. Northwest Police Station
12. 200 Read Street
13. Southeast Police Station
14. Southwest Police Station
15. Sun and Chesapeake
- ● New Station: Fairfield (1979)

Note: Station 1' not Operating

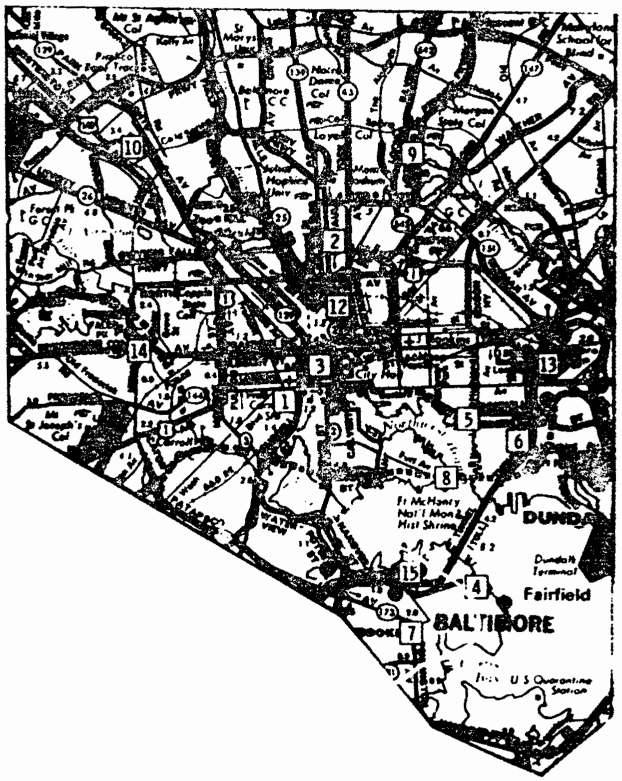


Figure 3.5. 1979 Ambient Air Quality Monitoring Network Area III (Baltimore City only)

The meteorological conditions associated with high ambient concentrations of TSP and O_3 were studied using the preliminary air quality and wind data for 1979 (DHMH 1979).

Of the approximately 100 days on which TSP was measured in 1979, the 24-hour secondary NAAQS was exceeded on 37 days. The primary standard was exceeded only on 4 days. All the secondary standard violations occurred within the City of Baltimore, with corresponding violations within Baltimore County on four of the 37 days. All levels greater than the primary standard were within the City of Baltimore. These stations were Fire Department Headquarters (#3), Fire Department No. 10 (#4), and Fort McHenry National Park (#8).

Table 3.6 lists the ambient TSP concentrations for the days during 1979 in which the 24-hour primary TSP standard was exceeded or nearly exceeded. Upon reviewing the available surface-level wind

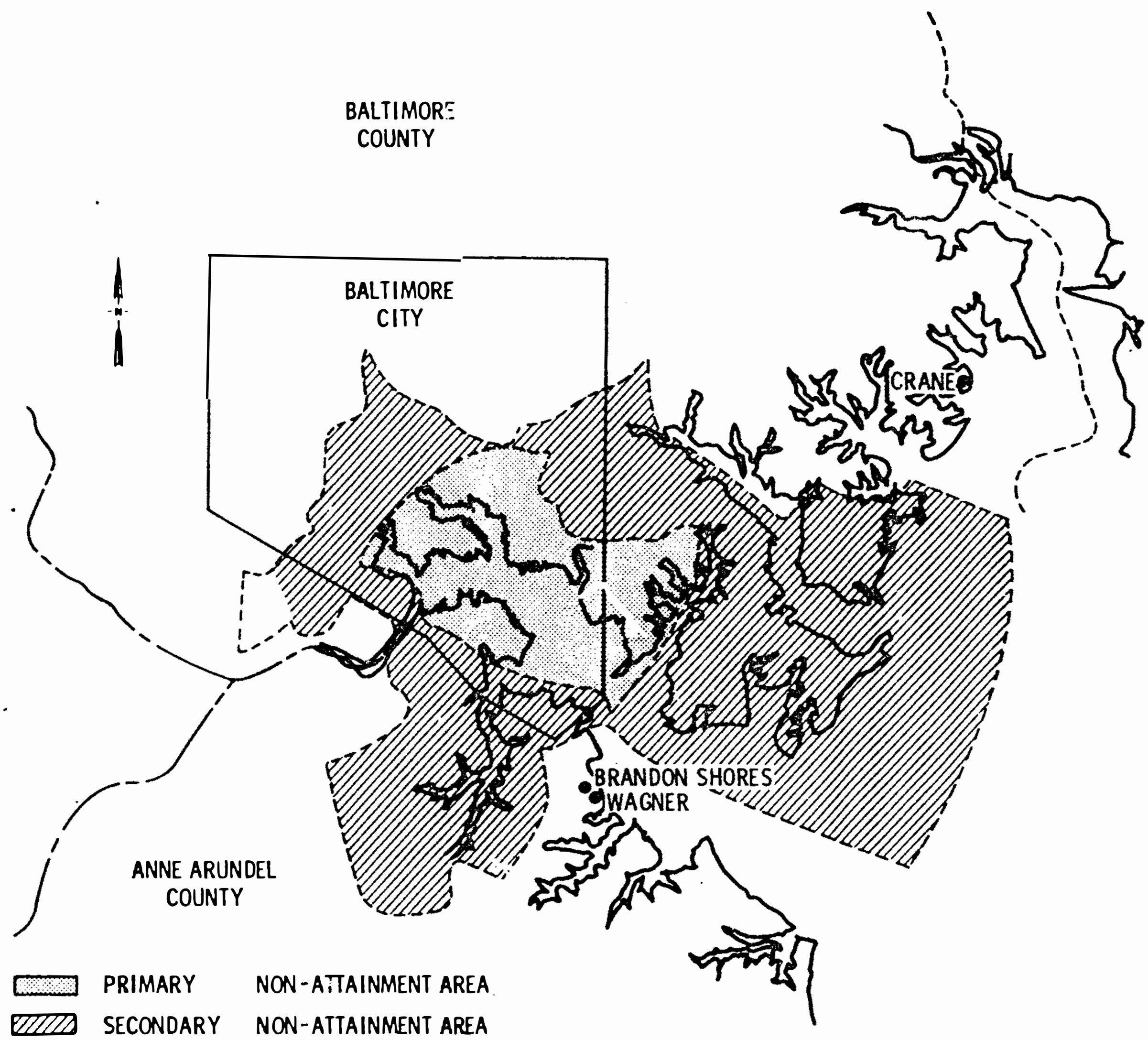


Figure 3.6. Location of BG&E Generating Stations in Relation to Primary and Secondary TSP Non-Attainment Areas contained within the Metropolitan Baltimore AQCR.

data for these days, it becomes apparent that all these days are dominated by light wind-speed (low ventilation) conditions.

The 9 days in 1979 on which the TSP standard was exceeded (Table 3.6) can be divided into two groups. One group consists of those days on which only one station reports relatively high levels (March 4 and 19, May 21, July 2, August 25); and the other group consists of those days on which the stations collectively report high levels (March 22, April 24, October 18, November 20). The latter

TABLE 3.4. Summary of 1978 Air Concentrations[a] Measured Within the Metropolitan Baltimore Air Quality Control Region

Monitoring Station	SO_2 3 Hr	SO_2 24 Hr	SO_2 Annual	TSP 24 Hr	TSP Annual	NO_2 Annual
Anne Arundel County						
1	384	138	19	215	62	60
2	—	72	9	—	—	42
3	—	48	11	82	37	34
4	314	103	30	126	51	49
5	—	46	10	107	43	38
6	340	139	28	132	52	21
7	—	43	14	83	43	43
1981						
6 Riviera Beach	199(1300)	102(365)	35(80)	137(260)	58(75)	33(100)

(a) ALL concentrations in ug/m^3
— Denotes no observations made
( ) The relevant NAAQ Standard, for comparison purposes

group is distinguished from the former insofar as the early morning hours (before sunrise) are dominated by calm conditions (Table 3.7).

Ozone (O_3) is a secondary pollutant in the lower atmosphere. It is not emitted directly into the air by man's activities, but is instead the product of atmospheric reactions. The major anthropogenic pollutants involved in the formation of ozone are hydrocarbons (HC) and oxides of nitrogen (primarily $NO + NO_2$). A mixture of these pollutants, when exposed to sunlight, undergoes photochemireactions and forms O_3. Ozone itself is very reactive and will readily oxidize many compounds (such

TABLE 3.5. Summary of Violations of 1978 Ambient Air-Quality Standards Within the Metropolitan Baltimore Air Quality Control Region

	TSP		O_3	CO	Pb
Monitoring Station	Primary	Secondary	Primary	Primary	Primary
Anne Arundel County					
1	0(a)	3	5	—	0
2	—(b)	—	—	—	—
3	0	0	—	—	—
4	0	0	2	—	0
5	0	0	—	—	—
6	0	0	2	0	—
7	0	0	—	—	—

(a) Units are number of times standard exceeded
(b) Denotes no observations made

as NO). In the absence of scavenging compounds, however, ozone can persist for days and be transported for hundreds of miles (Allwine and Westberg 1977; Westberg et al. 1978).

A number of different meteorological conditions or combinations of meteorological conditions over a source area can bring about ground-level ozone concentrations in excess of the NAAQS during the summer months. The major conditions are:

- stagnating, persistent anticyclone
- strong subsidence, low ventilation

TABLE 3.6. Maximum 24-Hour TSP Concentrations Observed Within Baltimore City During 1979

Date	Baltimore City Monitoring Station 3	4	5	7	8	10	13
March 4	58[a]	68	72	73	604	49	—[b]
March 19	96	292	—	—	—	64	86
March 22	206	248	257	182	168	95	172
April 24	277	275	—	—	—	201	189
May 21	257	147	121	89	89	86	—
July 2	75	246	81	51	93	48	62
August 25	70	62	88	82	311	147	73
October 18	177	59	224	223	211	126	143
November 20	—	239	—	—	—	248	208

(a) Units are ug/m³.
(b) Data not available.

TABLE 3.7. Surface-Level Winds Near Baltimore City on Select Days in 1979

Date	Before Sunrise WS	Before Sunrise WD	Sunrise To Sunset WS	Sunrise To Sunset WD	After Sunset WS	After Sunset WD
March 22	calm		4-9	NNW	calm	
April 24	calm		2-3	ENE	— (a)	
October 18	calm		2	NNE	calm	
November 20	calm		2	S	3	NW
March 19	—		1-4	WNW	1-3	SSE
May 21	—		3-5	SE	2	S
July 2	4-5	SW	5-11	WSW	3-8	WSW
August 25	2	WSW	2-3	WSW	calm	

WD = wind direction.
WS = wind speed (mph).
(a) Data not available.

- migrating anticyclone
- calm-to-light gradient flow
- moderate-to-persistent gradient flow
- moderately-sunny to very-sunny days.

In 1979, ozone data were collected at the Metropolitan Baltimore AQCR Linthicum (#4), Essex (#12), and Garrison (#13) monitoring stations. The NAAQS for 1-hour levels of ozone were exceeded 12 times that year (Table 3.8). On 3 days in particular, (March 15, June 1, and July 11), the synoptic

TABLE 3.8. Dates with One-Hour Ozone Levels Equal to or Greater than NAAQS in the Listed Monitoring Stations in 1979

	Monitoring Station		
	Baltimore County		Anne Arundel County
Date	12	13	4
May 15	137(a)	176	235
May 29	137	118	235
May 30	137	157	255
June 1	157	118	274
June 9	176	235	215
June 15	176	255	215
June 16	137	176	255
June 18	157	137	255
June 28	118	235	137
July 8	172	—	235
July 11	288	—	184
July 13	155	108	266
July 17	184	108	241
July 28	210	125	249
July 30	176	137	255
August 1	110	249	137
August 31	176	127	253
September 12	227	—	286

(a) units are ug/m³.

meteorology, in general, was that of a weak to flat pressure gradient with calm to light gradient flow out of the south to southwest. This meteorology resulted in high ozone levels near Baltimore caused by three possible events that sometimes were additive: 1) a stagnation of air emissions around Baltimore (June 1, July 11); 2) a buildup in the regional air mass (June 15 and July 11); and 3) the influence of emissions emanating from Washington, D.C. (June 15).

Air-quality trouble spots in the Metropolitan Baltimore AQCR are as follows:

- **Carbon Monoxide** One monitoring station in downtown Baltimore recorded violations of the 8-hour NAAQS in 1978. The high CO concentration appeared to be restricted to the downtown Baltimore area.
- **Lead** Same as carbon monoxide.
- **Sulfur Dioxide** No primary or secondary NAAQS for SO_2 were violated during 1978. The highest levels during 1978 were recorded in the south section of Baltimore City.
- **Ozone** The NAAQS for ozone was violated only at monitoring stations outside Baltimore City during 1978. The high levels were produced by a combination of regional buildup and precursor emissions from upwind metropolitan areas.

- **Nitrogen Dioxide** No violations of the NAAQS for NO_2 occurred during 1978. The highest annual average was recorded at a site in downtown Baltimore.

- **Total Suspended Particulates Matter** The primary and secondary NAAQS were exceeded numerous times during 1978. All violations of the primary standards for TSP were in the southern half of Baltimore City. The apparent cause was the stagnation of local low-level emissions under light windspeed conditions.

3.3 LAND USE

3.3.1 Generating Station Sites

The geology of the area surrounding Brandon Shores *and Crane* sites indicates that the stations are located over the Patapsco and Patuxent formations. A discussion of the hydrology and stratigraphy of these formations is given in Sections 3.4.2 and 4.3.2. The Patuxent formation outcrops in a somewhat irregular band, approximately 4 to 5 miles wide, from Washington, DC to Baltimore. At its closest approach, the outcrop is about 5 to 10 miles west of the BG&E stations. From this outcrop area, the Patuxent formation dips down at a rate of 85 to 90 ft/mile. The Patuxent formation is located at a depth of about 500 feet in the vicinity of the BG&E stations.

The Patapsco formation outcrops in a broad band that extends through Anne Arundel, Baltimore, and Harford Counties. The formation extends from the land surface to a depth of about 300 feet in the vicinity of the BG&E stations.

Brandon Shores

The 375-acre (152-ha) Brandon Shores site is located in an industrial area on the west shore of the Patapsco River approximately 10 miles southeast of Baltimore City center. Adjacent to the station along the southern border are the Herbert A. Wagner generating station and the Anne Arundel County Sewage Treatment Plant on Cox Creek. Brandon Shores is bounded on the west by forested land and Fort Smallwood Road (Route 173) and on the north by undeveloped land zoned for industrial use.

Two 620-MW boilers are currently under construction at Brandon Shores. Space has been reserved for waste handling, fuel-oil storage, a transmission switchyard, and for administrative and warehouse buildings. In addition, buildings and parking facilities for company headquarters personnel are planned for the site. The plant headquarters will be located along the Fort Smallwood Road at the northwest corner of the Brandon Shores site (Figure 3.7). The station is being constructed near the center of the complex, and the switchyard is located to the east and adjacent to the station. Oil storage, waste water, and forced-air cooling facilities are situated on the eastern portion of the site. Over 50 acres (20 ha) are available for coal storage either to the southwest or to the northwest of the generating units. Except for the headquarters site and the main road leading directly to the station from Fort Smallwood Road, a buffer of trees lines the west side of the site and separates the activities of the generating station from the road. A buffer of trees will also be maintained along portions of the site's northern and southern borders.

Although there has been no definite selection of a solid-waste disposal site, BG&E has acquired a purchase option on a 282-acre tract (Bishop and McKay property) just to the west of the Brandon Shores Generating Station for the purpose of waste disposal. This site can hold the solid wastes resulting from 7 to 10 years of operation of the Brandon Shores generating station on coal together with the waste from Wagner. Other disposal sites would have to be developed beyond this time. Dredge spoils from the development of a coal-barge channel at the Brandon Shores station have

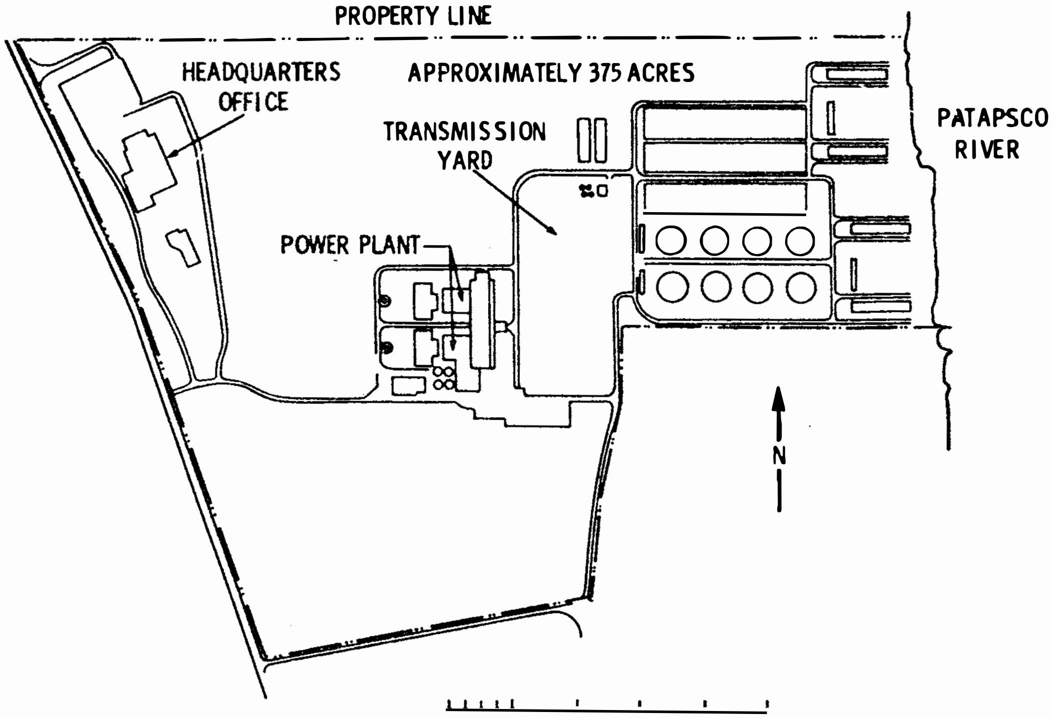


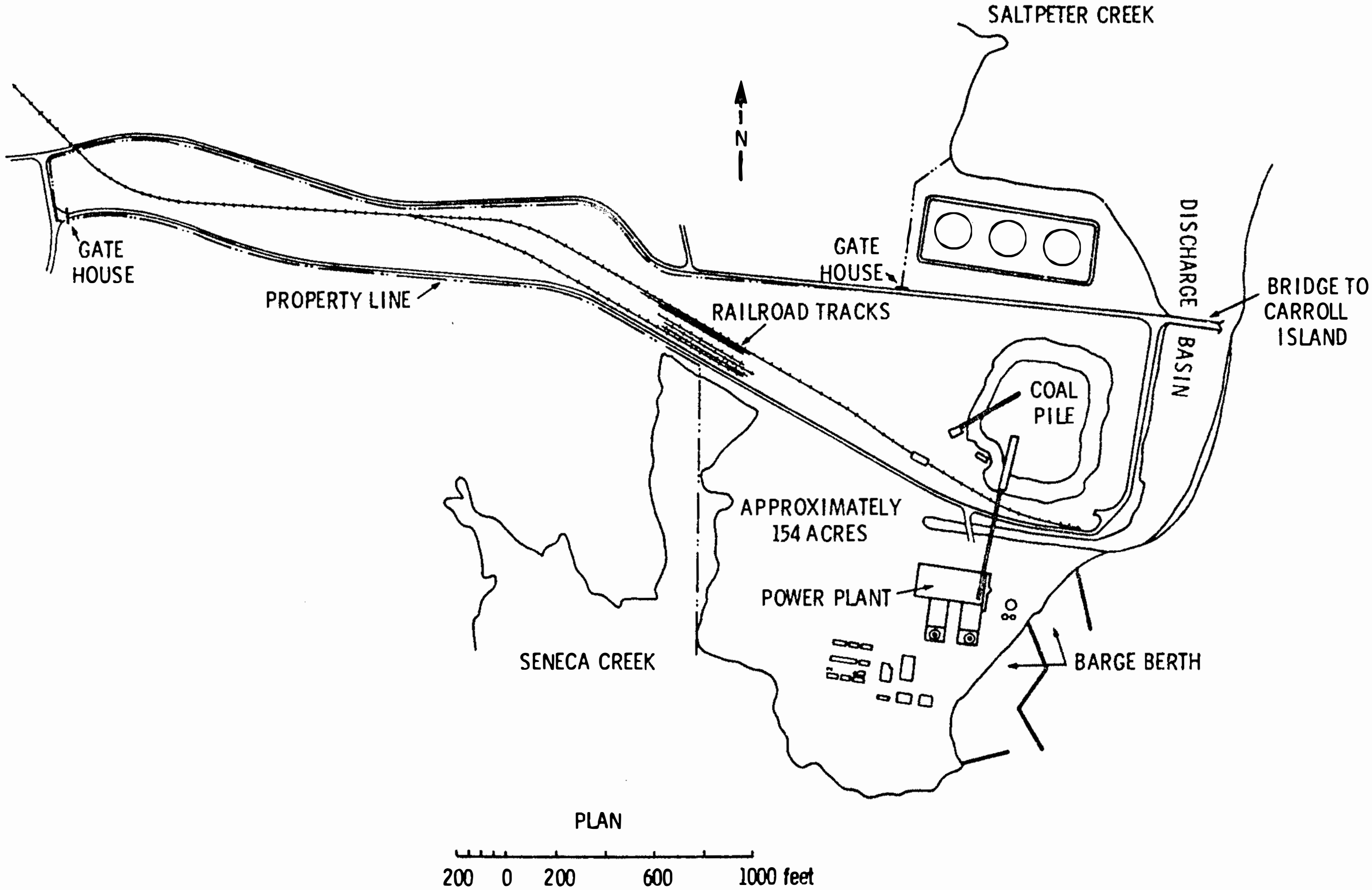
Figure 3.7. Brandon Shores Generating Station Site

been disposed of at the Marley Neck spoils disposal site. This licensed site is located just north of Brandon Shores and has accepted the 462,000 yd³ of dredge spoils that were generated by barge-channel construction. This disposal site is owned by the Marley Neck Patapsco Company.

Crane

The Crane Generating Station occupies 164 acres (66 ha) of land between Seneca and Saltpeter Creeks on the northern bank of Seneca Creek (Figure 3.8). The area north and west of the site is composed of woods, fields, and small residential areas. No major industry exists within a 5-mile radius of the station. A railroad enters the Crane site from the west and serves the main building. Located directly north of the station are oil-storage tanks and coal-handling equipment. Northeast of the boiler building is an existing coal-pile area that encompasses about 3.6 acres (1.5 ha) and can store approximately 120,000 tons of coal. East of the station and separated from it by the plant's discharge canal is Carroll Island. The island is undeveloped and densely wooded, and is classified as a wildlife sanctuary.

The Seneca-Saltpeter Creek area is a center for water recreation on Chesapeake Bay. Numerous private docks and small craft anchorages are within sight of the station. The banks of the discharge canal and the bridge across the canal to Carroll Island are popular fishing areas.



REF. BALTIMORE COUNTY WETLANDS PHOTO NO. BAI-25RL-54

Figure 3.8. *Crane Generating Station Site*

3.3.2 Wetlands

Both generating station sites border state-designated wetlands. However, almost all of the land at each of the sites is classified as upland.

The wetlands nearest Brandon Shores lie to the south of the generating units near the upper end of Cox Creek (Figure 3.10). The largest wetlands area is to the north of the site near Swan Creek. Neither of these areas are on the Brandon Shores station site.

In addition to wetlands associated directly with the Brandon Shores and Crane sites, there are also wetland areas adjacent to sites that have tentatively been identified for disposal of solid waste materials. The Bishop and McKay property located to the southwest of the Brandon Shores site (Figure 4.4), has been identified for disposal of combustion wastes (Dames and Moore 1980). A small portion of this property bordering Nabbs Creek (i.e., along the shoreline) is classified as wetlands (Figure 3.10). However, disposal of wastes in designated wetland areas is not recommended because they lie within the 100-year flood plain. Currently, precipitation runoff leaves the designated disposal area via Bishop Creek, which is an intermittent stream that drains into Cox Creek. Consequently, wetlands located at the headwaters of Cox Creek may also be affected by solid-waste-disposal activities on the Bishop and McKay properties. These wetlands also include shoreline areas of limited acreage.

Swan Creek and its associated marshlands border a site (Marley Neck site) used for disposal of dredge spoils from the construction of a Brandon Shores coal-delivery barge channel in the Patapsco River (Figure 4.4). This wetland area (Figure 3.10) includes 65 acres of open water and marshland located immediately to the southwest of the disposal site (USDT/MDT 1979). It is the largest functional wetland located on the southwest shore of the Patapsco River. It is primarily a freshwater system with saltwater intrusions which occur during high storm tides that would affect only those segments of the wetlands adjacent to the Patapsco River. This wetland area supports a diverse and vigorous assemblage of aquatic and terrestrial flora and fauna (USDT/MDT 1979). It is separated from the disposal site by a dike. This dike was enlarged to increase the capacity of the disposal site.

The cooling water intake for the Crane station is located at the boundary of the wetlands region into which the station's discharge canal extends. Oil off-loading facilities and breakwater piers also extend into the wetlands. Less than 5 acres of the site south of the station contain a wetlands area that supports the following vegetation categories: Fresh Marsh, Brackish High Marsh, and Brackish Low Marsh. Some submerged aquatic vegetation also exists in this area. Most of the wetlands (shoreline areas) lie to the northwest of the station boundary; the closest wetlands are less than 1000 feet and to the east and south of the generating units (Figure 3.10). The remainder of the Crane site is classified as upland.

Both sites border water that is exposed to high tidal-water surges (caused by the combination of hurricane winds and low barometric pressure) above the 100-year event water level. The Brandon Shores plant site is above the 100-year floodplain (Figure 3.10). The area of the site shown within the 100-year floodplain is near the plant's cooling towers, and does not include the coal-storage or waste-storage areas. A very small portion of the planned waste disposal site lies within the floodplain and would not be used for disposal. *Much of the Crane Station and the appurtenant structures lie within the 100-year floodplain. However, the existing coal tipple and storage areas lie well above the 100-year floodplain; land above this level is sufficient for waste storage. Should a 100-year flood event occur, no cumulative effects from the operation of Crane and Brandon Shores are projected.*

3.3.3 Unique Farm and Forest Lands

Although farms and forests exist within five miles of each of the four generating station sites, none of this land has been classified as prime or unique (AIS 1978).

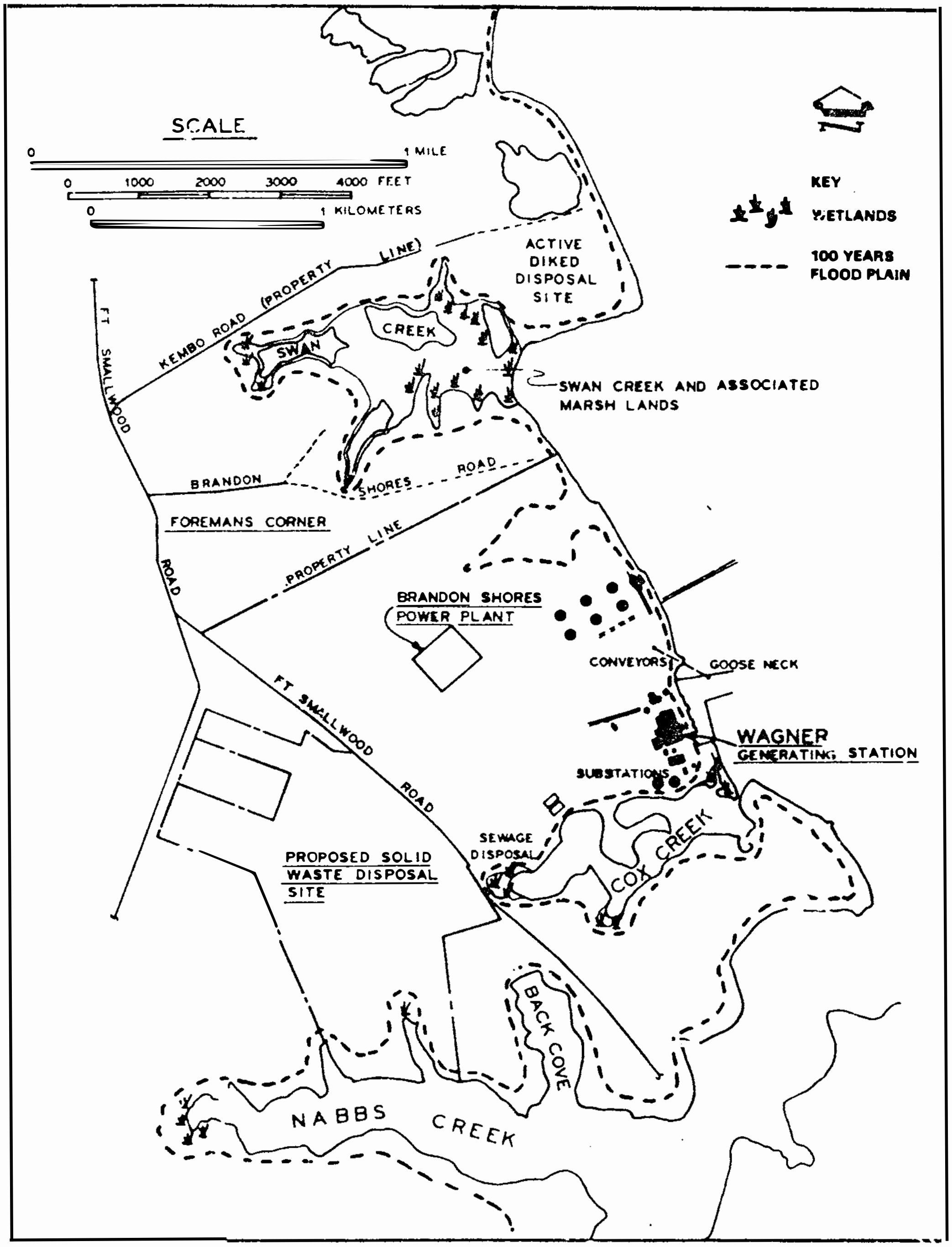


Figure 3.9. Floodplains and Wetlands in the Vicinity of Brandon Shores Generating Station. Source: Baltimore County Wetlands Photo Nos. AA1-4RL-42 & AA1-4RL-44

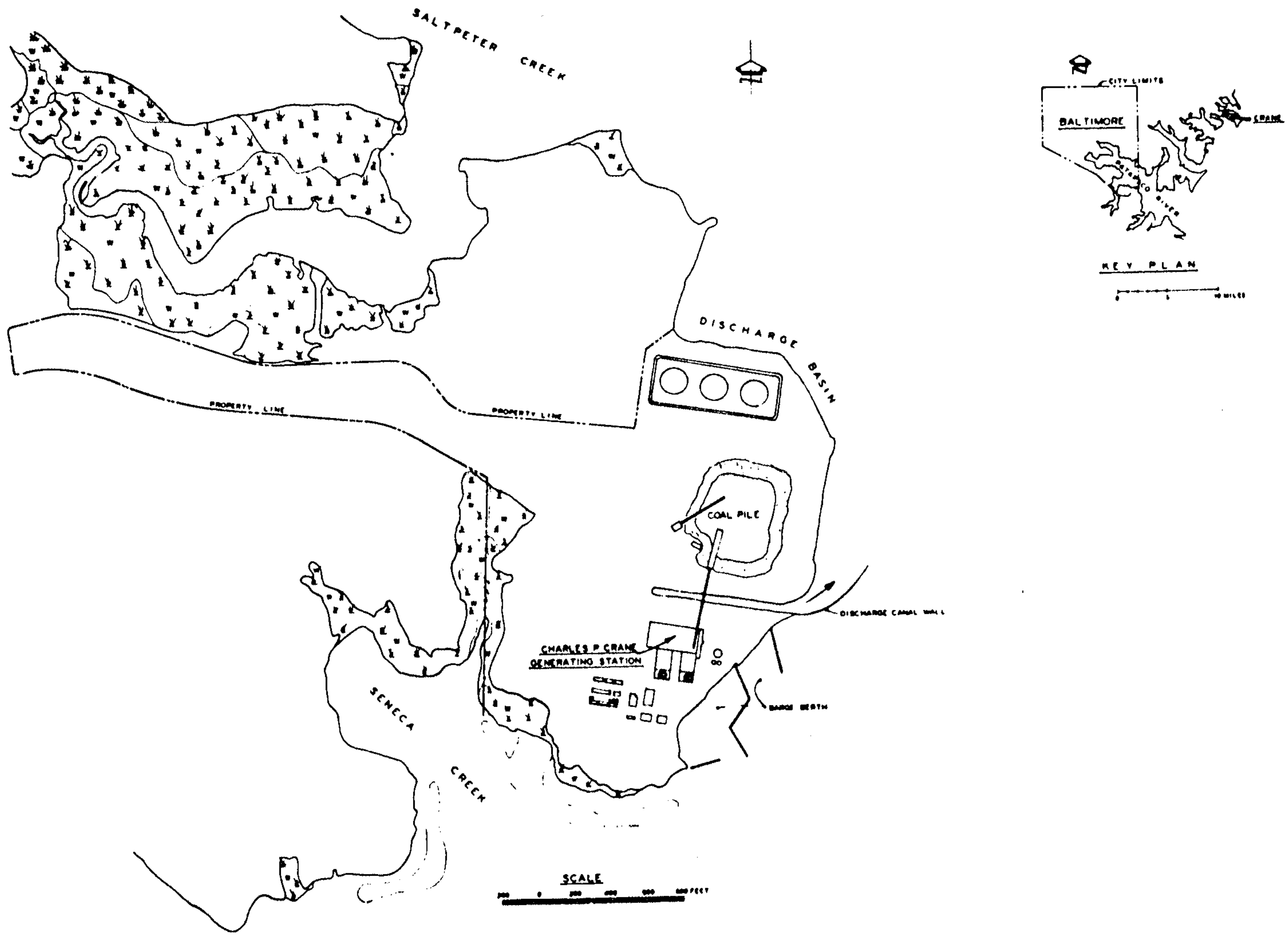


Figure 3.10. *Wetlands in the Vicinity of the Crane Generating Station Ref. Baltimore County Wetlands Photo No. BA1-25RL-54*

3.4 WATER

3.4.1 Present Use

The principal surface waters that are used by the BG&E generating stations include the Patapsco River, which borders the Brandon Shores Generating Station; *and Seneca and Saltpeter Creeks, which are adjacent to the Crane station.* These streams are estuarine and have variable salinities. The high salinities render the water unsuitable for most potable and general industrial uses.

The Brandon Shores Generating Station will use wet-dry cooling towers. The cooling water will be taken from the Wagner discharge canal and the tower blowdown returned there after passage through a retention pond. Cooling tower make-up water will be withdrawn from the Wagner canal at a rate of 33 cfs (0.93 m^3/sec). Total consumptive use in the cooling towers will be approximately 20 cfs (0.57 m^3/sec), and about 13 cfs (0.36 m^3/sec) will be discharged back into the Wagner canal (JHU 1972a).

At the Crane station, water for Units 1 and 2 is withdrawn from Seneca Creek at the rate of 740 cubic feet per second (cfs; 21 m^3/sec)[(a)] and later discharged into Saltpeter Creek. Most of this water is used for cooling. Woll (1978) reports the existence of a shallow well in the immediate vicinity of the Crane station.

3.4.2 Availability

The principal surface waters in the vicinity of the BG&E stations are the Patapsco River (Brandon Shores) and *Seneca and Saltpeter Creeks (Crane).* Ocean inflow maintains the water level in the estuaries of these streams. Although abundant, this water is not necessarily suitable for industrial use.

The major aquifers in the vicinity of the Brandon Shores and *Crane* are contained in sandy layers of the Patapsco and Patuxent formations. Near the stations, the Patapsco formation extends from depths of about 0 to 200 feet (0 to 61 m), and the Patuxent formation extends from about 350 to 500 feet (107 to 152 m) below the ground surface. Mack (1962) estimates that the Patuxent and Patapsco aquifers could produce as much as 50 million gallons per day (189,000 m^3/d) of ground water if fully used. The Brandon Shores station is located on the recharge zone for the Patapsco aquifer (Mack 1962). The ground-water yield in the Patuxent formation is highly variable. At some localities the sands are capable of yielding several hundred gallons per minute (gpm), but at other localities, they are too shallow or too narrow to yield more than a few gallons per minute to individual wells (Mack 1962).

The Patapsco formation contains the most productive aquifers in Anne Arundel County (Mack 1962), where yields up to 1500 gpm (5.7 m^3/m) in wells have been reported (Lucas 1976).

Ground-water flow in the upper Patapsco formation is in the direction of the nearest surface water body. The water table roughly follows land surface contours at depths varying from 0 to 20 feet (0 to 6 m).

The Patapsco aquifer is classified as a Type-one aquifer under the Maryland Groundwater Quality Standards Regulation 08.05.04.04 (EA 1980a). Type-one aquifers are defined as having a transmissivity greater than 1,000 gal/day/ft, a permeability of greater than 100 gal/day/ft^2, and a total dissolved solids concentration for natural waters of less than 500 mg/l. For all Type-one aquifers, the characteristics of constituents in discharged water may not exceed mandatory or recommended standards for drinking water as established by the Federal government (Maryland Groundwater Quality Standards Regulation 08.05.04.04). Maximum allowable contaminant levels are shown in Table 3.9.

(a) Letter from S. A. Link, BG&E, to Joe Polasek, ERA, dated April 1, 1981

TABLE 3.9. EPA National Interim Primary and Secondary Drinking Water Regulations

Interim Primary Regulations

Parameter	Concentration (mg/l)
Arsenic	0.05
Barium	1.
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.
Selenium	0.01
Chlorinated Hydrocarbons	
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
Chlorophenoxys	
2,4-D	0.1
2,4,5-TP Silvex	0.01
Total Trihalomethanes	0.10

Secondary Drinking Water Regulations

Parameter	Concentration (mg/l)
Chloride	250 mg/l
Color	15 color units
Copper	1 mg/l
Corrosivity	Noncorrosive
Foaming Agents	0.5 mg/l
Iron	0.3 mg/l
Manganese	0.05 mg/l
Odor	3 Threshold odor numbers
pH	6.5 to 8.5
Sulfate	250 mg/l
Total Dissolved Solids (TDS)	500 mg/l
Zinc	5 mg/l

Sources: EPA National Interim Primary Drinking Water Regulations (Code of Federal Regulations 40 CFR 141) EPA National Secondary Drinking Water Regulations (Code of Federal Regulations, 40 CFR 143)

3.4.3 Ambient Water Quality

The Patapsco River is a Class I water, generally suitable for water-contact recreation and aquatic life, according to Maryland's Classification of State Waters (Regulation 08.05.04.09). Maryland State Standards for Class I water are shown in Table 3.10. The ambient water quality of the estuary is given in Table 3.11. The mean concentrations of mercury and PCBs exceed EPA water-quality criteria for both fresh and marine waters; the mean cadmium concentration exceeds EPA criteria for fresh water; and the mean zinc concentration exceeds EPA criteria for marine waters, as does the iron concentration near Brandon Shores. The concentrations of manganese, chloride, and sulfate near Brandon Shores exceed Public Water Supply Criteria (EPA 1973). In addition, the mean concentrations of NH_3-N and oil and grease exceed Public Water Supply criteria. The concentration of hydrogen sulfide near Brandon Shores exceeds EPA water-quality criteria for both fresh and marine waters. However, the only data available for hydrogen sulfide concentrations were measurements taken in the very shallow Cox Creek estuary. This value may not be representative of the Patapsco River estuary.

Seneca and Saltpeter Creeks are designated as Class II waters, which means that they are suitable for shellfish harvesting, as well as for water-contact recreation and the sustenance of aquatic life (Table 3.12). The mean total dissolved solids concentrations in the creeks exceed EPA secondary

TABLE 3.10. Maryland Standards for Class I Waters[(a)]

Parameter	Standard
Fecal coliforms (#/100 ml)	200
Dissolved Oxygen (mg/l) (minimum)	4.0
(minimum daily average)	5.0
Temperature	90°F
pH (std. units)	6.5-8.5
Turbidity (maximum)	150 stu
(monthly average)	50 stu

(a) Source: Maryland Receiving Water Quality Standards Regulation 08.05.04.03 effective Sept. 1, 1974, Amended July 5, 1978

drinking water regulations. The concentrations of trace metals in the Seneca Creek estuary were not available in the technical literature.

Ground-water quality for the Patapsco and Patuxent aquifers is shown in Table 3.13. These data indicate that water in the two aquifers is generally of good quality. Mack (1962) indicates that the iron content may be high enough in some locations to require that the water be treated before it is used for drinking.

Table 3.14 shows that the ground-water quality for wells near Brandon Shores is similar to the median quality of ground water in the Patapsco and Patuxent aquifers. *However, water from a well drilled near Crane has a hardness content about 20 times greater than the median hardness of the Patapsco aquifers.*

3.5 IMPORTANT BIOLOGICAL RESOURCES

Resource areas that may be affected by conversion activities at the BG&E stations are: the Marley Neck area on the west shore of the Patapsco River between Curtis Bay and Stony Creek (Brandon Shores), and *the Crane site bordered by Saltpeter Creek to the north and Seneca Creek to the south.* Aquatic resources native to the lower Patapsco River associated with Brandon Shores represent one major aquatic area, *and the Saltpeter-Seneca Creek area associated with Crane represents the other.*

3.5.1 Agricultural Resources

The principal crops of Maryland in 1978, ranked by monetary value in decreasing order, were corn, soybeans, hay, and tobacco (Cawley et al. 1979). Farm acreage was reduced 32 percent from 1950 to 1975 in favor of expanding urbanization and industry. A review of the available statistics (Table 3.15) indicates the extent of agricultural activities in Anne Arundel (Brandon Shores site) and *Baltimore (Crane site)* Counties relative to statewide production.

Milk production is small when compared to Statewide production (Table 3.16). County statistics for livestock and poultry are not available.

Urbanization and expanding industry have also had an impact on Maryland's timber resources. The U.S. Forest Service's most recent statistics (Powell and Kingsley 1980) show that there was a 13 per-

TABLE 3.11. Ambient Water Quality—Patapsco River

Parameter	Concentration Near Brandon Shores(a)	Mean Concentration Patapsco River Estuary(b)	Range in Concentration Patapsco River Estuary(b)	EPA Water Quality Criteria(c)	
				Fresh Water	Marine Water
D.O. (mg/l)	11.0	9.0	5.0 - 12.1	5.0	4.0(d)
pH (units)	7.0	7.3	6.3 - 8.0	6.5 - 9.0	6.5 - 8.5
Conductivity (mmhos/cm)	(e)	11.0	4.6 - 18.2	NS	NS
Turbidity (NTU)	4	6.6	1.6 - 23	NS	NS
NH_3-N (mg/l)	NA	0.52	0.41 - 0.68	0.5(f)	0.5(f)
TKN (mg/l)	NA	1.95	0.50 - 6.3	NS	NS
NO_2-N (mg/l)	NA	0.02	0.009 - 0.05	1.0(f)	1.0(f)
NO_3-N (mg/l)	1.13	0.51	0.17 - 0.876	10(g)	10(g)
Ortho-P (mg/l)	NA	0.03	0.011 - 0.176	NS	NS
Total-P (mg/l)	NA	0.19	0.042 - 0.451	NS	NS
Cl^- (mg/l)	7640(e)	NA	NA	250(f)	250(f)
SO_4^{2-} (mg/l)	780(e)	NA	NA	250(f)	250(f)
H_2S (mg/l)	0.85(e)	NA	NA	0.002	0.002
TDS (mg/l)	13,700(e)	NA	NA	NS	NS
Alkalinity (mg/l as $CaCO_3$)	65.6(e)	NA	NA	720	NS
As (mg/l)	0.01	0.005	0.0019 - 0.0086	0.10(f)	0.05(d)
Ba (mg/l)	0.038	NA	NA	1.0(f)	1.0(d)
Cd (mg/l)	0.014	0.005	0.001 - 0.047	0.04	0.005
Cr (mg/l)	0.045	0.003	0.001 - 0.007	0.100	0.100(d)
Cu (mg/l)	0.129	0.026	0.001 - 0.043	1.0(f)	0.05(d)
Pb (mg/l)	0.10	0.025	0.006 - 0.156	(h)	0.05(d)
Hg (mg/l)	0.0015	0.0024	0.0003 - 0.0140	0.00005	0.00010
Zn (mg/l)	0.04(e)	0.250	0.005 - 1.335	5.0(f)	0.1(d)
Fe mg/l)	0.928	NA	NA	1.0	0.3(d)
Mn (mg/l)	0.10(e)	NA	NA	0.05(f)	0.10(d)
Se (mg/l)	0.003	NA	NA	0.01(f)	0.01(d)
PCB (mg/l)	NA	0.050	0.005 - 0.238	1×10^{-6}	1×10^{-6}
Oil Grease (mg/l)	NA	1.76	0.0032 - 6.06	0.0(f)	0.0(f)

D.O. = Dissolved Oxygen.
NA = Not available.
NS = No Standard.
(a) Source: EA 1980.
(b) Source: U.S.D.T/MDT 1979.
(c) Source: EPA 1976.
(d) Source: EPA 1973.
(e) Source: Dames and Moore 1980.
(f) Source: Public Water Supply Criteria in Water Quality Criteria (EPA 1973).
(g) Interim Primary Drinking Water Standards.
(h) (0.01) 96 hr. LC_{50} for a sensitive resident species using receiving water and soluble Pb measurements.

TABLE 3.12. Ambient Water Quality for Seneca and Saltpeter Creeks

Parameter	Mean Concentration(a)	Range in Concentration(b)	EPA Water Quality Criteria Fresh Water	EPA Water Quality Criteria Marine Water
D.O. (mg/l)	8.9	6.4 - 10.6	5.0	4.0(c)
pH (units)	7.1	6.8 - 7.7	6.5 - 9.0	6.5 - 8.5
Turbidity (F.T.U)	29	12 - 60	NS	NS
Conductivity (mhos/cm)	4,500	615 - 8,500	NS	NS
NH_3-N (mg/l)	0.06	0.01 - 0.27	0.5(e)	0.5(d)
NO_2-N (mg/l)	0.01	0.001 - 0.018	1.0(e)	1.0(d)
Un-ionized NH_3 (mg/l)	0.02	0.00 - 0.006	0.02	0.4(d)
NO_3-N (mg/l)	0.31	0.01 - 0.98	10(e)	10(e)
TKN (mg/l)	0.31	0.03 - 0.42	NS	NS
Total-PO_4 (mg/l)	0.120	0.060 - 0.190	NS	NS
T.O.C. (mg/l)	4.03	0.80 - 10.5	NS	NS
T.D.S. (mg/l)	858	290 - 1426	500(f)	500(f)
Salinity (ppt)(g)	3.0	0.3 - 7.0	NS	NS

D.O. = Dissolved Oxygen.
NS = No Standard.
(a) Source: EPA Storet Data.
(b) Source: Quality Criteria for Water (EPA 1976).
(c) Source: Water Quality Criteria (EPA 1973).
(d) Source: Water Supply Criteria in Water Quality Criteria (EPA 1973).
(e) Interim: Primary Drinking Water Standards.
(f) EPA National Secondary Drinking Water Regulations (40 CFR 143).
(g) Parts per thousand.

TABLE 3.13. Median Ground-Water Quality for the Patapsco and Patuxent Aquifers(a)

Parameter	Patapsco	Patuxent
SiO_2 mg/l)	7.9	9.3
Fe (mg/l)	0.35	0.87
Cl^- (mg/l)	2.5	2.5
Hardness (mg/l)	12	5
pH (units)	5.1	5.4

(a) Source: Mack 1962

cent decrease in commercial forest land in Maryland between 1964 and 1975. At present, less than 10% of the State's commercial forests are located in Anne Arundel (4.6%) and Baltimore (4.5%) Counties (Table 3.17).

Brandon Shores

Brandon Shores is located in the Marley Neck industrial area, which is characterized by undeveloped wooded areas, cleared grasslands, wetlands, and occupied industrial sites. In 1964, 29 percent of Anne Arundel County was devoted to agriculture (JHU 1972b); however, there is little farming activity near the generating station sites. Small residential gardens can be found in outlying, unincorporated residential areas.

TABLE 3.14. Quality of Ground Water in the Vicinity of Brandon Shores and Crane Generating Stations[a]

Parameter	Concentration in Wells Adjacent to Brandon Shores	Concentration in Wells Adjacent to Crane[b]
SiO_2 (mg/l)	7.0	—
Fe (mg/l)	0.43	0.72
Mn (mg/l)	0.02	—
Ca^{++} (mg/l)	2	—
Mg^{++} (mg/l)	1.5	—
Na^{+} (mg/l)	1.6	—
K^{+} (mg/l)	0.8	—
HCO_3 (mg/l)	4	28
SO_4^{2-} (mg/l)	11	—
Cl^{-} (mg/l)	2.7	—
NO_3 (mg/l)	1.4	—
Hardness (mg/l)	11	209
pH (units)	4.2	6.2

(a) Data compiled from Woll (1978).
(b) Sample was taken only 12 feet (3.7 m) below the surface.

TABLE 3.15. Agricultural Statistics for Anne Arundel County, Baltimore County, and the State of Maryland, 1978[a]

Commodity	Acreage Harvested	Production	Value $ Millions
Corn (Maryland)			
grain	590,000	57,230,000 bushels	128.768
silage	94,000	1,410,000 tons	25.662
Soybean (Maryland)	345,000	11,949,000 bushels	71.760
Anne Arundel	1,700	48,000 bushels	0.316
Baltimore	*3,000*	*90,000 bushels*	*0.585*
Tobacco (Maryland)	23,000	32.20 mil pounds	37.062[b]
Anne Arundel	4,400	6.16 mil pounds	7.090[b]
Wheat (Maryland)	108,000	3,996,000 bushels	11.988
Anne Arundel	1,500	47,000 bushels	0.141
Baltimore	*4,500*	*180,000 bushels*	*0.540*
Barley (Maryland)	85,000	3,825,000 bushels	6.885
Anne Arundel	100	5,000 bushels	0.009
Baltimore	*5,000*	*255,000 bushels*	*0.459*
All Hay (Maryland)	249,000	631,000 tons	44.190
Anne Arundel	4,500	9,500 tons	0.665
Baltimore	*15,000*	*37,000 tons*	*2.625*
Commercial Vegetables and Melons (Maryland)	46,110	NA	NA
Anne Arundel	155	NA	NA
Baltimore	*3,145*	*NA*	*NA*

(a) Cawley et al. 1979.
(b) Based on 1977 prices.
NA Not available.

TABLE 3.16. Dairy, Poultry and Livestock Statistics for the State of Maryland[a]

	Year	Production (million lb)	Value ($ millions)
		Dairy	
Milk (Statewide)	1978	1,540	—
Anne Arundel Co.	1978	4	—
Baltimore Co.	*1978*	*50*	
Cottage Cheese	1975	18.1	
		Poultry	
Broilers	1978	906,000	235.5
Eggs	1978	313,000	17.484[b]
Turkeys	1978	1,793,000	0.819[b]
		Livestock	
Cattle and Calves	1978	98.6	52.8[c]
Hogs and Pigs	1978	53.4	24.4[c]
Sheep and Lambs	1978	1.2	0.6[c]

(a) Cawley et al. 1979.
(b) Based on an average price of 67.9 cents per dozen and sales of 309,000 eggs.
(c) Gross income.

TABLE 3.17. Forestry Statistics (1976) for Anne Arundel and *Baltimore Counties* and the State of Maryland[a]

	LAND AREA (Acres)			
		Forested - Land Areas		
	Total Land Area	Non-Commercial	Commercial	Percent Commercial[b]
State	6,330,000	130,500	2,522,700	40
Anne Arundel	270,700	5,200	114,900	42
Baltimore	*432,700*	*10,900*	*113,500*	*26*

	NET VOLUME OF COMMERCIAL GROWING STOCK (mil cu ft)		
	Softwoods	Hardwoods	Total
State	793.0	2,699.1	3,492.1
Anne Arundel	29.0	150.5	179.5
Baltimore	17.2	151.0	168.2

	NET VOLUME OF COMMERCIAL SAW TIMBER (mil cu ft)		
	Softwoods	Hardwoods	Total
State	1,726.4	6,440.2	8,166.6
Anne Arundel	33.9	406.9	440.8
Baltimore	*24.9*	*412.3*	*436.7*

(a) Powell and Kingsley (1980).
(b) Percentage of total land area.

Eighty-four percent (150.5 million cubic feet) of the net volume of standing timber in the Anne Arundel County is composed of hardwoods (oak, hickory, maple, beech and birch); the remaining 16 percent (29 million cubic feet) is comprised of loblolly and shortleaf pine. Industrial development in the Marley Neck area has reduced the forested area to the point that it is no longer a viable timber resource. The forest species associations in the area are bald cypress, river birch-sycamore, and tulip-poplar (Brush et al. 1976). The Maryland State Department of Natural Resources has indicated that some privately owned timber sales are presently registered in the Marley Neck area. There are no managed aquaculture activities in the vicinity of either Brandon Shores or *Crane.*

Crane

The area around Crane is rural. The small farms which dot the landscape to the north of the station, raise mostly corn, soybean, wheat and tobacco.

Powell and Kingsley (1980) indicate that the growing stock on commercial forest land in Baltimore County totaled 168 million cubic feet (90 percent hardwoods). This timber is located on 113,500 acres which are scattered throughout the county. Presently there are no registered timber sales in the immediate vicinity of the Crane station. The forest associations in the immediate vicinity of the plant are tulip-poplar and river birch-sycamore associations (Brush et al. 1976).

3.5.2 Terrestrial and Aquatic Natural Resources

Terrestrial and aquatic natural resources endemic to the area include wildlife and finfish and shellfish.

Commercial Species

Chesapeake Bay supports a sizeable fishing industry. The 1976 estimated Maryland catch from the bay was 60 million pounds, and was valued at approximately 74 million dollars (U.S. Bureau of Census 1978). The lower Patapsco River provides habitat for as many as 51 finfish species (LM&S Engineers 1979). Only four species are reported to have actually spawned in the Patapsco and its minor tributaries: the bay anchovy, herring, white perch, and the yellow perch (EA 1980c). High levels of industrial pollutants and habitat displacement are most likely responsible for the diminished spawning in the area. Impingement and entrainment data indicate that the river does serve as a nursery for primarily bottom-dwelling species (EA 1980c, LM&S Engineers 1979). The Patapsco River exhibits a gradation of pollution (principally confined to the sediments) from the inner harbor (most polluted) to the mouth. This condition is reflected in the aquatic biota. Bottom-dwelling fauna is of low density and fish populations are reduced and of poor quality (e.g., diseased, frayed fins, etc). The water quality of the Patapsco also indicates that pollution is a problem in the river (Table 3.11).

In contrast, the relatively unpolluted Seneca and Saltpeter Creeks (Table 3.12) support a rich assemblage of benthic, planktonic, and nektonic species (EA 1979; Nichols et al. 1980). Shellfish harvesting and sport fishing are popular in this area.

The National Oceanic and Atmospheric Administration has designated specific areas for compiling commercial catch statistics.[a] *Saltpeter Creek falls within the Gunpowder River area (NOAA Area 045); Seneca Creek is affiliated with the Middle River area (059); and the mid-Patapsco River falls* in area (066). According to data on commercial catches for 1977 and 1978 (Table 3.18), *the Seneca-Saltpeter Creek areas (045 and 059)* are more

(a) Letter from Steve Early, Maryland Dept. of Natural Resources to T. M. Poston, PNL, not dated.

TABLE 3.18. Commercial Catch in Pounds and Percentage of Total Maryland Catch (in parenthesis) by NOAA Areas; 1977 and 1978

Species	Saltpeter Creek (045)		Seneca Creek (059)		Patapsco River (066)		Maryland[b] Total Catch
	Area[a]						
1977							
Bluefish	2	(0)	988	(0.3)	1,448	(0.4)	391,186
Carp	2,148	(2,1)	234	(0.2)	28	(0)	101,403
Catfish	2,977	(1.0)	168	(0.1)	131	(0)	190,391
Croaker	9	(0)					692,018
Eel	38	(0)					156,608
Flounder	23	(0)	5	(0)			677,468
Gizzard Shad	2,050	(16.1)					12,752
Herring[c]	300	(0.5)	7	(0)	10	(0)	65,497
American Shad (Roe)	73		89				76,580
American Shad (Buck)	14		39				
Hickory Shad			4	(0.5)			810
Menhaden	671	(0)	2,100	(0)	3,075	(0)	8,162,649
Striped Bass	14,187	(0.8)	18,454	(1.1)	520	(0)	1,732,144
White Perch	27,533	(4.8)	5,594	(1.0)	1,251	(0.2)	568,308
Yellow Perch	2,868	(16.2)					17,739
1978							
Bluefish			13	(0)	255	(0)	288,806
Carp	916	(1.0)	310	(0.3)	20	(0)	95,787
Catfish	1,234	(0.4)	340	(0.1)	136	(0)	350,558
Croaker							582,356
Eel							206,000
Flounder							
Gizzard Shad	,105	(1.2)					4,178
Herring[c]	542	(0.2)	18	(0)	20	(0)	255,191
American Shad (Roe)	12	(0)	3	(0)			6,614[d]
American Shad (Buck)					4	(0)	
Hickory Shad							1,136
Manhaden	373	(0)	333	(0)	3,280	(0)	7,085,357
Striped Bass	14,372	(1.2)	2,383	(0.2)	227	(0)	1,189,499
White Perch	33,213	(3.2)	4,689	(0.5)	527	(0.1)	1,040,383
Yellow Perch	1,304	(4.5)					29,261

(a) Data provided by Steve Early, Maryland Department of Natural Resources to T.M. Poston, PNL, no date.
(b) USDC 1978.
(c) Includes alewife, Maryland total is sum of alewife and herring.
(d) Total of both Buck and Roe Shad.

productive than the Patapsco River. Overall, these three areas account for only a small fraction of the total Maryland catch. Yellow perch and gizzard shad are the only two species which account for a notable percentage.

In a separate study, the Maryland Waterman's Association (MWA 1978) surveyed commercial finfishing in the upper Chesapeake Bay. *The Gunpowder River drainage which includes Saltpeter Creek was rated as good to fair for standard bottom netting techniques (i.e., anchor net, fyke net, etc.).* The Patapsco River was rated as fair for rockfish, perch, and catfish during the fall.

Recreational Species

The dense population of the Baltimore area precludes any major hunting activities. It is likely that sporadic hunting occurs in underdeveloped areas at Marley Neck and around Crane; however, more attractive areas are available for hunting in the Baltimore region. The wildlife habitats that these areas and associated wetlands provide are becoming scarce due to encroaching urbanization and industry.

The area around the Crane station is more conducive to hunting because of its rural nature. Waterfowl are abundant due to the availability of food in the area, and duck hunting is popular here. Carroll Island, located to the east of the Crane station, has been designated as a wildlife sanctuary. It falls within the boundaries of the Aberdeen Pr.,ving Ground and is owned by the Federal government. The pollution-induced impoverished nature of Patapsco River sediments, however, provides little if any food for waterfowl; hence most waterfowl observed in the Patapsco River are probably in transit.

Site-specific information concerning recreational fishing activities is not available. The Patapsco River and Seneca and Saltpeter Creeks are excluded from the closest study region—Area 3—as designated by the Maryland Fisheries Administration (Speir et al. 1977). Area 3 comprises the Chesapeake Bay area proper in front of the mouth of the Patapsco River north to Pooles Island (east of Carroll Island), excluding all tributaries on the west side of Chesapeake Bay (Figure 3.11). The data provided in this reference did indicate the significance of recreational fishing in Area 3 from May to October of 1976. The most sought-after species in decreasing order are bluefish, striped bass, white perch, spot, and croaker. Other game fish in the three streams include catfish, carp, and yellow perch.

Threatened and Endangered Species

A listing of threatened and endangered species that occur within a 5- or 50-mile radius of the BG&E generating stations is presented in Table 3.19.[a] None of these species have been reported at either of the generating station sites. Marine turtles that appear on both the Federal and State lists have been documented in Chesapeake Bay as far north as the Patapsco River, but sightings there are rare.

3.6 CULTURAL VALUES

3.6.1 Archaeological and Historical Sites

There are no historic landmarks listed by or eligible for inclusion in the National Register of Historic Places located on or immediately adjacent to the Brandon Shores or Crane sites (MDECD 1978). Historic sites and landmarks do exist, however, in Anne Arundel County, in Baltimore County, and in the City of Baltimore. A number of historic sites in these three areas have been placed on either the National Register of Historic Places or identified as a National Historic Landmark. A listing of National Historic Places and Landmarks is shown in Appendix D. The State Historic Preservation Officer has indicated the belief that the Federal action will have no affect on historic stru-tures or archeological resources (Appendix D).

(a) Letters from G. J. Taylor, Maryland Dept. of Natural Resources, to T. M. Poston, PNL, April 14, 1981; and G. A. Moser, U.S. Fish and Wildlife Service, to T. M. Poston, PNL, May 13, 1981.

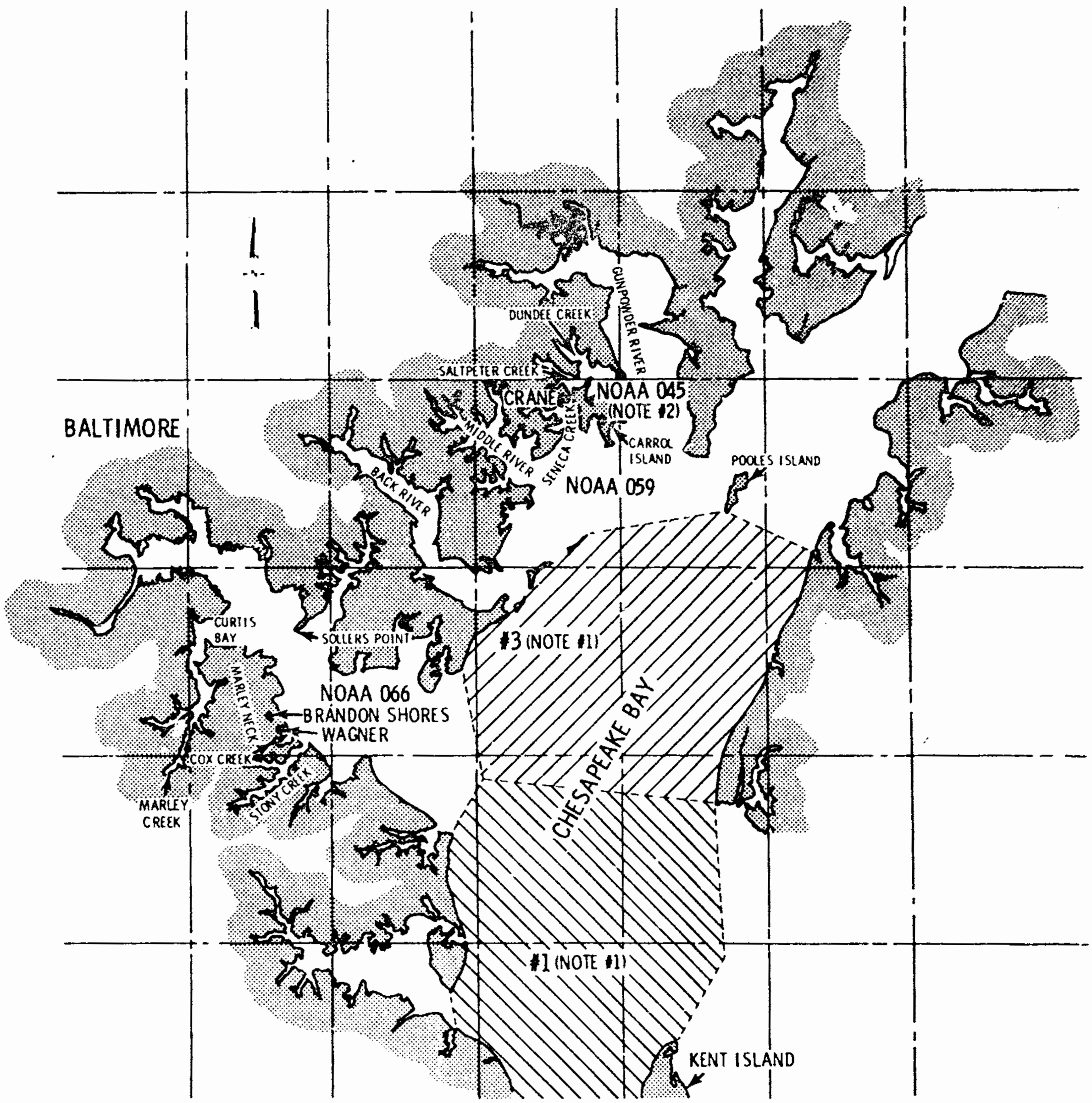


Figure 3.11. Proximity of NOAA and State Commercial and Recreational Fishing Areas to Brandon Shores, Crane and Wagner Generating Stations

3.6.2 Aesthetic Values

The Brandon Shores and Crane sites each contain waterfront property. The Brandon Shores site has frontage on the Patapsco River while the Crane site has frontage on Seneca and Saltpeter Creeks. The land adjacent to the generating stations is flat, providing little screening of site facilities by the terrain. Thus, site facilities can be seen for some distance from the water. The view of facilities from land at each

TABLE 3.19. Threatened or Endangered Species Found Within 5 and 50 Miles of Brandon Shores *and Crane*

Species (on both Federal and State lists)	Location
Bald Eagle (*Haliaeetus leucocephalus*)	*Nest n. of Crane Station within 5-mile (8 km) radius of station; also near Annapolis.*
Delmarva Fox Squirrel (*Sciurus niger cenereus)*	Along eastern shore, Chesapeake Bay within 50 miles (80 km) of stations.
Peregrine Falcon (*Falco peregrinus anatum*)[a]	Presently being reintroduced within 5 miles of BG&E stations.
Maryland Darter (*Etheostoma sellare*)	Deer Creek, Harford County, MD
Red-Cockaded Woodpecker (*Dendrocopus borealis)*[a]	Within 50 miles of BG&E stations
Species (on State Lists Only)	**Location**
Bog Turtle (Clemmys muhlenbergi)	Within 50 miles (80 km) of BG&E) stations
Eastern Tiger Salamander (*Ambystoma tigrinum tigrinum*	Within 50 miles of BG&E stations
Eastern Narrow Mouthed Toad (*Gastrophryne carolinesis*)	Within 50 miles of BG&E stations

(a) Letter from D. Valentine, ERA, to R. A. Craig, PNL, September 28, 1983.

site is screened to varying degrees by trees and other natural vegetation. This screen is more complete during the Spring, Summer, and early Fall. The facilities at Brandon Shores become more visible during winter months to both nearby residential areas and highway traffic. *Crane is sufficiently distant from main highways that loss of foliage does not increase the view from the road.*

Facilities at Brandon Shores lie within 2 miles (3 km) of Highway 695 and can be seen from the Francis Scott Key Bridge. There are a number of recreational sites of local importance that have views of the Brandon Shores facility, i.e., Fort Armistead Park (two miles away) and Fort Smallwood Park (two and one-half miles away). The view from these parks also includes many other industrial facilities.

3.7 AMBIENT NOISE LEVELS

The two generating stations have different noise environments. They differ by location, existing noise levels, sources of noise and their present level of compliance with noise standards. Noise limits for areas surrounding the sites are determined by land use zoning.[a]

3.7.1 Noise Level Criteria

The Maryland Department of Health and Mental Hygiene has jurisdiction over and is responsible for the enforcement of noise regulations. Existing State regulations for maximum allowable noise levels are based upon land use categories (Table 3.20). These maximum limits are promulgated to ensure that Environmental Noise Standards (ENS) are not exceeded. The ENS for industrial zones are

(a) Letter from M. Halka, Maryland Dept. of Site Planning, to T. M. Poston, PNL, October 30, 1980.

TABLE 3.20. Maximum Allowable Noise Levels (dBA) for Receiving Land Use Categories,[a] State of Maryland, Department of Health and Mental Hygiene

	Industrial	Commercial	Residential
Non-Construction			
Day	75	67	60
Night	75	62	50
Environmental Noise Standards	70 L_{eq} [b]	64 L_{eq} [c]	55 L_{eq}
Construction			
Day	90	90	90

(a) Measured at the fence line or zone boundary.
(b) Equivalent sound level.
(c) Day-night sound level.

expressed as the "equivalent sound level (L_{eq} 24)," an integrated average level of constant sound that represents the actual time-varying sound observed during a specified time period. The day-night average sound level (L_{dn}) is used for commercial and residential zones. It incorporates a 10 decibel penalty into the 24-hour average for sound generated during a 9-hour nighttime period.

Special provisions are made for construction sites. Noise levels must not exceed 90 dBA during day-time hours or the zones' nighttime maximum (Table 3.20). Prominent discrete tones or periodic noises must not exceed a level which is 5 dBA less than the applicable standard. Railroads are exempt from these regulations.

3.7.2 Brandon Shores Noise Levels

Because the Brandon Shores site is contiguous with BG&E's Wagner Generating Station, the State of Maryland views them as a single noise source, and has determined that the evaluation of compliance with State noise standards should include both facilities (Roig 1980). Both stations are zoned W-3 (heavy industrial) but are bordered by residential and commercial districts. The community of Foreman's Corner is located about 5000 feet (1520 m) to the northwest of the Brandon Shores site (Figure 3.10), and the nearest residence is located about 2000 feet (610 m) away on Ft. Smallwood Road. The closest community to the Wagner Generating Station, Orchard Beach, is located to the south across Cox Creek. Measurements of ambient noise levels (Leq) at Stony Beach (northeast of Orchard Beach) ranged from 54 to 60 dBA in a recent survey (Goodfriend 1980). The Wagner Generating Station contributed to these noise levels along with aircraft and the Bethlehem Steel plant located across the Patapsco River. Measurements at Foreman's Corner (intersection of Ft. Smallwood Road with Marley Neck Road) ranged from 45 dBA at night to 57 dBA during the afternoon (Goodfriend 1980).

3.7.3 Crane Noise Levels

The Crane site is zoned low-density, rural residential. The nearest community, Seneca Park, is located west of the plant. The nearest residence is about 1500 feet (460 m) away. Carroll Island, located southeast of the plant, is a designated wildlife refuge. The primary source of ambient noise in the area is the Crane Generating Station. Ambient noise levels under oil-fired operation (Section 4.6.2) were estimated at 49 and 52 dBA at the generating station boundary (Figure 3.9). These estimates were made using methods of the Edison Electric Institute (EEI 1978) and without accounting for terrain or barrier effects. Consequently, they should be regarded as conservative estimates of ambient sound levels, and may be unrealistically high.

3.8 DEMOGRAPHIC, ECONOMIC, AND SOCIAL CHARACTERISTICS

Baltimore Gas and Electric's Brandon Shores *and Crane* Generating Stations are located within BG&E's central Maryland service territory. The Brandon Shores station is located on the eastern shoreline of Anne Arundel County; *the Crane station is located on the eastern shoreline of Baltimore County.* Baltimore City is immediately adjacent to and between both counties (Figure 3.12).

The stations are important contributors to BG&E's overall ability to generate electricity to meet service-area customer needs. The demographic, economic, and social characteristics of BG&E's relatively compact service area are discussed below. These characteristics are important because population and economic activity create electrical demand. The conversion of the stations from oil to alternate fuels may result in localized social and economic impacts during the time construction is underway and during subsequent plant operation.

3.8.1 Demography

Baltimore Gas and Electric provides electrical service to an area of approximately 2300 square miles (5960 km^2) in central Maryland. Although BG&E serves portions of Calvert, Prince Georges, and Montgomery Counties, approximately 90 percent of the utility's customers and direct sales come from within the Baltimore metropolitan area. This metropolitan area is composed of the five coun-

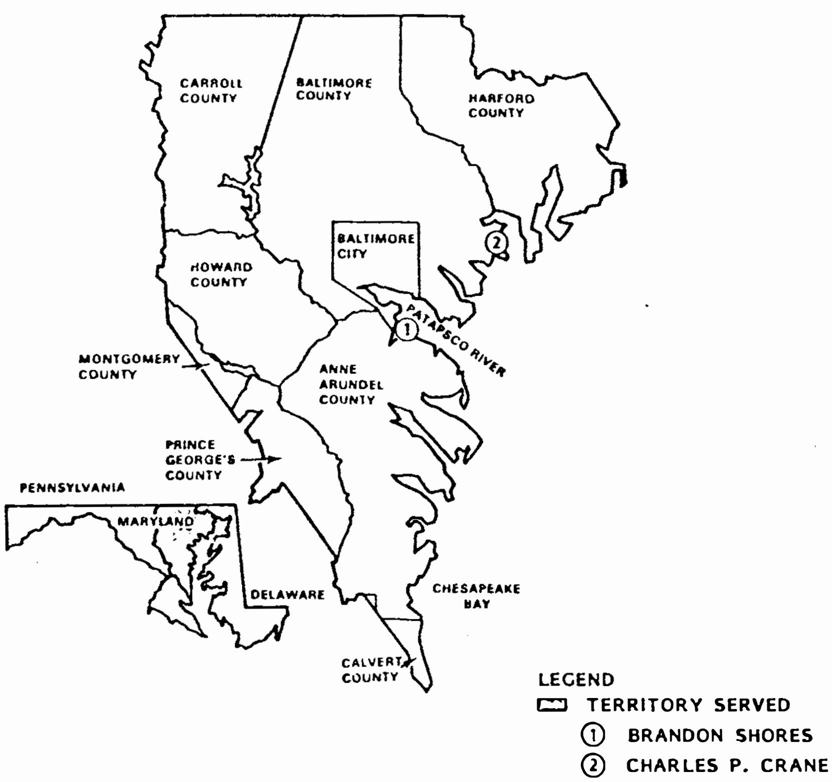


Figure 3.12. Baltimore Gas and Electric Service Area

ties of Anne Arundel, Baltimore, Carroll, Harford, and Howard, and the City of Baltimore. The 79 square mile (205 km^2) City of Baltimore, which ranks among the Nation's ten most populous cities, is an independent political subdivision of Maryland. The full metropolitan area is among the nation's twenty most populated. Population growth for the Baltimore Metropolitan Area was about 3.4 percent between 1970 and 1977, while statewide population growth for the same period was about 5.2 percent.

The population growth rate of the Baltimore metropolitan area can be compared with that for the state for each of the years from 1950 through 1980 (Table 3.21). Throughout this period, statewide growth rates have exceeded those of the Baltimore metropolitan area. Within the metropolitan area, significant population shifts have been underway since 1950. Between 1950 and 1980, the population has grown from 1,457,000 to an estimated 2,270,000 (an increase of 56 percent) while Baltimore City population has declined from 950,000 to an estimated 828,000 (a decline of 13 percent) (MDECD 1980a,b,c).

Population projections for 1990 by the Maryland Department of Economic and Community Development (MDECD) indicate that the Baltimore City population will stabilize at about the current level, while the population of the total Baltimore metropolitan area will increase to 2,569,000 (MDECD 1980a,b,c). Allowing for births and deaths, these projections suggest that the net migration away from Baltimore City will cease. For the total metropolitian area, total net migration will be close to zero. Thus, for the foreseeable future, population growth of the Baltimore area will be within the range considered reasonable for orderly development. The projected population increase should not put undue stress on the region as a whole, although the shifts in population may create some housing, transportation, and government service problems at the local level.

3.8.2 Economics

The central Maryland area served by BG&E has a highly diversified economic base covering a broad spectrum of manufacturing and non-manufacturing industries. In 1978, the Baltimore metropolitan area had a civilian labor force estimated at 1,034,000. The annual average unemployment for the same year was 64,000, or 6.8 percent of the labor force. This is 1.2 percent above that for the State as a whole for 1978, and 0.8 percent above the national average. In January 1980, the MDECD estimated that the labor potential of the Baltimore metropolitan area was over 260,000 persons, including the unemployed, underemployed, high school graduates, and women (who are not now in the labor force, but who would enter if jobs were available) (MDECD 1980a,b,c).

TABLE 3.21. Population Growth

Year	Population (in thousands)			Population Change, percentage		
	City	Baltimore Metro. Area	Baltimore Maryland	Baltimore City	Baltimore Metro. Area	Baltimore Maryland
1950	950	1,457	2,343			
				-1.2	23.8	32.4
1960	939	1,804	3,101			
				-3.5	14.8	26.5
1970	906	2,071	3,924			
				-6.2	3.4	5.2
1975	850	2,142	4,130			
				-2.5	6.0	5.9
1980 (proj.)	829	2,270	4,373			
				-0.1	13.2	14.3
1990 (proj.)	828	2,569	4,998			

Source: MDECD 1980b.

Employment statistics for the third quarter of 1978 indicate that the government sector (Federal, State and local) provides about 26 percent of the region's jobs, up from 21 percent in 1970 (DESS 1970; OPPE 1978). Employment provided by the private sector has declined from 79 percent to 74 percent during the same period. Within the private sector, some important shifts have taken place as well. Between the third quarter of 1970 and the third quarter of 1978, manufacturing's share of private sector jobs dropped from 34 percent to 24 percent, while jobs in the service industries increased from 13 percent to 24 percent of the total private sector employment (Table 3.22).

In recent years, the Baltimore metropolitan region has witnessed a reduction in its manufacturing base due in part to the decline in employment in the primary metals industry. Although significant growth has taken place within both the public and private service sectors, the region still has a large reserve of technically skilled labor.

The Baltimore metropolitan area provides broad opportunity for undergraduate, graduate, vocational, technical, and adult education. Existing programs produce large numbers of highly skilled workers. In addition, the Division of Vocational and Technical Education of the Maryland State Department of Education, in cooperation with the Maryland Division of Business and Industrial Development, offers a manpower training program to meet the needs of new and expanding industry. If the need is shown, training can be provided promptly with little or no expense to the employer. Thus, the region is well prepared to meet the training needs of industry throughout the 1980s.

On a region-wide basis, houses and apartment units are available for rent or sale. Within a short distance of both of the generating stations, housing and apartment vacancies exist. It is expected that, with normal economic expansion, housing will continue to be available in the communities near each of the generating stations.

TABLE 3.22. Private Sector Employment—Baltimore Metropolitan Area

Sector	1970 — 3rd Quarter Employment	Percentage	1978 — 3rd Quarter Employment	Percentage
Manufacturing	195,379	34	166,848	24
Contract Construction	45,657	6	52,466	8
Transportation/ Communications and Utilities	49,526	9	50,575	7
Wholesale/Retail Trade	170,340	29	198,816	29
Financial Insurance and Real Estate	43,166	7	53,556	8
Service and Others	77,608	13	169,425	24
	581,676	100	691,686	100

4.0 ENVIRONMENTAL CONSEQUENCES OF FUEL CONVERSION

The proposed Federal action, finalization of prohibition orders for Brandon Shores Units 1 and 2, would prohibit the use of petroleum at these units. Finalization of the orders would lead to the conversion of the Brandon Shores units to an alternate fuel, most likely coal. The conversion to coal, and the use of coal by these units, would result in environmental impacts. This section examines those impacts.

Because BG&E hopes to avoid delays in the start-up process, they have anticipated the finalization of the orders and have performed many of the construction measures that are necessary to convert the units to coal-fired operation. Accordingly, those impacts associated with the construction measures have already occurred; however, they are included in this section because 1) they are part of the effect of the Federal action, and 2) this EIS provides environmental documentation for permits issued to State and local agencies.

In addition, BG&E is voluntarily converting Units 1 and 2 at the C.P. Crane Generating Station to coal (and RDF, as available, at Unit 1). This conversion is not part of the Federal action. However, because both Brandon Shores and Crane facilities are owned by BG&E and because they are in close proximity, the effects resulting from the conversion of the Crane Units are described here to support State and local decision-making procedures (in accordance with 40 CFR 1506.20). In order to emphasize the separation of the effects of the voluntary conversion from the effects of the Federal action, the effects related only to the conversion of the Crane units have been printed in smaller type.

4.1 AIR QUALITY

The conversion of the four units would result in air-quality impacts on both local and long-range scales. "Local" refers to distances of 10 or 20 km from the stations. In this analysis, the term "long range" refers to distances extending beyond the vicinity of the stations to wherever winds carry the plumes. Appendix H describes the models and assumptions used in the air quality analyses. Local increases in atmospheric pollutants would be caused by both particulate fugitive dust and stack emissions, particularly in regard to such air pollutants as total suspended particulates (TSP), sulfur dioxide (SO_2), carbon monoxide (CO), hydrocarbons (HC), and nitrogen dioxide (NO_2). The potential for long-range effects from these emissions relates to the formation of acid rain and secondary pollutants (e.g., ozone) (see Section 2.5).

4.1.1 Characteristics of the Combustion Products from the Four Generating Stations

The stack emissions of Brandon Shores Units 1 and 2 *and Crane Units 1 and 2* have been identified (Tables 4.1 and 4.2). These tables contain estimates of the gaseous and solid combustion products that would be emitted from stacks during the burning of various types of fuels for a range of load factors. The fuel scenarios (Table 2.1) demarcate the fuels or combinations of fuels that would produce designated sulfur dioxide (SO_2) and total suspended particulate (TSP) emissions levels. The following bases were used for estimating the emission characteristics given in Tables 4.1 and 4.2:

- The stack gas from all boilers contains 10% water by volume.
- The SO_2 and TSP emissions are established from State of Maryland regulations and Federal NSPS limits.
- The emissions of Pb, Cl, and F are dependent upon particulate control at the stacks. The percent particulate removal for each stack is 99 percent for Brandon Shores 1 and 2 *and 85 percent for Crane 1 and 2.*

TABLE 4.1. Stack Emission Characteristics for Brandon Shores Units 1 and 2

	Scenarios 1 & 2	Scenarios 3 & 5	Scenario 4
Emissions, g/s	Units 1 and 2(a)	Units 1 and 2(a)	Units 1 and 2(a)
Particulates at 100% load(b)	35.0	35.0	35.0
SO_2(b) at 100% load	600	900	600
75% load	NV(c)	677	NV
50% load	NV	450	NV
NO_2	224.5	526	526
CO	23.9	30	30
Hydrocarbons	4.5	9.0	9.0
Pb (particulate)(d)	3×10^{-4}	0.01	0.01
Chloride(d)	—(e)	3×10^{-4}	3×10^{-4}
Fluoride(d)	—	0.01	0.01
^{222}Rn, Ci/yr(f)	—	0.87	0.87
Stack			
Actual Height, m	213.4	213.4	213.4
GEP Height, m	187.0	187.0	187.0
Diameter, m	6.71	6.71	6.71
Exit Velocity, m/s(g)			
100% load	30.2	23.7	20.8
75% load	NV	18.3	NV
50% load	NV	13.7	NV
Exit Temperature, °K(g)			
100% load	578	403	353
75% load	NV	394	NV
50% load	NV	364	NV
Heat Input at 100% load			
10^6 Btu/hour	5940	5960	5960

(a) Emission values are same for both units; values given are for single unit.
(b) Based on fuel scenario emissions.
(c) No computation for these entries; NV = No value used.
(d) Based on current particulate control at stack.
(e) "—" taken to be zero.
(f) Eastern coal (Dvorak et al. 1978)
(g) Source: Data supplied by BG&E in letter to ERA, February 1981.

- The stack gas is taken to be at one atmosphere pressure. The standard temperature for calculations is 25°C (298°K).
- Emissions of ^{222}Rn are for eastern coal and are taken to be insignificant for fuels other than coal.

The actual emissions of Pb, Cl, and F after conversion to an alternate fuel may be considerably smaller than shown in Table 4.2 for Crane. The difference would depend on the improvement in particulate control that would be required to meet the removal efficiencies for total particulate emissions shown in these tables. A typical, state-of-the-art, particulate removal efficiency is 99.5 percent.

4.1.2 Fugitive-Dust Emissions

Fugitive emissions arise from construction and routine operations. Although potential impacts are difficult to define because of large variability in emissions rates, impacts were characterized for these two sets of activities.

TABLE 4.2. *Stack Emission Characteristics for the BG&E Crane Units 1 and 2*

	Scenario 1		Scenarios 2, 3, 4, 5	
Emissions, g/s	*Unit 1*	*Unit 2*	*Unit 1*	*Unit 2*
Particulates at 100% load(a)	7.9	7.9	12.0	12.0
SO_2(a) at 100% load	294.5	288.8	864.3	854.0
75% load	220.9	216.8	664.5	363.9
50% load	147.3	144.5	429.7	424.6
NO_2	166.7	163.6	539.7	533.3
CO	7.8	7.7	9.8	9.7
Hydrocarbons	1.5	1.4	2.9	2.9
Pb (particulate)(c)	0.03	0.03	0.12	0.03
Chloride(c)	—(d)	—	3×10^{-3}	3×10^{-3}
Fluoride(c)	—	—	0.11	0.11
^{222}Rn Ci/yr(e)	—	—	0.27	0.27
Stack				
Height, m	108	108	108	108
Diameter, m	3.3	3.3	3.3	3.3
Exit Velocity, m/s(f)				
100% load	35.0	35.0	35.0	35.0
75% load	24.4	24.4	24.4	24.4
50% load	16.8	16.8	16.8	16.8
Exit Temperature, °K(f)				
100% load	422	422	422	422
75% load	394	394	394	394
50% load	394	394	394	394
Heat Input at 100% load 10^6 Btu/hour	1946	1910	1947	1924

(a) Based on fuel scenario emissions.

(b) No computation for these entries; NV = no values used.

(c) Based on current particulate control at stack.

(d) "—" taken to be zero.

(e) Eastern coal (Dvorak et al. 1978).

(f) Data supplied by BG&E in letter to ERA. February 1981.

The conversion of the Brandon Shores and Crane units from oil to coal involves some construction activity. This activity would produce uncontrolled releases of dust, primarily from vehicular traffic and heavy equipment operations.

Any impacts caused by releases of dust from construction activities would be short-term in nature (during the construction period only). NAAQS and PSD regulations do not apply to these incremental increases in TSP resulting from construction activity. Reasonable dust-control practices such as wetting surfaces would be required at the construction site to minimize local impacts.

Atmospheric dust entrainment occurs during routine operation of coal-fired generating stations. These releases occur as a result of coal, limestone, and residue (e.g., fly ash) handling, and wind erosion of storage piles of these materials. Releases from these sources are influenced by the amount of material handled, type of transportation used, the quantity and location of the stored material, and weather conditions.

Local TSP concentrations would be affected by the suspension of particulate matter from the operation of coal- and ash-handling and -storage equipment. In areas that are in attainment for TSP, increases cannot exceed the NAAQS, nor consume more than the available PSD increment. In a non-attainment area for TSP, increases must be less than the level of modeled significance (*de minimis* level) as defined by EPA. If this is not the case, additional steps would be required to achieve compliance. These involve implementing the lowest achieveable emission rate (LAER) and, if necessary, obtaining emission offsets.

Operational fugitive emissions from Brandon Shores *and Crane,* however, would consume PSD increment assuming a baseline has been triggered. Detailed modeling has been made of the fugitive dust emissions from conversions at Brandon Shores (Environplan 1980a, Environplan 1981) *and Crane (Environplan 1980b).* These show that the conversions as proposed by BG&E would meet the applicable TSP air-quality standards and regulations both in the attainment and nearby non-attainment areas. The BG&E proposals are similar to Scenario 3.

A complete modeling of fugitive-dust emissions was deemed inappropriate for this analysis given the uncertainty in the model inputs and the completeness of the Environplan reports. Instead, a fugitive-dust screening model that predicts worst-case concentrations was used to provide a basis for comparison of the relative potentials for fugitive-dust impacts at the two sites.

The source terms in the screening model are generic and represent a minimum level of controls on emissions. Emission factors and modeling assumptions for the screening model are given in Appendix H. Site-specific source terms were used in the Environplan reports. These detailed fugitive-dust computations by Environplan provide estimates of the magnitude of impacts in the region and consider several levels of emission control.

Table 4.3 lists the estimated 24-hour average, relative incremental TSP concentrations for all units and scenarios for which conversions are proposed. Since the fenceline effects are quite sensitive to the proximity to the station boundaries, both of two coal-pile sites identified for Brandon Shores were included in the screening analysis. Values are given for construction activity, and for routine plant operations, which include coal handling and storage, limestone handling and storage, and fly-ash handling. More detail is given in Appendix H.

The screening-model results for 24-hour incremental TSP increases provide a basis for comparison of the impacts among the scenarios (Table 4.3). A number of air-quality problems are projected if

TABLE 4.3. Screening Model Estimates of Twenty-Four Hour Average, Incremental TSP Concentrations Resulting from Fugitive Dust Emissions[a]

	Scenario			
	2	3	4	5
Brandon Shores[b]				
Routine Operation (Northwest Site)	0	124	129	129
Routine Operation (Southwest Site)	0	68	68	68
Construction	0	29	51	29
Crane				
Routine Operation	35	35	35	35
Construction	8	8	8	8

(a) Relative values for comparitive purposes only.
(b) Two coal-storage sites (northwest and southwest of the boiler buildings) and coal-handling systems are analyzed for Brandon Shores.

conventional coal-handling and storage methods were used. *Although the primary TSP standard would not be exceeded for any scenario by the addition of fugitive dust from Crane,* fugitive-dust emissions from Brandon Shores might violate NAAQS for all coal scenarios, especially if the northwest coal-storage site is used. The computed fenceline concentrations at *Crane and* Brandon Shores were large enough that TSP increases might occur on the TSP non-attainment area.

The conclusion that conventional coal-handling and -storage methods could lead to air-quality impacts that exceed standards was also made in recent detailed modeling efforts conducted for coal conversion at Brandon Shores *and Crane* (Environplan 1980a, *and Environplan 1980b*). This analysis was based on worst case assumption. Although these used different emissions characterization, the conclusions were the same; an additional level of coal-handling and -storage dust control would be required.

The evaluation of particulate fugitive emissions prepared for BG&E (Environplan 1980a, *1980b*, and 1981) for Brandon Shores *and Crane* based on improved coal-handling and -storage methods demonstrates complete compliance both in the attainment and non-attainment areas for TSP. One report (Environplan 1980a), based on worst-case assumption, showed possible violations even with improved fugitive-dust controls. The revised analysis (Environplan 1981) clearly shows all stations in compliance. The major difference is the allowance for variation of fugitive-dust emission rates with wind speed in the second analysis. The first analysis found maximum TSP concentrations under calm conditions—an unrealistic situation.

The fugitive-dust impact values reported for Crane (Environplan 1980b), although in compliance, are considered to be overestimates. They are based on the type of emission term formulation in the earlier Brandon Shores report that resulted in fugitive-dust maximums under calm conditions.

The Environplan TSP values for Brandon Shores *and Crane* are summarized in Table 4.4. Both PSD increments and the total TSP concentrations are given. *Two levels of control strategies are shown for Crane, as well as computations with and without calm conditions.* These show that particulate emissions from the coal-handling system at the Brandon Shores *and Crane* Generating Stations would comply with 24-hour average and annual average NAAQS and Class II PSD increments for TSP. In addition, no significant impact is projected to occur at any time in the designated secondary non-attainment area near these plants. No predicted concentration exceeds 5 $\mu g/m^3$ along the nearest boundaries.

4.1.3 Stack Emissions and Air Quality Impacts

The changes in the stack emissions caused by conversion may result in potential changes in air quality on both a local and regional level. Degradation of air quality may occur, reflecting increases in stack emissions in the various fuel-conversion scenarios relative to the the no-action scenario (Scenario 1). This section considers local maximum atmospheric concentrations, PSD increment consumption, local deposition patterns, and long-range impacts.

Local Air Quality

The magnitude of increase in the concentration of air pollutants at ground level in the vicinity of a generating station depends on the emission rate of a pollutant, its release characteristics, and prevailing meteorological conditions. NAAQS and PSD increments are promulgated to protect local air quality. The former are given in Table 3.4 and the latter in Table 4.5. All four units are in a Class II area for PSD consumption.

The emission values in Tables 4.1 and 5.2 were used in the modeling to assess the impact of the pollutants on ambient air quality.

TABLE 4.4. Summary of Fugitive Particulate TSP Increases from Conversion to Coal of Brandon Shores Units 1 and 2 *and Crane Units 1 and 2*

	Attainment Area for TSP			Non-Attainment Area for TSP		
	Maximum Annual	Second High 24-Hour		Maximum Annual	Highest 24-Hour	Second High 24-Hour
Brandon Shores[a]						
Increment	0.4[b]	2.0		0.05	2.0	1.2
Total[c]	53.8	116.0		-[g]	-	-
Crane[d] Increment	*30.7*	*472.2*		*0.15*	*4.9*	-
Crane[e]						
Increment	*5.7*	*39.5*		-	-	-
Total[c]	*49.1*	*144.5*		-	-	-
Crane[f] Increment	-	*20.1*	-	-	-	

(a) Environplan 1981. Based on five years of meteorological data (1964-1968).
(b) $\mu g/m^3$; computed with ISC model.
(c) Background plus increment.
(d) Environplan 1980b. Based on five years of meteorological data (1964-1968) using the current fugitive dust control strategy.
(e) Enviroplan 1980b. Based on five years of meteorological data (1964-1968) using additional fugitive dust control strategy.
(f) Recomputation of (e) with calm conditions eliminated for all dates with second-high values exceeding NAAQS based on assumptions that calm conditions given unrealistically high concentrations.
(g) "-" = No value given.

TABLE 4.5. Prevention of Significant Deterioration Increments for Class II Areas

	Concentration,[a] g/m^3
SO_2	
Annual	20
24-hour	91
3-hour	512
Particulate matter	
Annual	19
24-hour	37

(a) Allowable increase over baseline.

The analyses in Appendix H describe the method used in estimating potential air-quality impact and PSD increment consumption. Air-quality estimates are based on actual stack heights (Brandon Shores). PSD increments are based on current PSD-modeling guidelines and practices.

The changes in air pollutant concentrations were modeled for each of the fuel-conversion scenarios. The Environmental Protection Agency's CRSTER model was used to compute potential maximum short-term and average annual air-quality changes. Details of these computations are given in Appendix H. The tabular results presented in this section are presented in more detail in Appendix H.

Maximum pollutant concentrations and PSD increment consumption frcm stack emissions were computed with load factors of 50%, 75%, and 100%. The load factors resulting in the greatest impacts were then adopted for more detailed computations of maximum impacts.

Maximum ground-level SO_2 and TSP concentrations for each of the scenarios are given in Tables 4.6 to 4.9. These are the sums of the maximum modeled conversion increment for five meteorological years and the highest monitored values (1978 data - see Section 3.2.1.3 and Appendix H) in the immediate vicinity of the stations.

Air Quality

Current monitoring data contain no contribution from stack emissions from the Brandon Shores station. Increases in the concentration of air quality parameters are estimated by adding the calculated increase in a parameter to its maximum monitored value. No allowance is made for projecting any changes in ambient levels at the time of conversion. With the exception of adjacent units at Brandon Sho-es *and Crane*, other currently operating sources in the area are assumed to be contained in the monitored values, and are not modeled separately.

The exact coincidence in time and space of the highest computed and monitored values is quite unlikely. Hence, the use of maximum monitored values provides a degree of conservatism in the predicted maximum values.

Tables 4.6 and 4.7 summarize the maximum predicted SO_2 and TSP concentrations for Brandon Shores. All maximum TSP values for Brandon Shores, which are the sum of the ambient concentration plus the contribution for Brandon Shores, exceed the NAAQS, reflecting the proximity of the station to a non-attainment area for TSP. The increases in TSP are less than the levels-of-modeled-significance as defined by EPA, and as such are acceptable. All cases meet the applicable NAAQS.

For Crane, the maximum SO_2 and TSP concentrations in Tables 4.8 and 4.9 were obtained by adding the calculated concentrations to the maximum monitored values. All scenarios for TSP meet the applicable NAAQS.

TABLE 4.6. Predicted Maximum SO_2 Concentrations for Brandon Shores[(a)]

Scenarios	Highest Annual	Highest 24-Hour	Second High 24-Hour	Highest 3-Hour	Second High 3-Hour
1,2	29(64)[(b)]	164(64)	153(64,66)	538(68)	496(64)
3,5	30(64)	218(64)	200(64)	1018(64)	874(64)
4	30(64)	207(64)	186(68)	930(68)	731(64)
M[(c)]	28	139	(d)	384	(d)
Std[(e)]	80	(d)	365	(d)	1300

(a) Single-station values computed using EPA CRSTER Model with rural option for 5 years of meteorological data (1964-1968) and 100% load factor emission values. Values in g/m^3 followed by the year of the estimate in parentheses. Standards apply only to second high 24-hour and 3-hour values.

(b) Increase less than EPA level of significance.

(c) Maximum monitored values for 1978 used for maximum Brandon Shores background; this is indicated in the highest and second high predicted concentrations.

(d) No value applicable.

(e) National Ambient Air Quality Standards.

TABLE 4.7. Predicted Maximum TSP Concentrations for Brandon Shores[a] (Including Ambient)

Scenarios	Highest Annual	Highest 24-Hour	Second High 24-Hour
1,2	69 (increment is less than *de minimus)* [b]	217 (increment is less than *de minimus)* [c]	216 (increment is less than *de minimus)* [c]
3,5,	69 (increment is less than *de minimus)* [b]	218 (increment is less than *de minimus)* [c]	217 (increment is less than *de minimus)* [c]
4	69 (increment is less than *de minimus)* [b]	219 (increment is less than *de minimus)* [c]	218 (increment is less than *de minimus)* [c]
Monitored[d]	69 (increment is less than *de minimus)* [b]	215 (increment is less than *de minimus)* [c]	(e)
Std[f]	60	(e)	150
De minimis[g]	1	5	5

(a) Single-station values computed using EPA CRSTER Model with rural option for 5 years of meteorological data (1964-1968) and 100% load factor emission values. Values are $\mu g/m^3$ followed by the first year the value occurred. Violations are underlined.

(b) Monitored data are not in attainment for standards; computed concentration is less than 1 $\mu g/m^3$ annual average *de minimis* value for TSP.

(c) Increment is less than the 5 $\mu g/m^3$ 24-hour *de minimis* for TSP.

(d) Maximum monitored values for 1978 are used for Brandon Shores background estimates. The predicted values are the sum of monitored values and computed concentration changes.

(e) No value applicable.

(f) National Ambient Air Quality Standards.

(g) De *minimis* values for TSP in adjacent non-attainment areas in $\mu g/m^3$.

TABLE 4.8 Predicted Maximum SO_2 Concentrations for Crane[a]

Scenario	*Highest Annual*	*Highest 24-Hour*	*Second High 24-Hour*	*Highest 3-Hour*	*Second High 3-Hour*
1	22(68)	182(68)	161(66)	683(68)	456(68)
2,3,4,5	27(68)*	239(68)*	237(66)*	1547(68)	883(68)
Monitored[c]	[illegible]	126	(d)	235	(d)
Std[e]	80	(d)	365	(d)	1300

(a) Single-station values computed using EPA CRSTER Model with rural option for 5 years of meteorological data (1964-1968). Values are in $\mu g/m^3$ followed by the year of the estimate in parenthesis. All values are for 100% load factors except those marked with an asterisk (*), which are for 75%.

(b) Based on runs for both 100% and 75% load factors.

(c) Maximum monitored values for 1978 used for maximum Crane background. The highest and second high predicted values is the sum of this value and the predicted concentration changes.

(d) No value applicable.

(e) National Ambient Air Quality Standards.

The combined air-quality impacts of the conversions of the four units were also computed. Because there is no appreciable overlap between Crane and Brandon Shores plumes, the combined maxima are identical with the individual station maxima. These combined values are based on 10 km grid spacings and provide conservative estimates of the maximum values (Appendix H) from conversion of single stations. Only annual average combined maximum impacts were greater than those computed for the individual stations alone.

TABLE 4.9. Predicted Maximum TSP Concentrations for Crane[a]

Scenarios	Highest Annual	Highest 24-Hour	Second High 24-Hour
1	57[b]	148[c]	147[c]
2,3,4,5	57[b]	148[c]	147[c]
M[d]	57	146	(e)
Std[f]	60	(e)	150
DM[g]	1	5	5

(a) Single-station values computed using EPA CRSTER Model with rural option for 5 years of meteorological data (1964-1968). Values are in $\mu g/m^3$ followed by the first year that the value occurred. All are based on 100% load factor.

(b) Monitored data are not in attainment for standards; computed concentration is less than 1 $\mu g/m^3$ annual average de minimis value for TSP.

(c) Increment is less than the 5 $\mu g/m^3$ 24-hour de minimis value for TSP.

(d) Maximum monitored values for 1978 are used for Crane background estimates. The predicted values are the sum of a monitored value and the computed concentration changes.

(e) No value applicable.

(f) National Ambient Air Quality Standards. Standards apply to second-high 24-hour values.

(g) De minimis values for TSP for non-attainment areas in $\mu g/m^3$.

Nitrogen dioxide, a secondary pollutant, is formed primarily by the oxidation of NO. A conservative estimate of ground-level NO_2 can be made if one assumes that all NO_x emissions are in the form of NO_2. Based on this assumption, an increase in the annual NO_2 value would not exceed 10 $\mu g/m^3$ in the fuel conversion. For comparison, the existing NO_2 concentration in the vicinity of the plants would be approximately half of the ambient air quality standard. Estimates of annual and short-term NO_x concentration changes are given in Appendix H.

PSD Increments

Although the ordered conversion at Brandon Shores would be exempted from a formal PSD new-source review, these conversions may consume PSD increments through degradation of air quality. The extent of potential PSD consumption needs to be considered for the conversions. Several critical PSD aspects are currently under review; the following discussion of PSD is based on current interpretations.

The PSD increments given in Table 4.5 are the maximum possible computed changes in pollutant concentrations over baseline concentrations. In the non-attainment areas for TSP, the pollutant increments must be less than the *de minimis* values. Brandon Shores is considered an existing facility by current rules,[a] although failure to make timely construction progress could conceivably change this status. The original operation of Brandon Shores as permitted by the State of Maryland is generally conceded as part of the baseline. The "no-action" operation (Scenario 1) of Crane is also part of the baseline.

The PSD increment consumptions from the fuel-conversion scenarios were computed as differences between the conversion and baseline plumes using the EPA CRSTER model (Appendix H). Actual stack heights with no building wake effects were used for Crane, while Good Engineering Practice (GEP) stack height (187 m) was used at Brandon Shores. Other emission characteristics are listed in Tables 4.1 and 4.2.

(a) [illegible]om Richard D. Wilson, United States Environmental Protection Agency dated March 5, 1980 to Mr. Robert L. Da[illegible] [illegible]omic Regulatory Administration, Washington, D.C.

The PSD increments were computed as the differences between Scenario 1 and the other conversion scenarios for Crane. For Brandon Shores, coal-emission rates for SO_2 (900 g/s) were used instead of oil-emission rates in Scenario 1. This is based on a determination by EPA.[a] The original emission permit specified fossil fuel, which allows oil or coal firing at the specified exit conditions.

The PSD increments for SO_2 in Table 4.5 were assumed to be all available, reflecting the current situation. Since approval of PSD permit applications, as well as increases in background, result in consumption of increment, there appears to be no way to assure the increments will be available at the time of fuel conversions. For TSP, full increment has been assumed for all areas outside the non-attainment area. In practice, the area adjacent to the TSP non-attainment areas will have less than full increment.

The PSD values indicate the maximum consumption for the several fuel conversion scenarios. Although the approach used in Appendix H is accepted by EPA to define PSD increments, another future modeling effort based on actual fuel conversions and state-of-the-art modeling can be used to revise PSD consumption values by interested parties submitting PSD applications. PSD values in Appendix H are presented to demonstrate the feasibility (or limitation) of the increment consumption for the conversion scenario. Other approaches may give different results.

Table 4.10 lists the applications for PSD permits for facilities other than the Brandon Shores *and Crane* that may apply to the availability of increments in this region. None of these have significant increment consumption in the vicinity of Brandon Shores *and Crane*.

The region over which the PSD increments apply is critical to defining potential consumption. If the baseline has not been triggered for PSD increment, then emissions for the conversions would have been in PSD baseline. Under current PSD rules, the PSD baseline has been triggered for the area encompassing both plants.

The percentage of PSD consumption from individual conversions is given for each site and scenario in Table 4.11. For the computed values at both Brandon Shores *and Crane*, Scenarios 2, 3, 4, and 5 all consume less than 100% of PSD increments for the annual SO_2, 24-hour SO_2, 3-hour SO_2, annual TSP and 24-hour TSP.

As each of the conversions occur, the consumption of PSD increments would be cumulative. The scenarios provide a basis for studying the PSD implication of plume combinations. Maximum percentage of PSD increments accounting for the time and space combinations of plumes in each scenario are given in Table 4.12. These are based on adding the maxima within 1 km^2 areas over the region and using 100% load factors for 1964 meteorological conditions. Although these are conservative in that the overlaps of plumes on areas less than 1 km^2 may not have the exact overlap of maximum values that this analysis assumes, the combinations with other years of meteorological data and load factors may result in higher values. These results provide a basis for the comparison of scenarios. As noted earlier, a modeled potential limitation to conversion may be superceded by more detailed modeling.

(a) Letter from Richard D. Wilson, Environmental Protection Agency, Washington, D.C. dated March 7, 1980 to Mr. Robert Davies, Economic Regulatory Agency, Washington, D.C.

TABLE 4.10. Emission Characteristics and Location of Previous PSD Permit Applications

Source Name	Process Description	Location (UTM)[b]	Height (m)	Diameter (m)	Gas Temp. (°K)	Exit Velocity (m/sec)	Net Emissions Rates[a] SO_2 (gm/sec)	Net Emissions Rates[a] TSP (gm/sec)	Modification(M) or New(N) Construction
Miller Asphalt	Asphalt Plant	N 4367.0 E 333.0	N/A[c]	0.95	355	22.1	—[d]	0.53	N
Sykesville Const. Co.	Asphalt Production	N 4383.0 E 329.0	9.15	0.95	394	19.52	—	0.38	N
Arundel Corp.	Stone Crush. & Size	N 4379.0 E 404.0	N/A	N/A	N/A	N/A	—	1.15	N
Armco Steel	Stainless Steel Melt Shop	N 4351.7 E 364.7	27.44	6.53	366	3.51	—	(-4.78)	M
Campbell Grove Div./ Flintkote Co.	Portable Limestone Crusher	N 4385.2 E 327.3	12.20	0.61	295	20.73	—	0.28	N
Pulaski H'Way Solid Waste Reduction Ctr.	Waste Incineration	N 4351.0 E 365.9	51.82	2.13	533	25.0	7.88	2.35	N
Bethlehem Steel	Coke Oven Battery	N 4340.0 E 373.0	91.46	3.96	533	5.79	(-132.7)	(-22.9)	M
Firestone Plastics	Steam Boiler	N 4379.1 E 407.3	15.85	1.22	437	9.51	(-1.64)	(-0.12)	M
Southwest Baltimore[e] Resource Recovery Facility	Waste Incineration	N 4347.7 E 359.3	95.77	2.13	477	20.27	42.3	3.16	N

(a) Where modifications of existing facilities are involved, the quantities specified are the changes in emission rates before and after the modifications.
(b) Universal Transverse Mercator grid coordinates.
(c) N/A = Not available.
(d) "—" taken to be zero.
(e) Information provided by Mr. A. Bowles, State of Maryland, Department of Health and Mental Hygene, August 28, 1981.

TABLE 4.11. Percentage of Maximum PSD Increment Consumptions for Individual Sites[(a)]

Scenario	Facility	Annual SO_2	24-Hour SO_2	3-Hour SO_2
2	Brandon Shores	0	0	0
	Crane[(b)]	*23(68)*	*75(66)*	*83(68)*
3	Brandon Shores	10(64)	69(64)	97(67)
	Crane[(b)]	*23(68)*	*75(66)*	*83(68)*
4	Brandon Shores	10(64,68)	52(64)	69(64)
	Crane[(b)]	*23(68)*	*75(66)*	*83(68)*
5	Brandon Shores	10(64)	69(64)	97(69)
	Crane[(b)]	*23(68)*	*75(66)*	*83(68)*

(a) Assumptions, models, and concentration values are given in Appendix H. Entries are highest percentage of applicable total PSD increment from the five years (1964-1968) followed by year of computed value in parentheses.
(b) Based on analysis for 1964 only.

TABLE 4.12. Percentage of PSD Consumption Based on Maximum Combination of Plumes for 1964[(a)]

Pollutant	2	3	4	5
Annual SO_2	23	25	23	25
24-Hour SO_2[(b)]	75	75	75	75
3-Hour SO_2[(b)]	83	97	83	97

(a) Highest values added within 1 km^2 areas; based on Table H.20.
(b) Second-high values added within 1 km^2 areas.

Pollutant Deposition Patterns

A deposition model (Vaughan et al. 1975) was used to calculate the deposition patterns for wet and dry particulate matter expected from Scenario 3. The deposition values represent the general pattern for all scenarios. The model is a single-source Gaussian model that uses climatological data (i.e., joint frequency distributions of winds and precipitation). Using a source-depletion model, air-contaminant concentrations at ground level are calculated after allowing for upwind depletion by wet and dry deposition. Wet deposition was calculated using a scavenging efficiency approach, with the efficiency related to rainfall rate. Dry deposition was calculated using the deposition velocity concept. A particle deposition velocity of 0.3 cm/sec was used for both types of calculations. The climate used as input to the model was based on five years of data (1964-1968) for Baltimore, Maryland.

The annual deposition patterns calculated by the model (Figures 4.1 through 4.3) are superpositions of the deposition contours for the individual stations. In the figures, the plant locations are shown as dots.

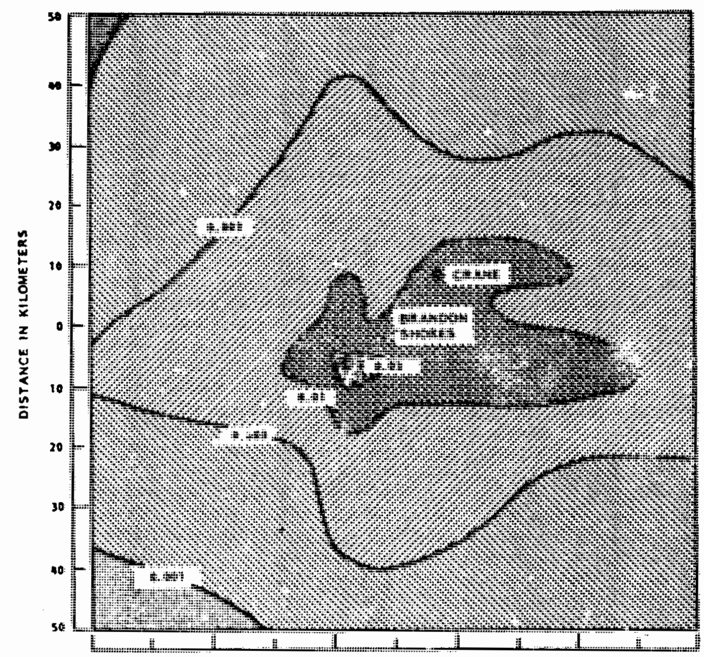


Figure 4.1. Wet-Deposition Pattern of Particulates for Scenario 3 (g/m²/hr)

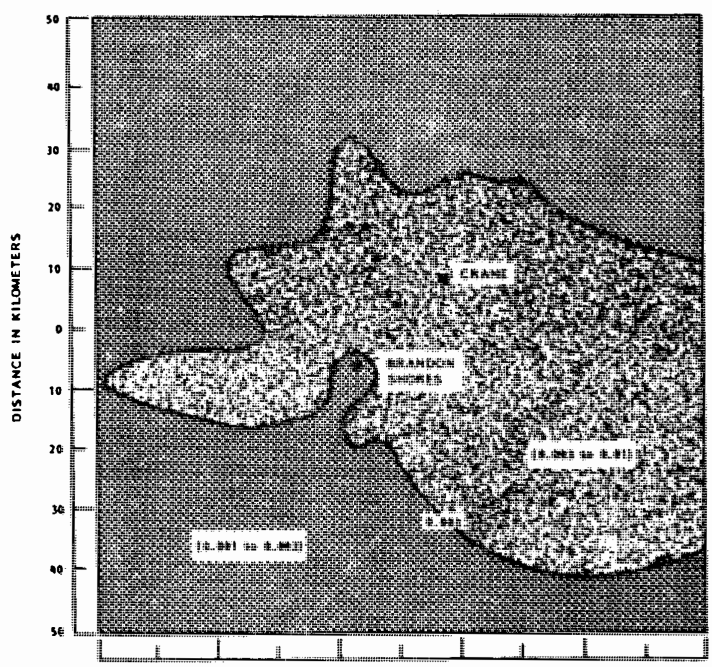


Figure 4.2. Dry-Deposition Pattern of Particulates for Scenario 3 (g/m²/yr)

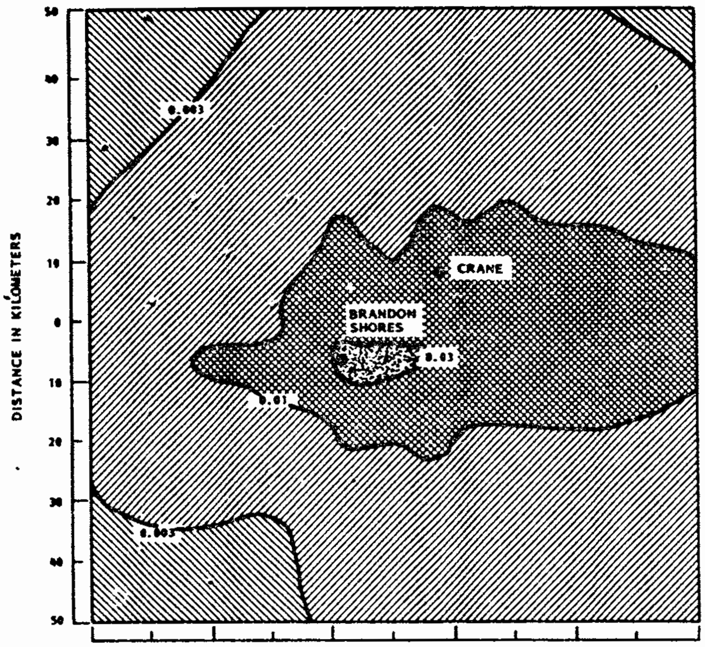


Figure 4.3. Wet Plus Dry Deposition Pattern of Particulates for Scenario 3 (g/m²/yr)

The wet-deposition calculations (Figure 4.1) show that the highest particulate deposition rates (from 0.03 to 0.1 g/m²/yr) occur in the area immediately surrounding the Brandon Shores and Wagner stations and extend 10 to 20 km to the east. To the north, south, and west, the deposition drops off quite rapidly, becoming less than 0.01 g/m²/yr at distances greater than about 10 km from the plants. East of the plants, the decrease with distance is considerably less and the levels remain in the 0.01 to 0.03 g/m²/yr as much as 50 km downwind.

The dry deposition pattern (Figure 4.2) shows a similar tendency toward relatively higher concentrations to the east, although not quite as much as in the previous case. The highest depositions here are from 0.01 to 0.03 g/m²/yr over an area of roughly 15 km². The model predicts dry deposition in the range of 0.003 to 0.01 g/m²/yr over much of the remaining area, falling to 0.003 g/m²/yr at distances of 40 to 50 km north, west, and south of the generating stations.

The total deposition pattern (wet plus dry) (Figure 4.3) again shows greatest deposition toward the east. The highest deposition values are 0.03 to 0.1 g/m²/yr and in the region immediately surrounding the plants and in an area some distance to the east. Similar patterns will occur for the other scenarios, which have proportionately lower deposition rates.

Long-Range Impacts

The conversion of the Brandon Shores *and Crane* units to alternate fuels results in changes in the amount of sulfur and nitrogen oxides introduced into the air masses that pass over this region.

Nitrogen oxides play a role in long-range impacts insofar as NO_x is involved in the formation of photochemical oxidants and is transformed into acid. Photochemical oxidants are of an environmental concern from a human health standpoint, and the concentration of ozone is used to represent the ambient concentration of photochemical oxidants. Known as secondary pollutants, photochemical oxidants form as a result of the photochemical reactions that occur among primary pollutants. Hydrocarbon and NOx are important precursors of ozone. The exact relationship of, and the reactions that occur among, these precursors are multitudinous, complex, and only partially understood.

Total SO_x and NO_x emissions for all scenarios are given in Table 4.13. These are based on 100% load factor emissions in Tables 4.1 and 4.2.

The acid rain problem, as currently understood in the Eastern U.S. and Canada, involves the build-up of pollutants in air masses traveling first eastward across the U.S. and then with a northward path up the eastern seaboard. Brandon Shores *and Crane* are located In a central area of concern for this problem. The increased pollutant burden needs to be analyzed relative to the acid rain problem.

The current concern over the long-range transport of SO_x and the conversion of SO_x to sulfur particulate matter stems from the fear that human health might be endangered by sulfur particulate matter, and from the potential that SO_x will cause an increase in the acidity of natural bodies of water. An increase in acidity is evident in many of the lakes in the northeast. As studies of this problem progress, the importance of both the acid content of precipitation and the dry removal rates of acidic compounds on natural surfaces is being recognized. Cumulative wet and dry deposition and potentially acidic soil are released into local ponds, streams, rivers, and lakes.

The increase in SO_x emissions adds the potential for an increase in acid rain impacts within the Northeast Corridor. The reader is referred to the Northeast Regional Environmental Impact Statement for a discussion of these effects (DOE 1981).

TABLE 4.13. Total Annual SO_2 and NO_x Emissions at 100% Load(a)

	Scenario				
Pollutant	1	2	3	4	5
SO_x	52.6	92.0	111	92.0	111
NO_x	24.6	48.9	68.0	68.0	68.0

(a) 10^6 kg/yr; based on Tables 4.1 and 4.2 for units considered for conversion only.

4.2 LAND USE AND SOLID-WASTE MANAGEMENT

4.2.1 Coal, Limestone and RDF Storage

According to DOE's internal analysis, if the four units at Brandon Shores *and Crane* were converted to coal, the reactivation or construction of coal piles and treatment facilities would not require any offsite land.

At the Crane station, BG&E is reactivating 3.2 acres of the present coal pile and constructing coal-pile runoff treatment facilities. The coal pile is located to the northeast of the main building and has a maximum capacity of 120,000 tons.

At the Brandon Shores station, BG&E would construct a new coal pile and coal-pile runoff treatment facilities at the site. Coal storage would consist of two coal piles of 170,000 tons and 400,000 tons with a combined estimated area of 10 acres. The two piles would probably be located at the southwestern corner of the boilers, but space is also available in the northwestern part of the property. The new treatment facility would consist of two 790,000-gallon collection ponds and an oxidation and neutralization basin.[a]

The limestone required for wet FGD systems at Brandon Shores under Scenarios 4 and 5 would be delivered by either railcar or truck. If a 30-day supply of 78-wt% $CaCO_3$ limestone were maintained, a maximum (Scenario 4) of about 27 acre-ft of storage space would be needed at Brandon Shores. If a 20-foot high pile were maintained, this would require about 1.4 acres. respectively. This pile could easily be accomodated on the generating station sites.

Because RDF tends to settle and become compacted when stored, it would have to be shipped daily to Crane under Scenarios 2, 3, 4, and 5. This would require about 2 acre feet (0.1 acre piled 20 feet high) at Crane. These amounts could easily be accommodated onsite; if necessary, a building could be constructed to protect the fuel from inclement weather.

4.2.2 Ash and Sludge Disposal

Ash Characteristics

Coal ash is divided into two categories: fly ash and bottom ash. Fly ash is a powder-like particulate material that is carried away from the combustion zone with the flue gas. Fly ash may be removed with electrostatic precipitators (ESP), mechanical collectors, baghouses, or wet flue gas desulfurization systems. Bottom ash is a heavier, slag-like material that is removed from the bottom of the furnace. The chief chemical constituents of ash are oxides of silicon, aluminum, and iron. Other constituents present in appreciable quantities are oxides of calcium, magnesium, and alkali metals; sulfur compounds; titanium oxides; and organic carbon compounds. Numerous trace metals are also present in fly ash and bottom ash (Table 4.14).

Various factors influence the ratio of fly ash to bottom ash produced, and the release of the pollutants into the environment. These include element volatility, particle size and weight, and boiler type. Elements that are nonvolatile in the coal combustion zone (1300 to 1600 C) tend to remain in the solid phase and are usually incorporated into the molten substance that forms both the fly ash and bottom ash. Other elements volatilize as the coal is burned and are carried up the flue. As the flue gases cool, these elements tend to condense on the surface of the fly ash particles in the flue gas. These elements are, therefore, more prevalent in fly ash than in bottom ash and tend to be more available for leaching. Elements such as Br, Cl, and Hg are extremely volatile and are released to the atmosphere as gases. The volatility of 36 elements is characterized in Table 4.15.

Coal-ash particle sizes range from less than 1 μm to 4 cm in diameter. The smaller fly ash-particles (5 μm to 100 μm) tend to be spherical in shape. As much as one fifth (by volume) of these spheres are cenospheres, which are hollow silicate glass spheres filled with nitrogen and carbon dioxide. Bottom ash is composed of coarser, heavier particles with porous surfaces.

(a) Preliminary system description for coal-pile runoff system, Brandon Shores Units 1 and 2. Data submitted to Joe Polasek, ERA, from S. A. Link, BG&E, March 23, 1981.

TABLE 4.14. Elements Found in Fly Ash and Bottom Ash (Hart and DeLaney 1978)

Element	Fly Ash, ppm		Bottom Ash, ppm	
	Minimum	Maximum	Minimum	Maximum
Aluminum (Al)	11,500	144,000	80,000	135,000
Arsenic (As)	2.3	1,700	0.98	40.0
Barium (Ba)	96.0	13,900	500	4,000
Boron (B)	10.0	3,000	70.0	300
Cadmium (Cd)	0.1	250	0.50	250
Calcium (Ca)	5,400	177,000	8,400	50,600
Chromium (Cr)	11.0	7,400	15.0	270
Copper (Cu)	30.0	3,020	2.80	720
Fluorine (F)	0.4	624.0	10.60	100.0
Iron (Fe)	7,600	289,000	27,000	203,000
Lead (Pb)	3.1	1,600	5.00	35.0
Magnesium (Mg)	4,900	60,800	4,500	32,500
Mercury (Hg)	0.01	22.0	0.01	4.0
Nickel (Ni)	1.8	8,000	10.0	700
Potassium (K)	1,534	34,700	7,300	15,800
Selenium (Se)	1.2	500	0.08	7.7
Silicon (Si)	196,000	271,000	180,000	273,000
Sodium (Na)	1,180	20,300	1,800	13,100
Sulfur (S)	0.11	0.25	0.06	0.09
Thorium (Th)	1.8	68.0	12.00	15.0
Titanium (Ti)	400	15,900	3,300	7,210
Uranium (U)	0.8	30.1	6.78	14.9
Vanadium (V)	20.0	1,180	44	670
Zinc (Zn)	14.0	13,000	24	950

TABLE 4.15. Distribution of Elements During Combustion (Hart and DeLaney 1978)

Nonvolatile (bottom ash and fly ash)	Intermediate Volatility	Volatile (fly ash)	Very Volatile (flue gas)
Aluminum (Al)	Cesium (Cs)	Antimony (Sb)	Bromine (Br)
Barium (Ba)	Chromium (Cr)	Arsenic (As)	Chlorine (Cl)
Calcium (Ca)	Nickel (Ni)	Cadmium (Cd)	Mercury (Hg)
Cerium (Ce)	Sodium (Na)	Gallium (Ga)	
Cobalt (Co)	Uranium (U)	Lead (Pb)	
Europium (Eu)	Vanadium (V)	Molybdenum (Mo)	
Hafnium (Hf)		Selenium (Se)	
Iron (Fe)		Zinc (Zn)	
Lanthanam (La)			
Magnesium (Mg)			
Potassium (K)			
Rubidium (Ru)			
Samarium (Sm)			
Scandium (Sc)			
Silicon (Si)			
Strontium (Sr)			
Tantalum (Ta)			
Thallium (Tl)			
Titanium (Ti)			

In pulverized-coal burners, only 15 percent to 20 percent of the ash is bottom ash. *In cyclone burners, such as those used at Crane, typically 80 percent of the refractory material is removed from the bottom of the boiler in a molten form. The quenched slag pieces, known as clinkers, are larger and more dense than bottom ash from pulverized coal boilers. Clinkers are angular and have a glassy surface. At Crane, all of the collected fly ash will be reinjected into the boiler and removed as bottom ash.*

The base case scenario (Scenario 1) calls for the burning of oil. Fly ash is produced from the combustion of oil; however, the ash content of oil is usually only about 1 percent of the ash content of coal. Therefore, the problem of oil-ash disposal is insignificant compared to that of coal-ash disposal.

Several of the conversion scenarios call for the use of low-sulfur (1 percent S or less) Eastern coal. Furr et al. (1977) measured the composition of fly ash from a low-sulfur (0.9 percent) bituminous coal that was strip-mined in Garrett County, Maryland, and burned at a Potomac Edison Company generating station. Trace elements measured were all within the ranges given in Table 4.14.

A possible alternate fuel option for Crane (Scenarios 2, 3, 4, and 5) calls for a mixture of coal and refuse-derived fuel (RDF). To the extent that processed RDF is available, BG&E intends to use up to 10 percent (by heat value) RDF with coal at the Crane Unit 1. Refuse-derived fuel is produced when non-combustible materials are removed from municipal solid waste; the remaining combustible waste is then shredded and dried. The properties of RDF vary with the source of waste and the manufacturing process. Data on the chemical composition of the RDF locally available to BG&E generating stations are not available. Studies of municipal wastes collected in the District of Columbia show that the elemental composition of ash (Table 4.16) is similar to that of Eastern coal (Campbell 1976). Chloride, chromium, copper, lead, manganese, and zinc tend to be higher in concentration in RDF. Incinerator fly ash and suspended particles from municipal wastes have elemental compositions similar to those of coal ash (Table 4.13) with the exception that slightly higher concentrations of cadmium, chlorine, lead, sodium, titanium, and zinc are present in fly ash (Greenberg et al. 1978). Because detailed information about the chemical characteristics of RDF ash was unavailable, it was assumed that the ash properties of a coal-RDF mixture would be similar to those of coal alone.

Wet Limestone FGD Sludge Characteristics

More than 95 percent of the sulfur compounds found in coal are oxidized during combustion, and escape with the flue gas in the form of sulfur dioxide (SO_2). Concern about the environmental effects of these releases has led to the use of flue-gas-desulfurization (FGD) systems which remove SO_2 from the flue gases. These systems are described in more detail by Bell et al. (1981). A number of FGD processes are commercially available. The most common method employed is the wet-FGD process, which uses limestone-water slurries.

In a wet-limestone FGD system, SO_2 dissolves in the slurry and reacts with calcium dissolved from the limestone. Some SO_2 (typically 10 percent to 40 percent) is oxidized to SO_3, which also reacts with calcium. Calcium sulfite and calcium sulfate precipitate and are removed from the system as sludge. The sludge also contains unreacted limestone (calcium carbonate), impurities from the limestone, and fly ash (Table 4.17). At Brandon Shores, most of the fly ash will be removed from the flue gas by electrostatic precipitators (ESP) before the flue gas enters the FGD system.

Calcium sulfate which occurs naturally as gypsum, and limestone pose no threat to the environment. Calcium sulfite can have a chemical oxygen demand (COD) in water but is relatively insoluble. Equilibrium concentrations of calcium sulfite are 30 to 70 ppm, depending on water hardness (Johnson and Lunt 1977). Calcium sulfite concentrations in the sludge can be decreased by oxidation or other chemical treatment of the sludge. Trace metals contained in FGD sludge are of more environmental concern. The relatively volatile trace elements that concentrate in wet-FGD sludge include arsenic, antimony, cadmium, copper, gallium, lead, nickel, selenium, and zinc (Table 4.18).

TABLE 4.16. Ash-Forming Elements in Coal, the Total Combustible Fraction of RDF, and Large-Volume Contributors (Campbell 1976)

	Concentration, ppm								
	Coal		Combustibles (Cyclones)		Newsprint		Ground Wood	Kraft	Corrugated Cardboard
	Coal 1	Coal 2	Average	Range	News	Comics			
Al	14,670	—(a)	9900	5700-17,000	—	16,000	—	730	280
Ba	96	94	75	20-175					
Be	—	1.3	3	—	1	—	1	1	
Ca	5,790	—	1200	3500-50,000	1400	1250	—	1450	1350
Cd	0.64	—	14	3-90	—	2	—	0.5	0.5
Co	4.6	20	4	3-7	—	13	—	2	2
Cr	26.7	25	45	15-200	6	28	14.6	5	10
Cu	12.2	14	160	30-500	20	36	2.1	514	
Fe	17,825	—	2700	800-5000	65	250	—	90	80
K	3,480	—	750	300-2000	55	240	—	50	200
Li	—	62	3	3-25	—	10	—	2	2
Mg	1,890	—	2200	560-8500	310	330	—	580	240
Mn	58	28	185	55-910	95	30	11.9	60	75
Na	930	—	4700	1500-10,000	430	33,400	—	1000	2750
Ni	23	22	14	5-180(a)	—11	8.1	3	3	
Pb	8.2	5.9	390	85-1600	9	45	20.1	12	6
Ti	710	—	2200	1100-4400	45	110	—	40	—
Zn	94	25	1000	180-7000	8	22	—	8	7

(a) "—" = No data available.

TABLE 4.17 Composition of Limestone FGD Sludge

Chemical Compound	Typical Composition (Percentage by dry weight)
$CaCO_3$	15
$CaSO_3 \cdot 1/2H_2O$	51
$CaSO_4 \cdot 2H_2O$	29
Impurities	4

Basis: Limestone is 95 Percent $CaCO_3$.
Stoichiometry is 1.27 moles calcium per mole SO_2 adsorbed.
Oxidation is 30 percent.
Fly ash is removed from the flue gas before the gas reaches the FGD system.

TABLE 4.18. Trace Elements Found in Wet Limestone FGD Sludge (Hart and DeLaney 1978)

Element	Concentration, ppm	
	Minimum	Maximum
Arsenic (As)	4.0	33.0
Barium (Ba)	20.0	500.0
Boron (B)	41.8	211.0
Cadmium (Cd)	0.4	25.0
Chromium (Cr)	1.6	17.0
Copper (Cu)	10.0	104
Fluorine (F)[a]	266.0	1017
Lead (Pb)	1.0	290
Manganese (Mn)	36.0	340
Mercury (Hg)	0.1	6.0
Nickel (Ni)	13.0	75.2
Selenium (Se)	2.1	60.0
Vanadium (V)	50.0	100.0
Zinc (Zn)	13.9	2050

(a) Holland et al. 1975

The structural and physical properties of sulfite sludge differ greatly from those of sulfate sludge. In a wet-limestone system, calcium sulfite crystallizes as single platelets ranging from under 5 μm to over 80 μm in size (Crowe and Seale 1979). These thin sulfite platelets have very little structural strength. Dynamic loads cause the crystals to collapse upon themselves and behave like quicksand, i.e., calcium sulfite is thixotropic. Sulfite sludges are also very difficult to dewater. Calcium sulfate, on the other hand, crystallizes separately into needle-like crystals or monoclinic prisms 5 μm to 200 μm in length. These forms have much higher structural strength and are much easier to dewater. Sulfate sludges have properties similar to these soils (Woodyard and Sanning 1978). The ratio of sulfate to sulfite in the sludge depends on factors such as the ratio of sulfur in the coal to excess air in the boiler, the design of the FGD system, and the presence of impurities (catalysts and inhibitors) in the system.

Three types of treatment are available for wet-FGD sludge: physical stabilization, chemical fixation, and forced oxidation. In physical stabilization, wet-FGD sludge is mixed with dry fly ash to produce a waste with low water content and good structural properties (such as high compressive strength). The chemical fixation process combines FGD sludge, ash, and chemical additives to form stable compounds similar to soil. Several processes are commercially available (Barrier et al. 1978). The IU Conversion Systems, Inc. (Philadelphia, PA) process involves a pozzolanic cementitious reaction among sludge, ash, and lime. Sludge and alkaline fly ash from western coals will also react by this process. Chemfix (Pittsburgh, PA) uses sodium silicate and Portland cement as the chemical additives. Dravo Inc. uses a derivative of blast furnace slag (Calcilox®). The third type of treatment is forced oxidation. As air is sparged through an FGD process slurry, calcium sulfite is converted to calcium sulfate (gypsum). Gypsum sludge is structurally stronger than untreated sulfite sludge and can be dewatered to a low water content (typically 80% solids). Calculations were based on the use of forced oxidation as the treatment method at the Brandon Shores because disposal costs are lower than for those chemical treatment methods (Barrier et al. 1979, Ansari and Oven 1980).

Waste from Other FGD Processes

Although wet-limestone FGD is the most common treatment process, other processes can be used (Table 4.19). When a lime-water slurry is used, the product is a $CaSO_3/CaSO_4$ sludge and is similar to that produced by limestone FGD. The dual alkali-system could also be used at Brandon Shores. In this process, a clear sodium solution is used to absorb SO_2, and lime is used to regenerate the sodium for reuse. The $CaSO_3/CaSO_4$ sludge produced is similar to those from lime or limestone FGD; however, dual-alkali sludge will contain a small amount of residual sodium.

Dry-FGD systems are being installed on generating stations that burn low-sulfur (less than 2 percent) coal. Reagent costs make wet-FGD more economical at higher sulfur levels. In dry systems a lime slurry is injected along with the flue gas into a spray dryer. The water evaporates and the calcium reacts with SO_2 to form dry $CaSO_3/CaSO_4$ solids. After processing in the spray dryer, the solids and fly ash are collected in a baghouse. The dry FGD solids are similar in composition to wet-FGD solids; however, the lack of water in the waste makes handling and landfilling easier and reduces the opportunity for leaching. Sodium solutions can be used, but lime is preferred because sodium reagents are expensive and the sodium wastes are difficult to dispose of due to their high solubility in water.

Some FGD systems are designed to produce a saleable by-product instead of a waste. Calcium-based wet systems can be modified to produce gypsum (by forced oxidation) instead of a calcium sulfite/sulfate sludge. Gypsum is used in wallboard, in cement, and as an agricultural supplement.

Other processes produce elemental sulfur or sulfuric acid. These regenerable processes are more complex and therefore more capital intensive than the processes that produce a sludge. The high capital costs can be offset by lower operating costs if the by-product can be sold. Also, the costs of waste disposal are greatly reduced. A long-term sales contract is considered necessary because of the uncertainty of the market demand for sulfur and sulfuric acid. Fly ash and bottom ash must be collected and disposed of separately.

Three regenerable processes which have been used commercially are the Wellman-Lord, the magnesium oxide, and the citrate processes (Beychok 1980). The Wellman-Lord process uses aqueous sodium sulfite which reacts with the SO_2 in the flue gas to form sodium bisulfite. Sodium bisulfite is

TABLE 4.19. Types of Flue Gas Desulfurization Processes

Process	Waste	Restrictions
Limestone	$CaSO_3/CaSO_4$ sludge	-
Lime	$CaSO_3/CaSO_4$ sludge	-
Alkaline Fly Ash	$CaSO_3/CaSO_4$/ash sludge	Only western coals produce alkaline fly ash
Single Alkali	Na_2SO_3/Na_2SO_4 liquor	Used in the West near sources of inexpensive sodium and where liquid waste can be evaporated
Dual Alkali	$CaSO_3/CaSO_4$ sludge	-
Dry Scrubbing	$CaSO_3/CaSO_4$ dry waste	Currently used only on low-sulfur (less than 2%) coals
Wellman-Lord	Sulfur or sulfuric acid	Need long-term market for sulfur or H_2SO_4
Magnesium Oxide	Sulfur or sulfuric acid	Need long-term market for sulfur or H_2SO_4
Citrate	Sulfur	Need long-term market for sulfur

thermally decomposed in an evaporator to regenerate the sodium sulfite and produce a concentrated gas stream of SO_2. Sulfur is produced if the concentrated SO_2 stream is reacted with natural gas. Sulfuric acid is produced if the concentrated SO_2 gas stream is oxidized and reacted with water. In addition to sulfur or sulfuric acid, a purge stream of anhydrous sodium sulfite and sulfate (70 percent sulfate) and a 5 percent slurry of fly ash from a venturi prescrubber are produced.

In the magnesium oxide process, slaked magnesium oxide reacts with SO_2 in the flue gas to form magnesium sulfite and sulfate crystals. The solids are separated from the liquid, dried in a kiln, and decomposed in a calciner. The calciner produces regenerated magnesium oxide and a concentrated SO_2 gas stream. The SO_2 is converted to sulfur or sulfuric acid in the same manner as the Wellman-Lord process.

In the citrate process, sodium citrate is used to buffer an aqueous bisulfite solution which absorbs SO_2. After absorption, the solution is regenerated by steam stripping, which produces a concentrated SO_2 gas stream. This stream is reacted with H_2S to form elemental sulfur. H_2S may be formed from the reaction of sulfur, steam, and natural gas. Two waste streams are produced—a purge of sodium sulfate (Glauber's salt) and a fly-ash slurry from a venturi prescrubber.

Potential Impacts of Limestone Storage

If a wet-limestone FGD system is used, limestone must be stored onsite. A 30-day storage pile would be reasonable for Brandon Shores according to DOE's engineering analysis. Environmental impacts could include loss of area, noise, fugitive dust, runoff, and leaching (Dvorak et al. 1978). Runoff and leachate may contain high levels of calcium and total dissolved solids.

Impacts of Fuel Conversion Scenarios

Each fuel-conversion scenario (Table 2.1) would have a different effect on the quantity and types of wastes produced and the potential for pollutant release (Tables 4.20 through 4.23). The waste production data in these tables were calculated based on an estimated 15 percent ash content of coal, 15 percent ash content of RDF, and a 0.10 percent ash content of oil. Ash calculations were based on a dry fly ash, bottom ash and oxidized sludge containing 80 percent solids by weight, and an untreated (filtered) FGD sludge 60 percent solids by weight.

If the Brandon Shores units are converted to coal with FGD, BG&E may consider using either locally available low-calcium (78 percent $CaCO_3$) or the normal high-purity (95 percent $CaCO_3$) limestone. The rate at which FGD sludge would be produced was thus calculated for both low-calcium and high-calcium limestone (Table 4.23). When low-calcium limestone is used, greater amounts of impurities in the limestone increase sludge production rates and lead to higher disposal costs. The FGD system must also be larger to accommodate the additional limestone required per mole of SO_2 removed. The additional impurities also increase erosion and pluggage (and therefore operating costs) and decrease reliability. Because of the additional costs for a FGD system using low-calcium limestone, high-calcium limestone (95 percent $CaCO_3$) is normally used in FGD systems. The use of high-calcium limestone was assumed in all other calculations.

The largest quantity of fly ash (1480 tons/day) is produced under Scenario 4. The greatest amount of bottom ash (970 tons/day) is produced under Scenarios 3, 4, and 5. Ash production rates for Scenarios 2, 3, 4, and 5 are similar and are much higher than ash rates under Scenario 1. FGD sludge is generated under Scenarios 4 and 5, with the greatest amount produced under Scenario 4 (about 1600 dry tons/day of oxidized sludge). Total solid waste production rates are highest in Scenario 4 primarily because of this quantity of FGD sludge. Under this scenario, about 95,800 ft^3/day of dry fly ash, wet bottom ash, and wet oxidized sludge are generated at 100 percent capacity.

TABLE 4.20. Estimated Production of Fly Ash at BG&E Plants Under Different Fuel Use Scenarios

Fuel Use Scenario	1		2		3		4		5	
	T/D Dry	Ft^3/D Dry	T/D Dry	Ft^3/D Dry	T/D Dry	Ft^3/D Dry	T/D Dry	Ft^3/D Dry	T/D Dry	Ft^3/D Dry
Brandon Shores 1	3.0	67	3.0	67	715	15,900	740	16,400	710	15,900
Brandon Shores 2	3.0	67	3.0	67	715	15,900	740	16,400	710	16,400
Crane 1	-	-	-	-	-	-	-	-	-	-
Crane 2	-	-	-	-	-	-	-	-	-	-
Total	6.0	134	3.0	134	1430	31,800	1480	32,800	1,420	32,300

The following assumptions were made:

- All plants at 100 percent capacity.
- Coal had an ash content of 15 percent, RDF was 10 percent, oil was 0.10 percent.
- *RDF had a HHV of 4,500 Btu/lb.*
- Oil had a HHV of 17,500 Btu/lb at Brandon Shores in Scenarios 1 and 2; *oil had a HHV of 16,667 Btu/lb at Crane in Scenario 1.*
- Coal had the following HHV's: 0.72 percent S coal was 12,000 Btu/lb, 2.2 percent S coal was 12,500 Btu/lb, 2.5 percent S coal was 12,000 Btu/lb.
- Fly ash was 80 percent of the ash from Brandon Shores. *Fly ash was 70 percent of the ash at Crane, but was recycled to the boiler and recovered as bottom ash.*
- For Scenarios 1 through 5, it was assumed that fly-ash collectors at all plants removed 100 percent of the fly ash from the flue gas (giving the maximum possible amount of fly ash.
- Fly ash was stored with a density of 90 lb/ft^3.

TABLE 4.21. Estimated Production of Bottom Ash at BG&E Plants Under Different Fuel Use Scenarios

Fuel Use Scenario	1		2		3		4		5	
	T/D Dry	Ft^3/D Wet	T/D Dry	Ft^3/D Wet	T/D Dry	Ft^3/D Wet	T/D Dry	Ft^3/D Wet	T/D Dry	Ft^3/D Wet
Brandon Shores 1	0.8	23	0.8	23	180	5,400	180	5,400	180	5,400
Brandon Shores 2	0.8	23	0.8	23	180	5,400	180	5,400	180	5,400
Crane 1	*1.4*	*44*	*310*	*9,200*	*310*	*9,200*	*310*	*9,200*	*310*	*9,200*
Crane 2	*1.4*	*43*	*300*	*9,000*	*300*	*9,000*	*300*	*9,000*	*300*	*9,000*
Total	4.4	133	612	18,200	970	29,000	970	29,000	970	29,000

NB: Totals may not add due to rounding.

The following assumptions were made:

- All plants at 100 percent capacity.
- Coal had an ash content of 15 percent, RDF was 10 percent, oil was 0.10 percent.
- *RDF had a HHV of 4,500 Btu/lb.*
- Oil had a HHV of 17,500 Btu/lb at Brandon Shores in Scenarios 1 and 2; *oil had a HHV of 16,667 Btu/lb at Crane in Scenario 1.*
- Coal had the following HHV's: 0.7 percent S coal was 12,000 Btu/lb, 2.2 percent S coal was 12,500 Btu/lb, 2.5 percent S coal was 12,000 Btu/lb.
- Bottom ash was 20 percent of the ash from Brandon Shores. Bottom ash was 30 percent of the ash from Crane. *Fly ash from Crane was recycled to the boiler and collected as bottom ash. Particulate collection efficiency at Crane was assumed to be 100 percent.*
- Bottom ash was stored wet (80 percent solids) with a dry density of 90 lb/ft^3.

TABLE 4.22. Estimated Production of FGD Sludge at Brandon Shores Plants Under Different Fuel-Use Scenarios

	Brandon Shores 1		Brandon Shores 2	
Scenario 4	T/D Dry	Ft^3/D Wet	T/D Dry	Ft^3/D Wet
Untreated Sludge (Low-Calcium Limestone)	798	27,700	798	27,700
Untreated Sludge (High-Calcium Limestone)	685	23,800	685	23,800
Oxidized Sludge (Low-Calcium Limestone)	907	19,400	907	19,400
Oxidized Sludge (High-Calcium Limestone)	793	16,900	793	16,900
Scenario 5				
Untreated Sludge (Low-Calcium Limestone)	—	—	798	27,700
Untreated Sludge (High-Calcium Limestone)	—	—	685	23,800
Oxidized Sludge (Low-Calcium Limestone)	—	—	907	19,400
Oxidized Sludge (High-Calcium Limestone)	—	—	793	16,900

Flue gas desulfurization was included for Brandon Shores only under Scenarios 4 and 5.

The following assumptions were made:

- Both units at 100 percent capacity
- Wet-limestone scrubbing systems were used.
- Low-calcium limestone was 78 percent $CaCO_3$ (22 percent impurities). High-calcium limestone was 95 percent $CaCO_3$
- 100 percent of sulfur in the coal was converted to gaseous SO_2.
- Oxidation was 30 percent for untreated sludge and 95 percent for oxidized sludge.
- Stoichiometry was 1.27 mole Ca per mole SO_2 absorbed.
- Sludge was disposed of wet with a dry specific gravity of 2.4. Untreated (filtered) sludge was 60 percent solids with a density of 96 lb/ft^3 wet. Oxidized sludge was 80 percent solids with a density of 117 lb/ft^3 wet.

TABLE 4.23. Estimated Production of Solid Waste at Brandon Shores and Crane Under Different Fuel Use Scenarios, Ft^3/Day

Fuel Use Scenario	1	2	3	4	5
Brandon Shores 1	90	90	21,300	38,800	21,300
Brandon Shores 2	90	90	21,300	38,800	38,800
Crane 1	*44*	*9,200*	*9,200*	*9,200*	*9,200*
Crane 2	*43*	*9,000*	*9,000*	*9,000*	*9,000*
TOTAL	267	18,380	60,800	95,800	78,300

Solid waste is the sum of fly ash from Table 4.20, bottom ash from Table 4.21, and high-calcium, oxidized FGD sludge from Table 4.22.

NB: Totals may not add due to rounding.

Waste-Management Alternatives

Solid wastes created during coal combustion may be handled in a number of ways. The three principal solid waste streams from the BG&E stations are fly ash, bottom ash (which includes the economizer ash and the coal-pulverizer rejects) and, under Scenarios 4 and 5, FGD wastes from Brandon Shores. Options for management of these wastes are summarized in Table 4.24.

A number of potential uses exist for the wastes that would be produced by BG&E. The company hopes to sell or use up to 50 percent of the fly ash produced at each generating station (Fuhrman 1981). Plans include using fly ash as a base for a parking lot at BG&E's Calvert Cliffs Nuclear Power Plant. BG&E is participating in a Federal study on briquettes made from fly ash and fluidized bed combustion wastes. Also, the company plans to build a berm on the Brandon Shores site to demonstrate the use of ash as structural fill. Fly ash may also be used in concrete or asphalt. Because of Federal regulations encouraging the use of fly ash in the concrete in Federally funded construction, the demand for fly ash should increase (Hansen and Heffelfinger 1980). The gypsum produced in an FGD system could be used in cement and wallboard manufacturer and as an agricultural additive. However, considerable market resistance to the use of FGD-produced gypsum still exists (Bucy and Ransom 1978).

Solid waste that cannot be used must be disposed of. Dispoal options available to BG&E may include ocean dumping, mine or quarry disposal, or ponding or landfilling.

The major advantage of ocean dumping relative to other alternative methods of disposal is that it does not require land (which is in limited supply near Brandon Shores). However, the Environmental Protection Agency regulations under the Marine Protection, Research, and Sanctuaries Act (40 CFR 227) prohibit ocean dumping if feasible disposal alternatives are available. Furthermore, the waste must meet certain criteria for the protection of aquatic life. For example, cadmium and mercury content in the solids must not be greater than 50 percent above background sediment concentrations or the waste must contain less than 0.75 mg/kg mercury and 0.6 mg/kg cadmium. Hart and DeLaney (1978) report ranges of mercury in fly ash, bottom ash, and FGD sludge as 0.01 to 22.0 ppm (mg/kg), 0.01 to 4.0 ppm, and 0.1 to 6.0 ppm, respectively, and ranges of cadmium as 0.1 to 250 ppm, 0.50 to 250 ppm, and 0.4 to 25.0 ppm, respectively. Thus, the waste may not meet the environmental criteria. Inert, insoluble solid material may be exempt from the ocean dumping regulations. Research on formation of stabilized solid blocks of sludge is in progress (Santhanum et al. 1979; Seligman and Duedall 1979).

Disposal in coal mines would be an inexpensive method because costs for land would be minimal and transportation costs would be reduced (if ash and sludge can be transported without cementation in empty coal cars). Fixed sludge could be used as structural support to prevent mine subsidence. The alkaline sludge could also help control acid mine drainage. Disadvantages include interference with present or future mine operations, impacts on ground and surface water, and difficulties in coordinating waste transportation with coal transportation. Disposal in quarries is subject to the same considerations. Because of the problems discussed above, neither mines nor quarries are commonly used as waste disposal sites.

The two most common methods of disposal are ponding and landfilling. Ponding is used for the disposal of slurries. At some generating stations, a slurry of less than 20 percent solids is pumped to a pond and allowed to settle. The supernatant is recycled to the plant. This method requires a large land area close to the plant. At other plants, the slurry is dewatered by a thickener or clarifier to 30 to 40 percent solids. The waste is then transported by pipeline or truck to a disposal site. In either

TABLE 4.24. Solid-Waste Management Options

Management Option	Advantages	Disadvantages
Use	Resource recovery, reduced disposal requirement, and reduced land use. Potential uses: Ash: concrete additive; structural fill; base for asphalt; brick manufacture; reclamation of aliminum, iron and trace metals FGD Sludge: sulfur; sulfuric acid; gypsum (used in cement and wallboard); chemically treated sludge (used for structural fill for berms, road base, dikes).	Use limited due to varying market conditions, low and fluctuating demands, and public opposition to product use (Bucy and Ransom 1977; Haskins et al 1981).
Ocean Disposal	Does not require land. (This method has been considered for FGD sludge disposal.)	Release of large quantities of pollutants to the ocean. This consequence may be mitigated by chemical fixation. Environmental opposition and regulations currently preclude use of this option (Duvel et al. 1979).
Mine Reclamation (Johnson and Lunt 1977)	Eliminates land costs for landfill or pond development. Helps control acid mine drainage and mine subsidance.	Interference with mine operations. Possible impacts on ground and surface waters. Difficulties of coordinating waste transportation with coal transportation.
Limestone Quarry Disposal	(Similar to mine reclamation without acid drainage benefits.)	
Ponding	Water in pond can be recycled, reducing or eliminating effluent discharge. Operationally quite simple and inexpensive. Fully proven technique for handling waste from power plants.	Requires large land area for pond development. Difficult and costly to reclaim. Requires expensive pond piping to prevent leaching of waste by water. Not required if the soil is impermeable. Leachate may seep through the soil and into ground water. Since wastes are pumped, ponds are preferably located next to the power station.
Landfill	Requires less land area than ponds. Easier to reclaim than ponds. Fully proven technique for handling FGD wastes (Coltharp et al. 1979). May be located offsite.	FGD wastes may require dewatering prior to landfilling to improve structural properties. This can be accomplished with settling ponds or mechanical devices such as centrifuges, filter presses and bolt filters. FGD sulfite sludge cannot be dewatered sufficiently for landfilling. This problem can be corrected by oxidation, stabilization of the sludge accomplished via mixing sludge with dry ash, or by chemical treatment (fixation). Leaching may be a problem.
Stacking	Requires less land area than landfill (this method is being considered for oxidized FGD sludge only).	Requires careful control of disposal operation and control of runoff and leachate. Has not been proven on utility gypsum on a utility scale (Morasky et al. 1980).

procedure, the result is a large area containing solids with a high water content (30 to 40 percent solids) that is difficult and costly to reclaim. Also, leaching is more likely to occur when wastes have a high water content. In many cases, a pond liner should be used to reduce the rate of leachate movement into the surrounding soil.

Landfilling requires further dewatering of the waste before disposal. A centrifuge or vacuum filter is usually used for sludge or slurried ash. Fly ash may be collected in a dry form. Because the water content is smaller (60 to 100 percent solids), much less land is required for disposal in landfill than in ponds. Leaching is also reduced because of reduced water content.

Onsite ponding or landfilling at the generating station sites is not possible on a long-term basis because of the scarcity of land. *The Crane station is located in a rural area and does have adequate space. However, much of this is marshland and is adjacent to a wildlife santuary (Carroll Island), which would probably preclude the establishment of a landfill at this site (Figure 3.8).* Brandon Shores is located in a suburban area, and has a limited space which will probably be used for coal storage and handling. Since ponding is more expensive than landfilling when the wastes must be transported more than about one mile (GAI 1979), wastes from the BG&E plants will probably be landfilled. It is expected that BG&E would use offsite landfills to dispose of ash and FGD sludge from Brandon Shores *and Crane.*[a]

Use of a central facility for disposal of all wastes could simplify landfill operation and legal requirements. The area of the landfill would depend upon the amount of waste generated (i.e., upon the fuel-use scenario chosen) and on the depth of the fill. The disposal areas required for the different fuel use scenarios are about 0.1 acres/year for Scenario 1; 6 acres/year for Scenario 2; 20 acres/year for Scenario 3; 26 acres/year for Scenario 5; and 32 acres/year for Scenario 4 at 100 percent capacity and a depth of 25 feet (Table 4.25). Land commitments for each generating station are presented in Table 4.26. Depending upon the site design, the landfill may range from 25 to 50 feet in depth. Using these depths, an estimate can be made of the land space required for disposal of solid wastes over the lifetime of the generating stations. *The estimated annual average capacity factors for each unit at Crane is 63 percent.* Brandon Shores Units 1 and 2 are estimated to operate at 66 percent capacity. The post-conversion life expectancies of each station are estimated to be: Brandon Shores, 35 years *and Crane, 20 years.* The lifetime land commitment varies from 400 to 670 acres among the scenarios in which Brandon Shores converts to coal (Table 4.26).

TABLE 4.25. Estimated Land Commitments (acres/year) Required for Solid Waste Disposal at 100 Percent Capacity[a]

	Generating Station (25-foot Depth of Landfill)		Total	
Scenario	Brandon Shores	*Crane*	25-foot Depth	50-foot Depth
1	0.06	*0.03*	0.09	0.05
2	0.06	*6.10*	6.2	3.1
3	14.3	*8.10*	20.4	10.2
4	26.0	*6.10*	32.1	16.1
5	20.1	*6.10*	26.2	13.1

(a) Data calculated from data in Table 4.23.

(a) Letter from S. A. Link, BG&E, to Joe Polasek, ERA, January 1980.

TABLE 4.26. Estimated Lifetime Commitments of Land (acres) for Disposal of Solid Wastes[a]

Scenario	Brandon Shores	Crane	Total
1	1.4	0.36	1.8
2	1.4	72	73
3	330	72	400
4	600	72	670
5	470	72	540

(a) Basis: Landfill depth was 25 feet. Brandon Shores units have a lifetime of 35 years/unit and a capacity factor of 66 percent. *Crane units have a life of 20 years and a capacity factor of 63 percent.*

The landfilling of solid wastes could result in environmental impacts. If the landfill is designed to minimize leaching, large quantities of metals will remain in the soil at the site. The composition and expected quantities of wastes in the landfill depend on the alternate fuel used. The greatest expected amounts of waste can be estimated for a representative alternate fuel using the expected production of wastes and the maximum reported concentrations of trace metals (Table 4.27). If BG&E is able to sell or use fly ash, these amounts would be reduced. Also, maximum concentrations of trace metal are not likely to occur. Thus, Table 4.27 shows a worst case of trace metal deposition in the landfill. The incorporation of large amounts of metals into the landfill may preclude subsequent agricultural use of the site. Ground water and surface water near the landfill site may also be affected if leaching does occur (see Section 4.3).

Landfilled, untreated sludges, especially those high in calcium sulfite, will probably not be strong enough to support roads or structures. Fly ash, bottom ash, and FGD sludges that are chemically fixed or oxidized will most probably be structurally sound. The structural properties of treated sludge are often better than those of soils, so construction on the site should not be precluded.

The waste disposal site selected will have to comply with Federal and State regulations on solid-waste disposal. Regulations under the Resource Conservation and Recovery Act (RCRA) specify disposal practices for solid and hazardous waste. Combustion wastes are currently declared nonhazardous. Nonhazardous wastes must be disposed of in sanitary landfills instead of open dumps, and precautions must be taken to control runoff and leaching. Maryland regulations currently follow the Federal regulations and classify combustion wastes as nonhazardous. If combustion wastes are declared hazardous or are combined with a hazardous waste, the wastes must be disposed of in a designated hazardous-substance (DHS) landfill (COMAR 10.51, Dec. 12, 1980).

The only existing DHS disposal site close to the BG&E stations, and large enough to accommodate much of the wastes, is the Joy Road Landfill operated by the Boehm Company (ERCO 1980). This site is in Crownsville, Maryland, which is about 15 miles from Brandon Shores *and 27 miles from Crane.* It has 182 acres available for landfill. However, this site is presently closed because of violations of landfill operating regulations, and may not reopen.[a]

(a) Communication from Larry Ramsey, Head of Permit Section, Maryland Department of Natural Resources, to Donald G. Watson, PNL, August 19, 1980.

TABLE 4.27. Trace Element Generation in Ash and Sludge by Scenario, Lb/Day

Scenario	1	2	3	4	5
As	23	69	4,900	5,200	5,000
Ba	210	5,100	48,000	50,000	48,000
B	42	400	9,200	10,000	9,400
Cd	5.2	310	1,200	1,300	1,200
Cr	99	420	22,000	22,000	22,000
Cu	45	920	10,000	11,000	10,000
F	9.2	130	2,000	3,400	3,600
Pb	21	62	4,600	5,700	5,100
Hg	0.32	5.2	71	91	80
Ni	110	950	24,000	25,000	24,000
Se	6.6	15	1,400	1,700	1,500
V	21	830	4,700	5,100	4,800
Zn	180	1,300	39,000	47,000	42,000

BG&E is currently investigating possible disposal sites near Brandon Shores *and Crane*. Criteria include easy access, location away from the 100-year floodplain and wetlands, hydrology such that the bottom of the landfill is at least 1.5 m above the seasonal high ground-water table, and topography such that the final landfill grade can be contoured to a maximum of 30 percent.[a] The site should have extensive soil layers of clay instead of sand, both of which are common in Anne Arundel County.

Bishop and McKay Disposal Site

BG&E has acquired purchase rights on a 282-acre site across Fort Smailwood Road (Figure 4.4) west of the Brandon Shores Generating Station (Fuhrman 1981). A purchase will depend on the outcome of the conversion decision and the results of further site investigations. Preliminary site investigations by Dames and Moore (DM 1980) for BG&E show that the site (owned by Bishop and McKay) is primarily rolling woodland, with the exception of a 200-foot wide transmission line corridor.

Drainage to Bishop Creek is confined onsite by a culvert under the transmission line right-of-way and by a bridge on Fort Smallwood Road. Both of these areas (about 6.5 acres) would flood in the event of a 100-year flood. Low-lying acres along Nabbs Creek would also flood. All wetland areas (along Nabbs Creek) are located within the 100-year floodplain and would not be affected by waste disposal (see Figure 3.10). The total floodplain is only a small fraction of the site, and waste can easily be placed elsewhere. The State of Maryland has taken the position that wetlands are a resource that is to be protected. Accordingly, use of the Bishop and McKay property for solid-waste disposal would only be permitted if proper safeguards for tidal floodplains and wetlands were applied.[b]

(a) Letter from S. A. Link, BG&E, to Joseph D. Polasek, ERA, January 1980.
(b) Letter to Howard Cassell, Maryland Department of National Resources, from R. A. Craig, PNL, August 18, 1982.

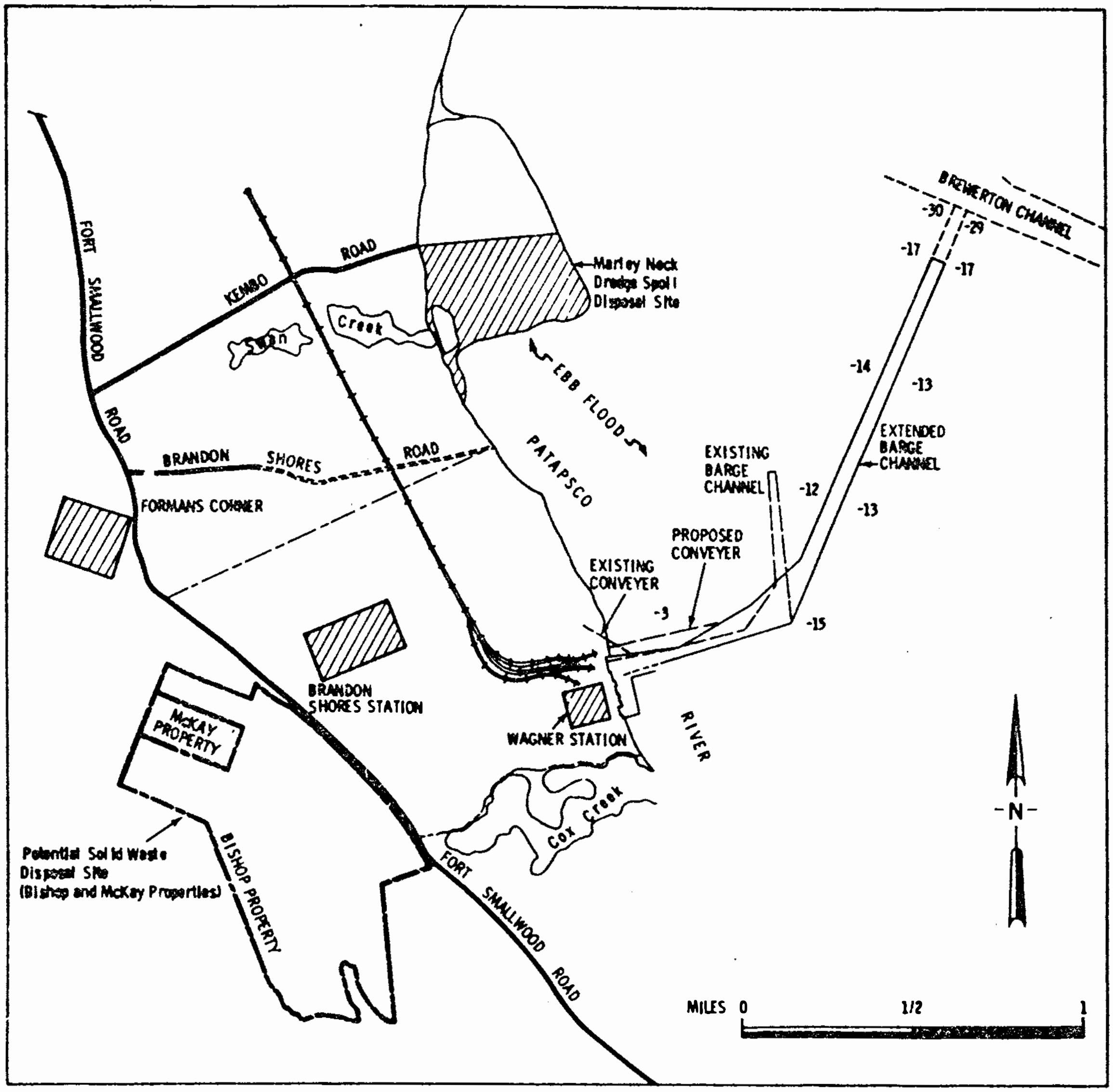


Figure 4.4. Layout of Dredge-Spoil Disposal Site, Barge Channel, and Proposed Solid-Waste Disposal Site

Soil borings show a surface layer (2 to 15 feet deep - Layer 1) of fine silt to medium sand, a layer (extending to 35 to 70 feet below ground level - Layer 2) of stiff silt and clay, a layer (extending to 60 to 90 feet below ground level - Layer 3) of saturated silty sand, and a layer of hard silty clay. The latter three layers are believed to belong to the Patapsco formation, which is regionally underlain by a clay layer (the Arundel formation) and a sand and gravel layer (the Patuxent formation). Permeabilities of 1.9 to 12 x 10^{-7} cm/sec in Layer 2 and 4.0 to 7.7 x 10^{-4} cm/sec in Layer 3 were measured. The permeability of Layer 2 is low enough to protect the Layer 3 aquifer from contamination by leachates (DM 1980).

The use of the Bishop and McKay site would minimize the environmental effects and the costs resulting from transportation of the waste. Since the soils are generally stable and have good strength properties, most of the site (about 200 acres) could be used for waste disposal. Development of the site would reduce the amount of woodland habitat available. BG&E plans to optimize the design and operation of the disposal site to minimize leaching and runoff problems. Details are given in Section 4.3.3.

The Bishop and McKay site could contain 7 to 10 years production of solid waste from the Brandon Shores Wagner stations, depending on the scenario selected. At that point, another disposal site would be required for the remaining life of Brandon Shores and Wagner. This second disposal site has not yet been identified. Following closure of the Brandon and McKay site, BG&E plans to develop the site into an industrial park.

BG&E does not plan to use the Bishop and McKay sites (a site at Rossville is planned) for disposal of waste from the Crane station. Therefore, the combined conversion of Brandon Shores and Crane will not cause any cumulative or interactive effects as a result of solid-waste disposal.

4.2.3 Dredge Spoil Storage and Disposal

Construction of the barge channel (Figure 4.4) to a coal-unloading facility at Brandon Shores required the removal and disposal of approximately 462,000 yd^3 of dredge spoils. The dredge spoils were placed in an upland disposal site on Marley Neck owned by the Marley Neck Patapsco Company, a subsidiary of Chessie Resources (Figure 4.4).[a] The total area of the disposal site is about 80 acres, of which about 15 acres is taken up with dike and roadway construction. This leaves about 65 acres for dredge-spoil disposal.[a] The site has been used for the disposal of dredge spoils from sites in the Baltimore Harbor area.[a]

The site is diked on the east, north, and south sides. The size of the containment dikes were increased to place BG&E spoils on the site and increase the total capacity of the site to 1.5 million cubic yards. After disposal of the spoils from the channel, the remaining capacity is about 640 thousand cubic yards.[a] A 1.8-acre sedimentation basin in the southeast corner of the site was also constructed.

The ultimate use of the site will depend upon the structural stability and chemical quality of the dredge spoils deposited on the land. Most of the surrounding land is zoned for heavy industrial use, and Chessie Resources Inc. has previously expressed interest in converting this and surrounding land into a port facility.[b]

4.3 WATER QUALITY

4.3.1 Coal-Pile Runoff

Runoff from coal piles results when precipitation percolates through or runs off stored coal, washing soluble chemicals and particles away. This leachate tends to have a low pH, high suspended- and dissolved-solids concentrations, and a high concentration of trace metals.

(a) Letter to William Schwarz, McLean Contracting Company, from Andrew Felmy, PNL, dated April 24, 1981.
(b) Letter from Chessie Resources Inc. to William K. Hellman dated July 17, 1979. Letter is reproduced in Technical Report No. 3 of USDT/MDT (1979).

Chemicals in coal-pile runoff are produced when the metallic sulfides present in the coal are oxidized. The leachate characteristically has a very low pH and a high concentration of metal sulfates. The low-pH leachate dissolves other trace metals as it percolates through the coal pile. This dissolution can be mitigated by carbonates or other neutralizing substances present in the coal. Coal with a high sulfide concentration and a low carbonate content will produce the most acidic runoff. As a result, coal-pile runoff from high-sulfur coals tends to be poorer in quality than runoff from low-sulfur coals. Scenario 3 and the worst-case, short-term scenario calling for the conversion of the Brandon Shores generating stations to relatively high-sulfur coal would result in coal-pile runoff of the worst quality. The suspended solids in the runoff would be made up mostly of coal dust. Elevated concentrations of suspended solids would be present during periods of rainfall when high runoff rates suspend coal fines and transport them from the pile. Suspended solids are generally not a problem during conditions of low runoff (TVA 1979).

Coal-pile runoff typically contains large amounts of organic carbon. Studies on coal-pile runoff by Monsanto (MRC 1978) show that the organic carbon has a small biochemical oxygen demand (BOD). Moreover, Monsanto did not identify any toxic organics above background concentrations. Therefore, organic carbon is not expected to be a significant hazard.

The physicochemical characteristics of two coal-pile leachates recently investigated are considered typical for runoff from eastern coals (Table 4.28). These leachates were collected and analyzed at two coal-fired powerplants owned by the Tennessee Valley Authority.

TABLE 4.28. Physicochemical Characteristics of Untreated Coal-Pile Runoff (TVA 1979)

Characteristic (Units)	Plant 1[a]	Plant 2[b]	Average
pH (standard units)	2.81	2.56	2.67
Acidity (mg/l as $CaCO_3$)	3.335	1,650	2,490
SO_4 (mg/l)	5,010	3,050	4,030
TSS (mg/l)	470	270	370
TDS (mg/l)	7,800	4,000	5,900
Fe (mg/l)	940	350	640
Si (mg/l as SiO_2)	174	33	104
Al (mg/l)	260	43	150
Ca (mg/l)	300	320	310
Mg (mg/l)	245	65	155
Cu (mg/l)	0.90	0.20	0.55
Zn (mg/l)	6.46	2.42	4.44
Cd (mg/l)	BDL[c]	BDL	—
Ni (mg/l)	2.6	0.30	1.4
Cr (mg/l)	0.006	0.006	0.006
Be (mg/l)	0.04	0.01	0.02
Hg (mg/l)	BDL	0.0021	0.0021
As (mg/l)	0.15	0.020	0.085
Pb (mg/l)	BDL	BDL	—
Ba (mg/l)	0.17	0.14	0.16

(a) Average total sulfur content of coal - 2 percent (samples are weekly composite samples and represent an average over that period of time).
(b) Average total sulfur content of coal - 4 percent (samples were collected for one storm event of 2.0 in.).
(c) BDL = below detectable limit.

The amount of coal stored at a generating station may vary with anticipated power demands, coal availability, and costs. Because of such variability, this analysis assumes that both Brandon Shores *and Crane* will maintain full coal piles; an assumption which sets up a worst-case perspective for potential environmental hazards. For purposes of estimating the annual volume of coal-pile runoff produced at Brandon Shores *and Crane* (Table 4.29), runoff was taken to be equal to 72.6 percent of the rainfall on the piles. This percentage is derived from actual field measurements (TVA 1979) and represents a conservative yearly average. Actual relationships between rainfall and runoff vary according to the length and intensity of the rainstorms, the length of time between storms, the physical characteristics of the coal, and the space over which the coal pile is distributed. An average yearly rainfall of 40 inches (102 cm) and a 24-hour, 10-year rainfall event of 5.5 inches (14 cm) were assumed for each of the powerplants.

NPDES regulations restrict the amount and quality of effluents that can be discharged from coal-storage piles. The Federal regulations allow a maximum TSS discharge of 50 mg/l and require that the pH be between 6.0 and 9.0. Also, if a treatment facility is required, it may not release untreated discharges produced by any storm less severe than the 24-hour, 10-year rainfall event. The only exception to this rule is made when untreated effluent overflows during a storm more severe than the 24-hour, 10-year event.

It is anticipated that the treatment of coal-pile runoff would involve the oxidation of reduced metals, the neutralization of acidic effluent with lime, and the clarification and filtration of the fluid mixture (Figure 4.5). Treated coal-pile runoff from the Brandon Shores units would be discharged into the Patapsco River estuary. *The treated runoff from the Crane Generating Station would be discharged to the Seneca or Saltpeter Creek estuaries.* When lime precipitation is used on coal-pile runoff, a metal hydroxide (primarily iron hydroxide) sludge is produced. This sludge would be periodically removed from the settling basins. Because the metals will redissolve under acid conditions, this sludge should either be disposed of in a hazardous-waste landfill or should be chemically treated. When fly ash and lime (both already onsite) are added to the sludge, a strong, relatively impermeable solid is formed. *(Flyash from another plant or cement could be used at Crane.)* The solid is suitable for disposal in a regular solid-waste landfill (Malone et al. 1980) and could be disposed of with the ash and FGD sludge (Section 4.2.2).

TABLE 4.29. Estimated Volume of Coal-Pile Runoff

Plant	Coal-Pile Area (acres)(a)	Annual Runoff (gal)(b)	Maximum Runoff, gal/min: 24-Hour, 10-Year Rainfall Event
Brandon Shores 1 and 2	13.0	10,300,000	980
Crane 1 and 2	*3.2*	*2,500,000*	*240*

(a) 1 acre = 2.47 ha.
(b) 1 gal = 0.0038 m^3.

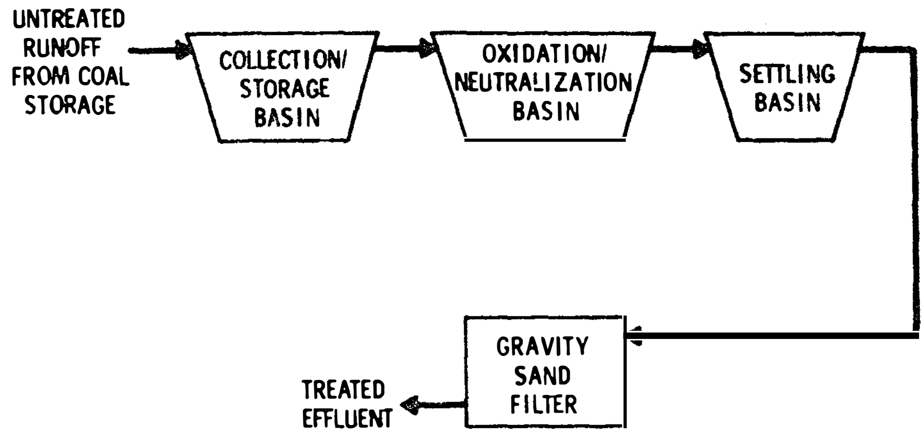


Figure 4.5. Treatment Process for Coal-Pile Runoff

The expected characteristics of treated coal-pile effluent and the EPA criteria for water quality are shown in Table 4.30. The treated runoff is of relatively good quality. All parameters are within EPA water-quality criteria except those for zinc and iron, whose concentrations may exceed recommended criteria for marine waters. However, the ambient concentrations of zinc and iron are also high in the Patapsco River estuary (Table 3.12). The mean concentration of zinc already exceeds the estimated concentration in the treated coal-pile runoff. The concentration of iron in the river near Brandon shores is almost identical (0.928 mg/l) to the expected concentration in the treated coal-pile runoff (1 mg/l). Therefore, discharge of treated coal-pile runoff should not change the ambient iron concentration of the Patapsco River estuary.

The effect of treated coal-pile runoff on the ambient quality of the Seneca and Saltpeter Creek estuaries at the Crane station is more difficult to predict because there are no measurements of ambient concentrations of zinc and iron in the Seneca and Saltpeter Creek estuaries. However, the maximum expected discharge rate of treated coal-pile runoff is only 200 gpm. This quantity of discharge is less than one tenth of one percent of the total cooling-water intake. If the treated effluent were discharged into the cooling-water return, the net change in the concentrations of zinc and iron are projected to be less than 1 µg/l. Such small changes in the concentration of the cooling-water return would be undetectable by present analytical techniques. Therefore, discharge of treated coal-pile runoff to the Seneca or Saltpeter Creek estuaries would present minimal water-quality impacts.

Water percolating through the coal pile into the underlying soil will have the same high acidity and content of metals as the surface runoff and could contaminate underlying ground water. The potential for contamination of ground water will depend upon the soil stratigraphy under the coal pile. The presence of relatively impermeable, clayey soils could effectively isolate infiltrating coal-pile runoff from the underlying ground water. The interaction of coal-pile runoff with soil material would neutralize some acidity and lead to the adsorption of metal ions onto soil particles. However, the magnitude of this effect cannot be predicted without 1) specific studies on the acid neutralization and metal ion adsorption properties of the soils underlying the coal piles, or 2) knowledge of the mineralogical composition, surface area, and soil permeability. Therefore, the following analysis assumes a worst case of negligible neutralization of acidity or metal ion adsorption by the underlying soils.

TABLE 4.30. Expected Characteristics of Treated Coal-Pile Runoff Effluent and EPA Water Quality Criteria

Parameter	Concentration in Treated Effluent (mg/l)	EPA Water Quality Criteria[a]	
		Fresh Water	Marine Water
pH	8.0 (Std. Units)	6.5 - 9.0	6.5 - 8.5
Fe	1.0	1.0	0.3[b]
Ca	1,300	NS	NS
Mg	150	NS	NS
Cu	0.03	1.0[c]	0.05[b]
Zn	0.15	5.0[c]	0.10[b]
Ni	0.05	(d)	0.10[b]
As	0.05	0.10[c]	0.05[b]

(a) Source: EPA 1976.
(b) Source: EPA 1973.
(c) Public Water Supply Criteria In Water Quality Criteria (EPA 1973).
(d) (0.01) X (LC_{50} for sensitive resident species).

Figures 4.6 and 4.7 show the soil stratigraphy under the Brandon Shores *and Crane* coal piles, respectively. The sand, silt and clay designations in these figures represent the major particle size of the soil fraction found in each boring section.

The soil profile under the expected location of the coal pile at Brandon Shores shows a complicated stratigraphy (Figure 4.6). The central part of the coal pile is underlain with a relatively impermeable clay layer at depths of 10 to 30 feet. This clay layer prevents the passage of infiltrating precipitation, and therefore results in the formation of a perched water table at depths of seven to nine feet below the ground surface.

The relatively permeable sandy soil above the clay layer could allow the passage of infiltrating coal-pile runoff into this perched ground water. Clay strata are absent from the western edge of the expected coal-pile area to the depth of the soil borings (about 40 feet). The absence of the impermeable clay strata allows infiltrating water to penetrate into the ground-water table at depths of 15 to 25 feet. Relatively permeable sandy material also separates this lower ground water from any infiltrating coal-pile runoff. Aquifers in the Patapsco formation lie beneath the Brandon Shores site. These aquifers are classified as type-one aquifers and are a potential drinking water supply. It is not known if the ground water detected in the site borings is hydrologically connected to the Patapsco aquifers. The possibility exists that infiltrating coal-pile runoff could contaminate these aquifers. Impermeable liners and underdrain collection systems will be installed beneath the Brandon Shores coal pile to minimize the possible contamination of ground water.

The water table at the Crane generating station is about 3 to 4 feet below the surface. Relatively permeable sandy soil separates the coal pile from the water table (Figure 4.7). Clay strata do exist at depths of about 20 to 30 feet but are not continuous. The probable direction of ground water flow is toward the Seneca or Saltpeter Creek estuaries. Woll (1978) reports the existance of a shallow well near the Crane generating station but does not give information about the use of this well.

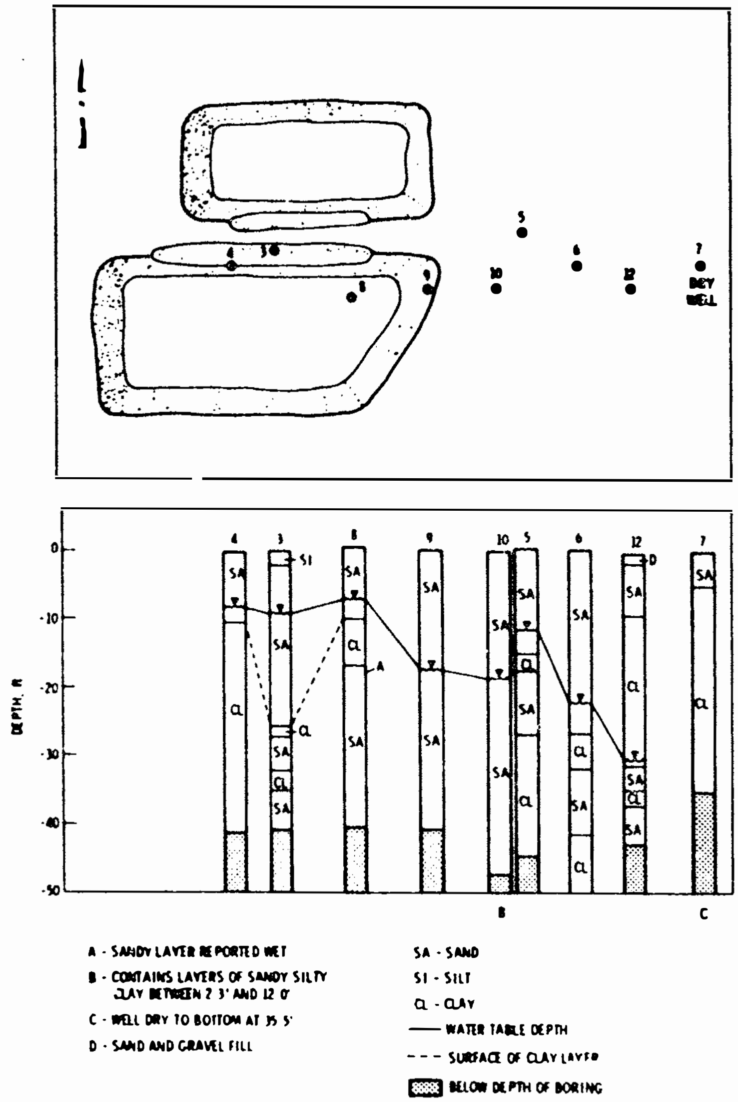


Figure 4.6. Soil Stratigraphy Under the Projected Location of the Brandon Shores Coal Pile[(a)]

(a) Data for Figures 4.6 and 4.7 submitted by S. A. Link, BG&E, to Joseph D. Polasek, ERA, January 10, 1981.

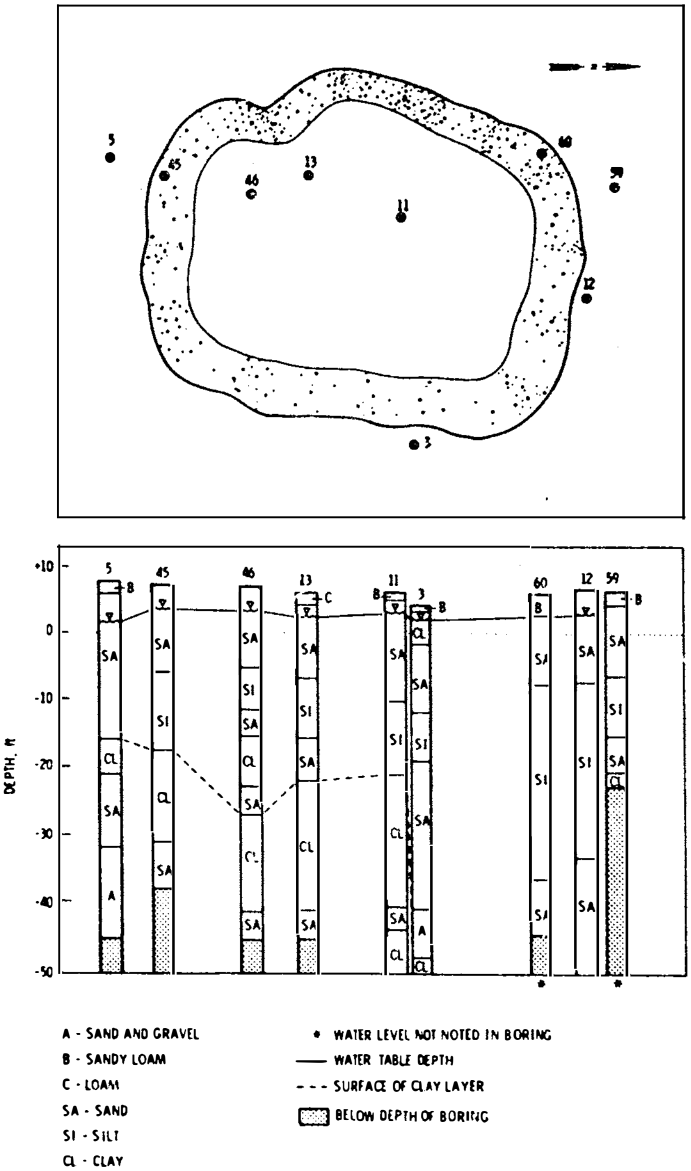


Figure 4.7. Soil Stratigraphy Under the Projected Location of the Crane Station Coal Pile

The potential exists for ground-water contamination from infiltrating coal-pile runoff because of the high water table and relatively permeable overlying soils. An impermeable liner would be required at the Crane Generating Station to minimize the possible contamination of ground water. BG&E plans the installation of such a liner together with underpile drains.

4.3.2 Ash and FGD Sludge Leachates and Effluents

The two common methods of disposing of coal ash and FGD sludge are ponding and landfilling. Since slurries are difficult and expensive to handle and transport over long distances, ponding is only feasible onsite. Because adequate area for long-term storage is not available onsite, landfilling offsite is the most likely option for the Brandon Shores and Crane plants (Section 4.2). Disposal of the dry fly ash and wet bottom ash may occur separately or in combination with FGD sludge. Landfilling may affect water quality through surface runoff or the leaching of pollutants into ground water.

The chief constituents of coal ash are oxides of silicon, aluminum, and iron. Other major components are calcium, magnesium, sodium, potassium, and titanium oxides (Hart and DeLaney 1978). Numerous trace metals are also present (Table 4.27).

Several processes are available to BG&E for flue gas desulfurization (FGD). Wet FGD with a limestone slurry is the most widely used and, thus, the most likely method of flue gas desulfurization if an FGD system is needed at the BG&E plants (Peterson et al. 1981). Sludge from this process is primarily composed of calcium sulfite, calcium sulfate, and calcium carbonate. Sludge from lime and dual alkali processes and dry waste from dry FGD are composed of calcium sulfite and calcium sulfate. Calcium sulfate (gypsum) and calcium carbonate (limestone) are naturally occurring minerals and are not hazardous. Calcium sulfite reacts with oxygen to form calcium sulfate, thus depleting the oxygen in water or chemical oxygen demand (COD). However, calcium sulfite solubility is low (30 to 70 ppm), so this effect is small (Johnson and Lunt 1977). Long-term (equilibrium) CODs are quite small once the original sludge liquor has been displaced by freshwater from precipitation. Rossoff et al. (1978) measured equilibrium CODs as about 10 mg/l after displacement of the original liquor. The utility could oxidize the sludge to the sulfate form before disposal. Regenerable FGD processes produce marketable sulfur or sulfuric acid instead of sludge, but the ash must be collected and disposed of separately.

Runoff and leachate from FGD sludge have the potential to affect the environment through increased alkalinity and total dissolved solids (Dvorak et al. 1978). On land, excess alkalinity (due to dissolved calcium) may exceed the buffering capacity of the soil and consequently increases the soil pH. Vegetation may be adversely affected by both the increased pH and the resultant decrease in availability of nutrients such as phosphorus, iron, and magnesium. On the other hand, toxic trace metals will also be less available. In an aquatic system, increased alkalinity may exceed the aqueous buffering capacity, also increasing the pH. Some increased alkalinity may be beneficial as a counterbalance to acidic coal-pile runoff and acid precipitation. Also, heavy metal concentrations will be reduced. High total dissolved solids (TDS) may affect aquatic biota through effects on osmotic pressure.

Runoff and leachate from the limestone storage pile may also have higher levels of alkalinity and total dissolved solids. However, the solubility of calcium carbonate is less than that of calcium sulfite—14 mg/l and 50 mg/l, respectively (CRC 1973), so impacts will be much smaller.

The major environmental concern about ash and FGD sludge involves the possibility of addition of toxic trace metals to ground and surface waters (Geswein 1977). Trace metals are present in sludge in the fly ash particles captured along with SO_2 from the flue gas. Trace metal concentrations in runoff should be negligible because of the minimal water contact time (Woodyard and Sanning 1978; Coltharp et al. 1979).

Because leachate slowly seeps through a landfill, it has time to dissolve more of the waste (including trace metals) and carry it into the soil. To quantify differences in potential impacts, Coutant et al. (1978) examined the quality of ash-pond water at the Bull Run Steam Plant of TVA. Although effluent (overflow) from the ash-pond system caused little environmental impact, water that seeped through the settled ash and ash-pond embankment showed the potential for causing major environmental impacts (high concentrations of iron, low concentrations of dissolved oxygen, high acidity, and toxicity to fish).

Leachate Quantity

Leachate is formed as the liquid in the wastes gradually seeps into the ground beneath the landfill and is later replaced by precipitation. Movement of the liquid and trace metals is retarded by low moisture in the wastes and by low permeabilities of the wastes in soil. Movement is increased as the amount of water in and above the landfill increases. Several sludge treatment methods which reduce moisture content or permeability are commercially available. Landfill clay or plastic liners with very low permeabilities may also be used to retard the movement of wastes.

Bentonite clay liners are very effective and have permeabilities as low as 10^{-8} cm/s. Bentonite is found only in the West. Current costs are $50 to $60/ton, plus $60/ton shipping costs to the East Coast (Calzonetti 1980). Four to five pounds of bentonite per square foot may be required (at $2 to $5/yd^2). Bentonite may also be used as an extender for local clays to reduce costs. Synthetic (plastic or rubber) liners are practically impermeable but are subject to ripping, degradation in sunlight, and sealing problems between strips. In addition, the ability of synthetic liners to retain their integrity over a number of years is uncertain. Plastic liners cost $1.50 to $4.50/yd^2 (Duvel et al. 1979).

The exact quantity of leachate cannot be predicted unless the physical properties of the waste and the hydrogeological characteristics of the disposal site are known. Order-of-magnitude estimates may be made if the permeabilities of the landfill and soil are known. Permeabilities of FGD sludge range from 10^{-4} to 10^{-7} cm/sec; that for fly ash varies from 10^{-4} to 10^{-4} cm/sec; and that for bottom ash averages 10^{-3} cm/sec (Duvel et al. 1979; GAI 1979). The company investigated sites with low permeabilities, because these sites would reduce the quantity of leachate produced.[a] The permeability of the clay layer at the proposed Bishop and McKay site is 1.9 to 12 x 10^{-7} cm/sec. The movement of leachate is usually limited by the layer of lowest permeability.

At higher permeabilities, the quantity of leachate is limited by the amount of infiltration into the landfill by precipitation, not by permeability. The infiltration rate depends on such factors as grade, vegetative cover, climate, drainage, and runoff control. If an average infiltration rate of 20 percent of the 40 in./year annual rainfall is assumed, Duvel et al. (1979) estimate that the maximum leachate flow as 600 gal/day/acre for limiting permeabilities greater than 7 x 10^{-7} cm/sec. If the permeability is reduced to 2 x 10^{-7} cm/sec (for example, by the clay liner at the Bishop and McKay site or by addition of a clay liner at the top or bottom of a landfill), then the maximum leachate flow is reduced to 200 gal/acre/day.

Leachate Composition

Even if the quantity of leachate were known, its exact composition could not be predicted. Concentrations in the solid waste and associated liquid vary with coal types, boiler configuration, the ash and ash collection system, the limestone and FGD system, and the treatment method for the FGD sludge. Ranges of values reported for coal ash and FGD sludge liquids from a number of coals and

(a) Letter from S. A. Link, BG&E, to Joseph D. Polasek, EPA, January 1980.

FGD wet limestone systems are given in Table 4.31. Sludge leachate values were the maximum concentrations reported after leachate tests in several soil types. Sludge was treated by either the Poz-O-Tec®[a] process, which involves the addition of fly ash and lime, or by the Calcilox®[b] process, which involves the addition of blast furnace slag and flyash. None of the trace elements exceeds the Resource Conservation and Recovery Act (RCRA) standards for leachates from hazardous wastes (defined as 100 times greater than Federal Drinking Water Standards).

Data on trace element concentrations in oxidized sludge leachate were not available. However, the EPA (1979) reports that leachate from oxidized sludge will be similar to that from unoxidized sludge. (Trace element quantities in the waste should not be affected by oxidation.) Permeabilities of sulfite and sulfate sludge are similar, i.e., 10^{-4} to 10^{-5} cm/sec and 10^{-5} cm/sec, respectively (Duvel et al. 1979). The major differences between oxidized and unoxidized sludge will be the physical properties and the amount of liquid in the waste.

Additional quantities of trace elements may become soluble as leaching of the solid waste continues. Only trace metals located at the surface of the relatively insoluble ash can be leached away (Theis and Wirth 1977). Surface concentrations of trace metals in fly ash are given in Table 4.32. FGD sludge is composed of calcium sulfate, calcium sulfite, and calcium carbonate, all of which have limited solubilities. As the sludge comes in contact with water, the trace elements incorporated in the crystal structure become available for leaching. The rate of leaching can be minimized by appropriate design of the disposal site and operating techniques.

The soil underneath a landfill can act to decrease the migration of toxic trace elements. Different types of soil systems attenuate the trace metals by adsorption, ion exchange, and precipitation. The concentrations of cationic trace elements may be significantly reduced by ion exchange. Anionic trace elements tend to be more mobile, although mobility depends on the oxidation state. Holland et al. (1975) performed soil attenuation tests for representative trace elements in ash and sludge leachates. They measured leachate concentrations at various depths of a soil column. The distance required to reduce leachate concentrations to 5 percent of the original is given in Table 4.33. The soils used in the tests are described in Table 4.34. The average cation exchange capacity of the clay layer at the Bishop and McKay site was 3 meq/100 g.

Holland et al. (1975) found that all trace elements, even anions, were attenuated to some extent in soils, including the most permeable sandy soils. Clays had very low permeabilities and showed the greatest attenuation. The most mobile species tested were chromium (Cr), fluoride (F), and selenium (Se). Boron (in anionic form) is also present in high concentrations in waste liquid (Table 4.31). These four species are potentially the most likely to cause ground-water contamination.

Water-Quality Impacts at the Site

The greatest impacts would occur in those scenarios with the greatest quantities of solid waste and highest liquid content in the wastes. Fly ash will be disposed in dry form, but some leaching will occur as precipitation seeps into the landfill. Fly ash may also be combined with the other wastes that are wet. Bottom ash *and slag (from Crane)* would be transported hydraulically at the station and disposed of wet (typically 20 percent water). FGD sludge may contain 20 to 70 percent water. Sludge from Brandon Shores would be filtered before landfilling to reduce the liquid content, the transportation costs, and the leaching potential. Untreated sludge usually can be filtered to 40 percent

(a) Registered trademark of I.U. Conversion Systems, Inc.
(b) Registered trademark of Dravo, Inc.

TABLE 4.31. Comparison of Ranges in Elemental Concentrations of Various Liquid Wastes with Water Quality Standards (all values in ppm)

Element	FlyAsh Pond	Bottom Ash Pond	Sludge Leachate	Treated Sludge Leachate	ERA Interim Primary Drinking Water Standards[b]	RCRA[a] Standards
Arsenic (As)	0.005 - 0.023	0.002 - 0.015	0.008 - 0.30	0.008 - 0.05 [c]	0.05	5.0
Barium (Ba)	0.2 - 0.40	0.1 - 3.0	0.002 - 2.00	0.3 - 2[c]	1.0	100.0
Boron (B)	1 - 24.6	1 - 24.60	0.22 - 40.00	0.5 - 1.3[d]	0.75[e]	-
Cadmium (Cd)	0.023 - 0.052	0.001 - 0.085	0.0005 - 0.047	0.01 - 0.03	0.010	1.0
Chromium (Cr)	0.012 - 0.17	0.005 - 0.023	0.001 - 0.25	0.02 - 0.05	0.05	5.0
Copper (Cu)	0.16 - 0.45	0.01 - 0.14	0.002 - 0.56	0.02 - 0.10	1[f]	-
Fluorine (F)	1.00	1 - 14.85	0.05 - 2[g]	0.05 - 1.75[d]	1.4 - 2.4	-
Lead (Pb)	0.01 - 0.20	0.01 - 0.08	0.003 - 0.039	0.05	0.05	5.0
Mercury (Hg)	0.002 - 0.0006	0.0002 - 0.006	0.0004 - 0.07	0.0015 - 0.006	0.002	0.2
Nickel (Ni)	0.06 - 0.13	0.5 - 0.20	0.015 - 0.05	0.015	-	-
Selenium (Se)	0.001 - 0.004	0.001 - 0.05	0.0005 - 0.54	0.04 - 0.09[d]	0.01	1.0
Silver (Ag)	< 0.01 - 0.01	< 0.05	0.036 - 0.038[d]	0.010 - 0.022[d]	0.05	5.0
Vanadium (V)	NA[h]	0.02	0.1 - 0.20	0.08 - 0.29[d]	10.0[e]	-
Zinc (Zn)	1.1 - 2.7	0.02 - 0.16	0.01 - 4.20	0.01 - 0.02	5[f]	-

Source: Hart and DeLaney 1978, except where noted.

(a) RCRA standards are defined as 100 times greater than the primary drinking water standards.
(b) Knight et al. 1980.
(c) Holland et al. 1975 (p. 21).
(d) Coltharp et al. 1979 (p. 6-78).
(e) Irrigation Standards.
(f) Proposed Secondary Drinking-Water Standards.
(g) Jones and Schwitzgebel 1978 (p. 12, Shawnee and Four Corners sludge).
(h) NA = Not available.

TABLE 4.32. Surface Concentrations of Trace Metals of Fly Ash, Percent of Total Concentration (Theis and Wirth 1977)

Metal	Range	Average
Arsenic (As)	65 - 100	93
Cadmium (Cd)	2 - 58	25
Chromium (Cr)	15 - 84	44
Copper (Cu)	25 - 75	48
Lead (Pb)	5 - 40	8
Nickel (Ni)	5 - 42	11
Zinc (Zn)	10 - 70	30

TABLE 4.33. Attenuation of Trace Elements in Leachate by Soil, Distance in Feet Required to Reduce Leachate Concentration to 5 Percent of the Original Landfill Value

	After Two Years				After Ten Years			
Soils[a] Type Number	Sand 1	Clay 3	Silt-Loam 4	Loam Clay Loam 5	Sand 1	Clay 3	Silt-Loam 4	Loam Clay Loam 5
Ash Leachate								
Arsenic (As)	16	9	4	7	50	34	11	23
Chromium (Cr)	200	9	7	100	700	34	22	420
Copper (Cu)	16	9	4	ND[b]	50	34	11	ND[b]
Fluorine (F)	2,00	50	70	95	10,000	280	350	390
Selenium (Se)	120	10	17	15	500	37	63	52
Sludge Leachate								
Chromium (Cr)	200	60	56	94	1,000	290	220	560
Copper (Cu)	3	7	3	3	10	19	10	10
Fluorine (F)	200	34	78	94	1,000	160	310	560
Mercury (Hg)	90	7	5	4	420	19	18	12
Zinc (Zn)	3	7	3	4	16	19	10	12

Source: Holland et al. 1975. Data from laboratory soil column tests using soils and leachates from operating power plants. Soils were graded by the U.S.D.A. test.

(a) Sample 2, 90 percent illite clay, virtually stopped leachate penetration (Table 4.34 gives soils used in leachate tests).

(b) ND = not determinable.

TABLE 4.34. Soils Used by Holland et al. (1975) in Leachate Tests

Sample Number(a)	Textural(b) Classification	Average CEC(c) (meq/100 g)	Average Permeability (cm/s)	Assumed Porosity (percentage)
1	Sand	3.8	5.1×10^{-4}	50
2	Clay (90 percent illite)	ND(d)	5×10^{-8}	10
3	Clay (90 percent kaolinite)	31	7.4×10^{-6}	10
4	Silt loam—silty clay loam	30	1.2×10^{-5}	10
5	Loam—clay loam	21	2.1×10^{-5}	10

(a) These were soil samples from operating powerplants.
(b) Dry sieving, pipetting, and centrifugation (U.S.D.A. standards).
(c) Cation-exchange capacity in units of milliequivalents of cation per 100 g of soil. Measured as amount of NH_4^+ as in $(NH_4^+)(OA_C^-)$.
(d) ND = not determined.

liquid. Chemically treated or oxidized sludge can be filtered to 20 percent liquid. The use of low-calcium limestone would increase the amount of waste and thus the amount of liquid by about 15 percent; the increase would consist primarily of relatively inert silicon dioxide. The greatest quantity of solid waste (fly ash; bottom ash; and high-calcium, oxidized FGD sludge) would be produced under Scenario 3 - a total of 101,700 ft^3/day at 100 percent capacity (Section 4.2.2). The actual quantity of leachate would depend on the amount and type of waste at the site at any one time, the permeability of wastes and soil, the rate of infiltration of precipitation, and the final design and operation of the site (including leachate collection systems).

Disposal of solid waste at the Bishop and McKay site could have some impact on local ground- and surface-water quality. Surface water drains to the Patapsco estuary via Bishop Creek, Marley Creek, and Nabbs Creek (DM 1980). About 70 percent of the site drains into the intermittent Bishop Creek, a tributary to Cox Creek. Bishop Creek is confined onsite by a culvert under the transmission line right-of-way and by a bridge on Fort Smallwood Road.

Industrial ground-water use is primarily from the Patuxent formation, which is confined by the Arundel clay (see Section 4.2). The saturated siltysand layer (Layer 3) of the Patapsco formation provides water to both industrial and domestic users. Both aquifers are believed to be hydraulically connected to the Patapsco River.

The Patapsco clay layer (Layer 2) which separates Layer 3 from the surface water is regionally discontinuous, making hydraulic connections likely (DM 1980). The aquifer appeared, based on six soil borings, to be confined by the clay layer throughout the site. The water quality in Layer 3 (from a well on the Bishop and McKay site) met all the National Interim Primary Drinking Water Standards except those for pH. Ground water in Layer 1 is believed to drain to the Patapsco River. However, no flow measurements were taken to confirm this (DM 1980).

Before the site is used, additional ground-water monitoring should be performed. The direction of ground-water flow in Layer 1 and the continuity of Layer 2 should be confirmed.

BG&E plans to optimize the design and operation of the disposal site to minimize leaching and runoff problems. It was assumed that the engineering design and operation would be similar to those of other utility solid-waste disposal sites in Maryland. Reference was made to Potomac Electric Power's Chalk Point fly ash landfill (in southern Maryland about 40 miles from Brandon Shores), which is currently in operation, and Delmarva Power and Light's Vienna No. 9 solid-waste disposal site (in eastern Maryland about 60 miles from Brandon Shores), which is in the construction permitting process (GOI 1974).

Ground-water contamination will be minimized by an existing clay layer (Layer 2) if this layer is continuous. Otherwise, a clay or synthetic liner would be required. Ground water from Layer 3 should be monitored regularly for contamination. The top sandy layer of soil (Layer 1) should be separated from the waste by clay or synthetic liner walls to prevent contamination of the Patapsco river. Inactive areas of the landfill should be sealed, capped with soil, and seeded. Surface runoff from other parts of the site should be diverted from the active face of the landfill. Runoff from active areas should be collected in sedimentation basins. Effluent from the basins could be released to Bishop Creek if it meets NPDES permit requirements. Otherwise, the effluent must be treated or recycled to the Brandon Shores Generating Station. A leachate-collection system may also be needed at the bottom of the landfill. Any leachate collected must meet NPDES permit requirements before discharge.

In summary, the Bishop and McKay properties form a promising disposal site for the solid wastes which will be produced if BG&E converts Brandon Shores. Environmental effects from transportation would be minimized. If the clay layer is continuous, as expected, impacts on ground water will be minimized. The landfill can and should be designed and operated to reduce surface-water contamination. The available area outside the wetlands and floodplains and suitable for disposal is large (200 acres) and could contain about one-third to one-half of the total amount of solid waste generated under Scenarios 2, 3, 4, and 5 (Table 4.26).

4.3.3 Dredging and Dredge Spoil Effluents

The channel covers an area of approximately 70 acres of bottom sediments. This area includes approximately 25 acres of bottom sediments disturbed by previous dredging. Additional dredging was required to deepen the channel.[a] Either hydraulic or clamshell dredges are typically used to do this kind of work.

Hydraulic dredges employ a cutting or suction head on an intake line. The sediment is pumped as a slurry through a pipeline to a disposal area. The sediment slurry typically contains 80 to 90 percent water by weight (Barnard 1978).

Clamshell dredges employ a biparting bucket, which is lowered and raised by a hoisting cable. The bucket is allowed to fall freely through the water body in an open mode. The weight of the bucket and the rate of descent cause it to sink into the bottom sediments. The bucket is closed, brought to the surface, and its contents are dumped into a barge adjacent to the dredge. The barge transports the spoils to a disposal area.

In general, hydraulic dredges mix less sediment into the surrounding water than clamshell dredges. Most of the turbidity associated with clamshell dredging results from the sediment resuspension that occurs when the bucket hits the bottom and is pulled away (Barnard 1978).

Hydraulic dredges typically transport large volumes of water along with the sediments. This water goes to the same disposal area as the dredged sediment. The extra volume of material may require a larger disposal area than if the same sediments were dredged by clamshell. If the sediments are sent

(a) Areas were estimated from drawings included with the Water Quality Certification issued to BG&E.

to confined disposal areas, the excess water may require treatment before it is discharged from the disposal site. Treatment normally consists of the addition of polymers or flocculating agents to reduce the turbidity of the discharged water.

The barge channel at Brandon Shores was constructed by clamshell dredge. The permit for the required enlarging of the spoil disposal site stipulates that only material dredged by clamshell be placed at the site (Department of the Army permit issued to Chessie Resources Inc).

Any water-quality impacts that occur during dredging operations would be expected to have lasted only as long as the dredging operation itself. The dredging of the proposed barge channel was completed in March 1982.[a] The suspended sediments from dredging operations form a plume of turbid water, which decreases in density with distance away from the dredging operation as a result of mixing and dilution. Within the turbid plume, pollutant concentrations may increase as a result of both the additional pollutant content of the suspended sediments and the solubilization (i.e., release) of pollutants from the suspended sediments. The dissolved oxygen content of the water may decrease as a result of reaction with reduced sulfur, iron, or manganese compounds contained in the suspended sediments.

The concentration of pollutants released from suspended sediments does not correlate with the total pollutant concentration in the sediments (Brannon et al. 1976). The standard elutriate test is a reasonably accurate measure of the solubilization of pollutants from dredged sediments (Jones and Lee 1978).

Dredging operations unavoidably create a turbidity plume. In recognition of this, the water-quality criteria set by the U.S. EPA incorporate the concept of a mixing zone (EPA 1976). A mixing zone is defined as "an area continuous to a discharge where receiving water quality may neither meet all quality criteria nor requirements otherwise applicable to the receiving water." The criteria specify that a mixing zone not occupy more than 10 percent of the cross-sectional area of an estuary. Turbidity levels at the edge of the mixing zone must not exceed an average monthly level of 50 JTU (about 80 mg/l suspended solids, nor a maximum turbidity level of 150 JTU (about 250 mg/l suspended solids (EA 1980a).

The calculated concentration of suspended solids in the dredging plume exceed 250 mg/l for a distance of up to 240 meters from the dredging operation and exceed 80 mg/l for a maximum distance of 700 meters (EA 1980a). These calculations initially assumed that the sediments would be removed by a hydraulic dredge. However, the high sediment loss rate[b] used in the analysis (assumed to be 5 percent) should also be applicable to a clamshell-dredging operation.[c] The estimated plume dimensions are in good agreement with the findings of Barnard (1978), who found that the turbidity plume from typical clamshell-dredging operations extended downstream about 300 meters at the surface with average water column concentrations of suspended solids of generally less than 100 mg/l (Barnard 1978). Ecological Analysts (EA 1980a) also calculated that the 80 mg/l suspended solids plume would occupy a maximum of 6 percent of the cross-sectional area of the estuary. This calculation assumed that the worst case of the turbidity plume would extend directly across the estuary. The calculated plume cross-sectional area of 6 percent is less than the maximum allowed 10 percent limit on the mixing zone cross-sectional area of an estuary (EPA 1976).

(a) Letter to Lynda Nesenholtz, ERA, from Charles A. Herndon, BG&E, July 7, 1982.

(b) This is actually a sediment suspension rate.

(c) Letter to S. A. Link BG&E, from Frank Pine, Ecological Analysts Inc., dated August 1, 1980.

In addition to the concentration of suspended solids, the concentration of other water-quality parameters must comply with EPA water-quality standards at the edge of the mixing zone. Table 4.35 gives the estimated concentrations of various pollutants at different locations in the turbidity plume along with EPA water-quality criteria and the ambient quality of the Patapsco River estuary.

Table 4.35 shows that the predicted cadmium and mercury concentrations 700 meters from the dredging operation could exceed EPA water-quality criteria for both fresh and marine waters, and the concentration of copper 700 meters from the dredging operation could exceed EPA water-quality criteria for marine waters. However, the predicted concentrations at the edge of the mixing zone (700 m) would be similar to the present ambient quality of the Patapsco River near Brandon Shores. Therefore, degradation of the water quality of the Patapsco River is not projected to occur with respect to the constituents in Table 4.35.

Dredging may reduce the dissolved oxygen content of the water. Ecological Analysts (EA 1980a) measured the dissolved oxygen concentration of elutriate samples that were in contact for about one hour with suspended sediments from the area of the proposed barge channel. The dissolved oxygen concentration in these samples (mean 7.7 mg/l) was less than the ambient concentration of the Patapsco River estuary (11 mg/l). The decrease is probably a result of the reaction of dissolved oxygen with reduced iron, sulfur, or manganese compounds. The residual dissolved oxygen concentration (7.7 mg/l) still meets EPA water-quality criteria for both fresh and marine waters.

Therefore, the dredging of the barge channel should not have significantly affected the ambient quality of the Patapsco River estuary outside of an allowed mixing zone.

TABLE 4.35. Estimated Concentrations in the Turbidity Plume Resulting from Barge Channel Dredging at Brandon Shores (all values mg/l)

Constituent	Predicted Concentration 240 meters from the Dredging Operation(a)	Predicted Concentration 240 meters from the Dredging Operation(a)	The Ambient Quality of the Patapsco River Near Brandon Shores	EPA Water Quality Criteria(c)	
				Fresh Water	Marine Water
Cadmium	<0.014	<0.014	<0.014	0.004	0.005
Chromium	0.083	<0.045	<0.045	0.100	0.100(b)
Copper	0.147	0.135	0.129	1.0(d)	0.05(b)
Lead	0.027	0.013	0.007	(e)	0.05(b)
Mercury	<0.0015	<0.0015	<0.0015	0.00005	0.00010

(a) Source: Ecological Analysts (EA 1980a). All values were calculated using the equation

$C(x) = x/1{,}000{,}000\,[C_s + C_a\,(1 - 1/D) + C_e/D]$ where

$C(x)$ = maximum concentration of a constituent where the suspended solids concentration equals x

x = suspended solids concentration in ppm

C_s = concentration of the constituent in the sediment

C_a = ambient concentration of the constituent

C_e = Concentration of the constituent in the standard elutriate

D = dilution in the discharge.

(b) Source: EPA 1973.

(c) Source: EPA 1976.

(d) Source: Public Water Supply Criteria In Water Quality Criteria (EPA 1973).

(e) (0.01) X (96-hour LC_{50} for a sensitive resident species) using receiving water and soluble Pb measurements.

Dredge spoils from Baltimore Harbor cannot be disposed of in an unconfined manner into the waters or onto the bottom lands of Chesapeake Bay or the tidewater portions of its tributaries outside of Baltimore Harbor (EA 1980a). Section 8-1601 of the Annotated Code of Maryland defines Baltimore Harbor as the "tidal portions of the Patapsco River and its tributaries lying westward of a line extending from Rock Point in Anne Arundel County to North Point in Baltimore County." The barge channel to Brandon Shores is west of this line. Therefore, disposal of dredge spoils from the Brandon Shores barge channel is limited to confined disposal or overboard disposal within the harbor (EA 1980a).

Overboard disposal of dredge spoils in Maryland waters requires that the bulk chemical concentrations in the sediments meet certain requirements (EA 1980a). These requirements, along with sediment concentrations from the area of proposed dredging, are shown in Table 4.36.

The surface sediments (0 to 4 feet below the sediment/water interface) are relatively more contaminated than the deeper sediments (Table 4.36). The mean chemical oxygen demand and concentrations of copper, chromium, and lead in surface sediments exceed Maryland State limits for overboard disposal. In the deepest sediments (4 to 10 feet below the sediment/water interface), none of the constituents exceeds Maryland State standards for overboard disposal. The mean concentration of chromium and the chemical oxygen demand exceed State standards in the mid-depth samples (2 to 6 feet below the sediment/water interface). In addition, the surface sediments contain a significant clay fraction (34 percent), whereas the mid-depth and deepest samples contain only 13 percent to 14 percent clay. The higher clay content is predicted to create a larger turbidity plume for the surface sediments relative to the deeper sediments at an open water disposal area. Therefore, overboard disposal of the surface sediments inside Baltimore Harbor would probably have been prohibited. Overboard dispsoal of deeper sediments inside the harbor appears to be acceptable.

The dredge spoils were disposed of at an upland area on Marley Neck (Figure 4.4), which is located about one mile from the barge channel (Section 4.2.3). The disposal design included a 1.8-acre sedimentation basin in the southeast corner of the site. A dike separates the sedimentation basin from the remaining disposal area. Excess water flows through an overflow pipe into the sedimentation basin. Water overflow from the basin is discharged via a spillway into the Patapsco River.

The discharge of water from a confined disposal basin must conform to standards specified in the Water Quality Certification issued to BG&E by the Department of Health and Mental Hygiene. This certification places limits on the quality of the effluent that can be discharged from spoil-containment areas. The standards are given in Table 4.37, along with the estimated constituent concentrations in discharged water.

The predicted concentrations in the discharged water exceed the standards for arsenic and mercury. Therefore, discharges of water from the confined disposal area should be limited. Two previous reports[a,b] refer to the expected quantities of effluent discharged from the Marley Neck disposal site. Both reports refer to the possible placement of 600,000 yd^3 of dredge spoils at the Marley Neck site. One report[a] states that if the spoils were dredged with clamshell methods, no effluent discharge would occur. The other report[b] states that discharges over the spillway would not occur for "normal" amounts of rainfall. Discharges would only occur when "major storms" dump large volumes of water into the disposal site. The 600,000 yd^3 of dredge spoils were ultimately placed at another site.[c] The BG&E spoils had a volume of only 462,000 yd^3. Therefore, water discharges from the site could be expected to occur only during periods of heavy rainfall.

(a) Letter from M. F. Boussu; N.O.A.A., to S. W. Peck; Army C.O.E., not dated.

(b) Letter to Jon Romeo; ACOE, from E. U. Dalton; Aackenheil and Associates, dated January 10, 1980.

(c) These dredge spoils were from the I-95 dredging project and were disposed of in the Canton/Seagrit Disposal areas (USDT/MDT 1979).

TABLE 4.36. Concentration of Various Constituents in the Sediments at the Location of the Brandon Shores Barge Channel[(a)]

Parameter	Maryland State Standards for Overboard Disposal	Surface Sediments[(b)]	Mid Depth Sediments[(c)]	Deepest Sediment[(d)]	Total Bulk Sediment
Volatile Solids	110,000	72,500 ± 20,800	44,500 ± 14,300	12,400 ± 48,300	78,300 ± 58,800
Chemical Oxygen Demand	100,000	143,000 ± 33,000	107,000 ± 55,000	86,000 ± 48,000	120,000 ± 22,800
Hexane Extractables	5,000	680 ± 750	320 ± 1,250	120 ± 340	449 ± 372
Total Organic Carbon	20,000	16,800 ± 5,900	10,800 ± 22,800	9,700 ± 25,800	13,500 ± 4,800
Zinc	300	104.3 ± 101.5	157.7 ± 247	48.9 ± 76.4	103.4 ± 69.5
Mercury	1	0.425 ± 0.211	0.217 ± 0.185	0.120 ± 0.183	0.296 ± 0.12
Cadmium	2	1.0 ± 0.9	1.1 ± 1.03	0.9 ± 0.8	1.008 ± 0.426
Copper	80	94.9 ± 52.8	65.0 ± 78.2	39.9 ± 124.7	73.5 ± 31.4
Chromium	80	142.5 ± 94.9	118.7 ± 156.8	60.6 ± 89.0	116.1 ± 57.1
Lead	100	105.7 ± 51.3	68.9 ± 85.4	38.1 ± 57.1	80.0 ± 32.9
TKN	2,500	650 ± 330	500 ± 1,300	310 ± 1,120	528 ± 260
Total Phosphorous	2,500	140 ± 80	60 ± 90	50 ± 170	100 ± 40

(a) Source: Ecological Analysts (EA 1980b). All values are in mg/kg with ± the 95 percent confidence interval from the mean.
(b) Surface sediments range between 0 and 4 ft below the sediment/water interface.
(c) Mid-depth sediments range between 2 and 6 ft below the sediment/water interface.
(d) Deepest sediments range between 4 and 10 ft below the sediment/water interface.

TABLE 4.37. Estimated Quality of Water Discharged from the Confined Dredge-Spoil Disposal Area

Parameter	Water Quality Certificate Standard (mg/l)	Expected Concentration (mg/l)
Total Suspended Solids	400	195 ± 378[a]
pH (std units)	6.5 - 8.5	6.7 ± 0.4[a]
Dissolved Oxygen	5	7.7 ± 1.9[a]
Arsenic	0.003	0.032[b]
Copper	3.0	0.159[c]
Iron	1.0	N/A[d]
Mercury	0.0001	0.003[c]
PCB's	1×10^{-6}	N/A
Lead	NS[e]	0.040[c]
Cadmium	NS	0.028[c]
Chromium	NS	0.100[c]

(a) Concentrations in the elutriate after one hour of settling. Source: EA 1980a.
(b) Computed from the equation $C_d = (400 \times 10^{-6} C_s) + C_a + C_i$ where
C_s = bulk sediment concentration. Source: EPA 1977, for
C_s = 31 mg/kg
C_a = ambient concentration
C_i = concentration in elutriate minus concentration in elutriation water
C_d = concentration in discharged water. The suspended solids concentration was assumed to be 400 mg/l in all calculations.
(c) Computed by Ecological Analysts (EA 1980a).
(d) N/A = Not Available.
(e) NS = No standard.

Contamination of ground water at the site could occur if water contained in the spoils infiltrates through the underlying soil into the ground water. The concentrations of chemical constituents in the infiltrating water can be estimated from the values found in the standard elutriate test (Table 4.38).

The constituent levels in water discharged from the disposal site into underlying ground water are regulated in the Water Quality Certificate issued to BG&E. These standards are shown in Table 3.10 as EPA Interim Primary Drinking Water Standards. The estimated concentrations in water which could infiltrate into underlying ground water (Table 4.37) all meet the ground-water standards except possibly for cadmium, for which the analytical detection limit is greater than the standard for ground-water discharges (Table 3.10). The infiltrating water would also contain high concentrations of chloride, sulfate, and total dissolved solids, because the water associated with the spoils comes from the Patapsco River, which has high ambient concentrations of these constituents. However, any water that infiltrates into the underlying soil would probably flow back into the Patapsco River, which borders the site on the southern and eastern sides. In addition, the spoils previously deposited at the site came from the Baltimore Harbor area.[a] The water associated with these spoils also would have contained high concentrations of chloride, sulfate, and total dissolved solids, and water

(a) Letter from M. F. Boussu; N.O.A.A., to S. W. Peck; Army C.O.E., not dated.

TABLE 4.38. Composition of Patapsco River Sediment Elution Wate (standard elutriate test, all values mg/l)

Parameter	Concentration[a]
Nitrate/Nitrate Nitrogen	1.00 ± 0.21
Arsenic	0.02 ± 0.004
Barium	0.07 ± 0.013
Cadmium	0.014
Chromium	0.045
Copper	0.123 ± 0.029
Iron	0.806 ± 0.151
Lead	0.008 ± 0.003
Mercury	0.0015
Selenium	0.003
Silver	0.03

(a) Source: Ecological Analysts (EA 1980a). Associated error terms are for the 95% confidence interval from the mean.

currently in the disposal site would have similar concentrations. Therefore, water infiltrating into the underlying soil would present minimal potential for water-quality impacts.

Periodic maintenance dredging of the proposed barge channel would be required. In the Baltimore Harbor area, this type of activity typically occurs every 4 to 6 years depending upon the frequency of severe storms and the exact location of the dredged area relative to river discharge points.[a]

Exact maintenance dredging requirements cannot be predicted but would be determined when the need for dredging arises. Water-quality impacts from maintenance dredging would be similar to impacts which occur during the original dredging operation. The total time required to complete dredging and the total quantity of spoil removed would be less than for the original operation.

4.4 TERRESTRIAL ECOLOGY

This section on terrestrial ecology focuses on the ways in which combustion emissions and solid-waste disposal would affect animals, vegetation, and the human environment. Potential impacts that are inherently limited in duration, magnitude of impact, or areas of impacts are not addressed. Examples include fugitive dust and storage of coal or limestone. The effects of noise caused by construction and plant operations are addressed in Section 4.6.

(a) Letter to William Schwarz, McLean Contracting Company, from Andrew Felmy, PNL, dated April 24, 1981.

4.4.1 Atmospheric Emissions

Vegetation

Different species of plants exhibit varying sensitivities to atmospheric pollutants. A plant's response is mediated by biological factors as well as abiotic factors such as humidity, temperature, photoperiod, light intensity, and edaphic factors. The principle hazard to vegetation from air emissions is caused by foliar deposition of SO_2. Particulate matter does not constitute a hazard to vegetation through foliar deposition; however, their trace metal burden may accumulate in plants to potentially detrimental concentrations via root uptake (plant uptake is addressed in Section 4.4.2).

Heck and Brandt (1977) have grouped into "sensitive," "intermediate," and "resistant" categories respective to their susceptability to acute (less than 8 hours) exposures of SO_2 and NO_2 (Table 4.39). Based upon numerous laboratory studies, Heck and Brandt (1977) report that 5 percent of the vegetation crown will be damaged if the concentration ranges listed under "most sensitive conditions" are present. Appendix B lists the qualitative sensitivity of crops, garden plants, and native species to SO_2.

Predicted maximum ground-level, 3-hour concentrations of SO_2 have been presented for each generating station and fuel scenario (Tables 4.6 and 4.8). All coal conversion scenarios are capable of producing or contributing to ground-level concentrations of SO_2 in excess of 540 $\mu g/m^3$, the lower limit of SO_2 that may injure vegetation. The actual ground-level concentrations of SO_2 are influenced greatly by meteorological conditions, as indicated by year-to-year variability. Appendix H tabulates predicted maximum changes in SO_2 resulting from the five years of meteorological data used in the air-quality analysis.

It is necessary to identify when and where the highest ground-level concentrations of SO_2 will occur in order to estimate potential impacts on vegetation. Areas most likely to be affected were identified by examining the fifty highest predicted concentrations under the meteorological conditions of 1964—the year that produced the highest estimated ground-level concentrations of SO_2 at Brandon Shores. It is important to realize that meteorological conditions are quite variable, and that maximum ground-level SO_2 concentrations can occur in any direction and distance within reasonable limits. Therefore, the predictions of areas of maximum impact derived from the 1964 meteorological data should be viewed with caution because they do not represent predictions but a historically worst-case scenario.

Brandon Shores. The fifty maximum ground-level concentrations of SO_2 were calculated at distances of 0.8, 1.0, 1.3, 1.7, and 2.3 km from the stacks. They occurred within the 1.3 to 2.3 kilometer range, predominately towards the east and at lesser frequencies towards the north and northwest. Forty-nine of the values occurred during the months of May, June, and July between 9:00 a.m. and 3:00 p.m. The direction and distance suggest that residential areas will not be affected as often as the developed and undeveloped land to the north of the Brandon Shores site. Portions of the plume may extend over the Patapsco River at certain times. Private residences along the southwest shore of the Patapsco River and the Swan Creek wetlands may also receive high levels of SO_2.

Crane. *Eighty-six percent of the fifty highest SO_2 values occurred within 1.3 to 2.3 km of the generating station. Twenty-eight percent were located west of the generating station and 44 percent were located to the east and northeast. The 50 highest values consistently occurred between 9:00 a.m. and 3:00 p.m. May, June, and July accounted for 86 percent of the 50 highest SO_2 concentrations. Potentially affected areas included residential areas to the west and a northern portion of Carroll Island. Wetlands in the immediate vicinity of the generating station would not be affected by high levels of SO_2 because of the height of the stacks (i.e., no building wake effect).*

TABLE 4.39. Concentration Ranges of SO_2 and NO_2 Required to Produce 5 Percent Injury to Vegetation by Short-Term Exposure(a)

	SO_2 ($\mu g/m^3$)		
Duration, Hour	Sensitive	Intermediate Sensitivity	Resistant
1.0	1,310 to 6,500	5,240 to 19,650	> 18,340
2.0	790 to 5,240	3,930 to 13,100	> 11,790
3.0(b)	540 to 3,930	2,920 to 9,960	> 9,170
4.0	390 to 3,140	2,620 to 9,170	> 7,860
8.0	262 to 1,965	1,310 to 5,240	> 3,930
	NO_2 ($\mu g/m^3$)		
1.0	5,640 to 18,800	16,930 to 37,610	24,450
2.0	4,700 to 14,100	13,160 to 141,000	33,850
4.0	3,760 to 11,280	9,400 to 22,570	18,800
8.0	2,820 to 9,400	7,520 to 16,930	15,040

(a) Values taken from Heck and Brandt 1977.
(b) Interpolated value.

The highest predicted 3-hour SO_2 concentration (including background) among all units over five years of meteorological observations was below the lower limit of SO_2 effects on plants of intermediate sensitivity. Only the most sensitive plants (Appendix B) would therefore be expected to incur foliar damage from the SO_2 emissions. Actual incidences of foliar damage would be rare. For example, out of the 42 highest predicted ground-level SO_2 concentrations (excluding background) within a six-kilometer radius of Brandon Shores for Scenario 3 (Figure 4.8), about 33 of these concentrations would be less than the minimum concentration (540 μg SO_2/m^3) that would produce an effect on the most sensitive plants. These values were the highest of 840,960 predicted concentrations computed for one year's time within a six-kilometer radius of the station; 849,918 of these concentrations were less than 300 $\mu g/m^3$. Background concentrations of SO_2 range up to 384 $\mu g/m^3$ (3-hour value); however, this value is an extreme, and background levels would rarely exceed 200 $\mu g/m^3$. Consequently, actual ground-level concentrations (background plus emission levels) of SO_2 would reach a level of 540 $\mu g/m^3$ only in isolated instances. This general pattern holds true for the frequency distribution of SO_2 emissions and background levels from all coal conversion scenarios. The major differences are in the highest SO_2 concentration predicted for each scenario and generating station.

For foliar damage to occur, several conditions must be satisfied. Initially, ground-level concentrations of SO_2 (emissions plus background) must attain a particular concentration capable of producing foliar damage. The plants must be at their most sensitive stage of growth (e.g., germination, flowering, and rapid growth), and the ambient conditions (humidity, temperaure, and light) must also be optimal for adverse impact. The plants must be located where the maximum SO_2 concentrations occur. Although it is possible for all coal conversion scenarios to produce sufficiently high SO_2 concentrations to damage vegetation, the frequency and extent of this impact would be minimal. It is also evident from the predicted yearly maximum emissions (1964-1968 meteorological data, Appendix H) that in some years no concentrations of SO_2 capable of producing foliar damage would occur (Table H.2, Scenario 2, 3-hour maximum for 1965). Because of these factors, it is not possible to prepare a meaningful comparison of scenarios with regard to the potential for foliar damage to vegetation. For comparative purposes, the air-quality tables (4.6 and 4.8) provide an indication of the relative potential for such impact.

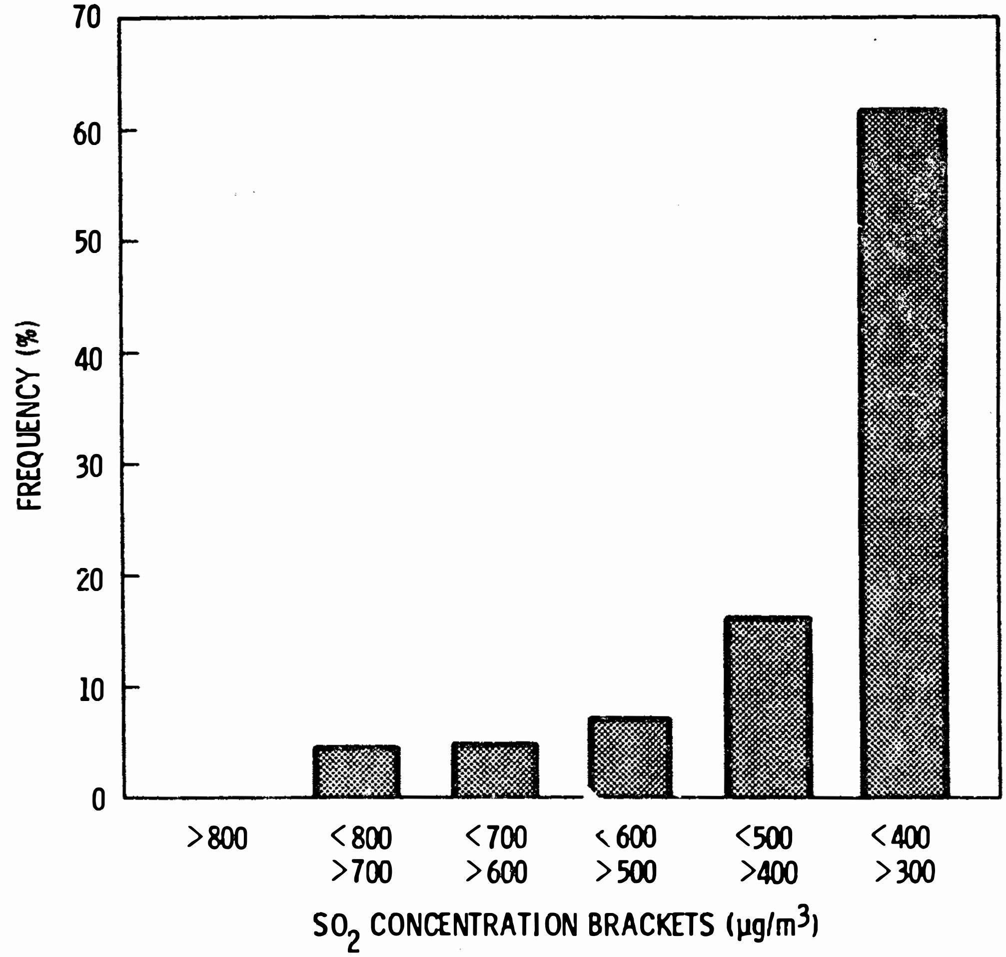


Figure 4.8. Relative Frequency of the 42 Highest 3-hour SO_2 Concentrations (not including background) Within a 6-km Radius of Brandon Shores, Scenario 3, 1964 Meteorological Data

Chronic effects such as reduced growth, inhibition of photosynthesis, and impaired reproduction are not as probable as acute effects. Mukammal (1976) reports a lower threshold of 130 $\mu g/m^3$ SO_2 for exposures calculated on a seasonal or annual basis.

Plants are more resistant to exposures of NO_2 than SO_2 (Table 4.39). Additionally, emission rates of NO_2 resulting from conversion are lower than for SO_2. Unless NO_2 acts synergistically with high levels of SO_2, NO_2 emissions would not directly affect vegetation, either in a chronic or acute mode.

Wildlife and Domestic Animals

Present air-quality standards are based on the known potential for air pollutants to affect human health. These standards are derived from laboratory experimentation, epidemiological studies, and estimated margins for quantitative error. Incipient long-term effects (those that appear after prolonged exposure) are detected in laboratory animals at concentrations of approximately 13,000 to 25,000 g/m^3 of SO_2 (Coffin and Stokinger 1977). Acute effects would require even higher concentrations. The highest estimated SO_2 ground-level concentrations are lower than the levels that have produced effects. This suggests that the predicted worst-case releases of SO_2 from coal combustion would not be high enough to affect animals.

Particulate emissions from coal combustion contain varying concentrations of trace metals (Table 4.14), depending upon combustion temperature, plant design, and coal type. Small particles that escape pollution control equipment tend to have higher concentrations of trace metals than do the larger particles that are retained (Natusch et al. 1974). The smaller particles represent a more serious respiratory hazard than the larger particles, since the primary route of particulate exposure to wildlife is by inhalation. Secondary routes of exposure include ingestion of aerially contaminated foliage, ingestion of food contaminated by plant uptake from the soil, and food-chain transfer routes. These secondary routes are of minor significance because plant-soil concentration ratios tend to be low, as are gastro-intestinal absorption efficiencies. These two factors reduce trophic-level transfer for most metals.

Predicted incremental increases of total suspended particulates (TSP) from conversion to coal (Tables 4.7 and 4.9) are small (2 percent to 15 percent) when compared to background TSP levels (Appendix H). The chemical composition of coal combustion particulates may also differ greatly from the composition of the background constituents. These minor increases in TSP are not projected to cause any acute effects in wildlife. Long-term effects of chronic exposure to TSP are not known. However, the life span of domestic animals and wildlife is shorter than man's and would result in a short exposure time. The conservatism employed in the NAAQS should ensure the health of animals.

4.4.2 Impacts of Solid-Waste Disposal

Qualitative differences in the amounts of solid waste generated in the event that the subject units convert to coal would involve the production of slag, bottom ash, fly ash, and possibly FGD sludge. Dredge spoils from the barge channel were disposed of at a site immediately north of the Brandon Shores generating station (Section 4.3.1). Tables 4.14 and 4.15 list concentration ranges of trace metals which may be found in the aforementioned waste materials. Dredge spoils may also contain, in addition to trace metals (Table 4.35), quantities of pesticides, grease, oil, and halogenated hydrocarbons.

The primary terrestrial impact due to fuel conversion is the loss of natural habitat by the establishment of waste disposal sites. Because an existing site for the disposal of dredge spoils was available and was used, no additional loss of natural habitat occurred.

Disposal of combustion wastes will require a commitment of terrestrial habitat. The most economical approach to the solid waste issue would be to develop one large landfill that could serve the BG&E plants that burn coal. A 282-acre site (Bishop and McKay property) has been identified and studied (DM 1980). This site is located immediately west of the Brandon Shores site (Figure 4.4). Seventy percent of this site (about 200 acres) would be readily available for solid-waste disposal.

The Bishop and McKay property could accommodate the solid wastes from Brandon Shores generated under all scenarios except Scenario 4, if these wastes are deposited to a depth of 25 feet. BG&E plans to market 50 percent of the combustion ash produced by this generating stations (Fuhrman 1981). The successful marketing and use of ash would greatly reduce the demands at the Bishop and McKay property. If marketing activities are not successful, an additional site would have to be developed within 7 to 10 years of conversion.

The Bishop and McKay properties do not possess any unique natural features (DM 1980). The area is a composite principally of forest land interspersed with open lands covered with herbaceous plants (about 6 percent of the total land area) resulting from past or continued use by man. The property provides a suitable habitat for wildlife that is not readily disturbed by the close proximity of industrial and urban development. The property is part of a much larger undeveloped area which serves as an important tract of wildlife habitat in the southern Baltimore metropolitan region. Development of the Bishop and McKay property into a solid waste disposal site would require the clearing of forested lands. Only the resident species most tolerant of the intrusions by man would remain. Provided that the site is properly managed and sufficient soil cover is applied to the buried wastes, the property could be rehabilitated to support wildlife. A typical succession of meadow to shrub to forest would occur over many years, after the site is closed. The successful return of wildlife to the site would depend upon the extent of development in adjacent forested tracts in the Marley Neck area. BG&E's present plans are to develop these properties as an industrial park. In this case, the wildlife habitat would be permanently lost.

4.4.3 Threatened and Endangered Species

The threatened and endangered species found within a five-mile radius of either of the generating stations include the bald eagle and the peregrine falcon. There is little potential for impact attributable to fuel conversions on these species. This potential is even more remote for the species found between the 5- and 50-mile radii. Concentrations of atmospheric pollutants (SO_2, NO_2) from fuel conversion are so diluted beyond five miles that it would be difficult, if not impossible, to identify how much of the existing concentration would be attributed to a specific generating station.

4.5 AQUATIC ECOLOGY

Streams that could be affected by the fuel conversion of the BG&E generating stations include the Patapsco River, Saltpeter Creek, and Seneca Creek.

4.5.1 Impacts of Handling and Storing Coal and Solid Waste

Untreated coal-pile runoff is generally acidic and may contain elevated levels of trace metals, iron, sulfur, dissolved solids, and suspended solids. The more acidic runoff, which is a function of the sulfur and carbonate content of the coal, generally contains high levels of trace metals (Table 4.28). Coal-pile runoff would be treated prior to discharge except when excessive precipitation results in flows exceeding the capacity of the treatment facility (i.e., the 24-hour, 10-year storm). The potential hazard of untreated effluent entering either the Patapsco River estuary or Saltpeter Creek is mitigated by the additional dilution resulting from excessive precipitation. Under normal rainfall conditions, treated effluent does not represent a hazard to the receiving waters.

The potential hazards of trace-metal discharges to aquatic organisms include acute or chronic toxicity and bioaccumulation. Acute toxicity data and bioconcentration factors for selected metals are summarized in Table 4.40. Bioconcentration ratios represent the potential for a metal to accumulate in an organism under theoretical equilibrium conditions. The sorption mechanisms include ingestion, physical adherence to the organism, or direct absorption from the water. The ratios are derived by dividing the concentrations of a given trace metal found in animal tissue by the concentration of the same metal in the water. The values in this table are based on worldwide averages of background water concentrations. Lower concentration ratios would result from water with levels of trace metals which exceed those found in background water, depending upon the physicochemical characteristics of the receiving waters and the absolute concentration of the metal in the water.

TABLE 4.40 Concentration Ratios and Acute Toxicity Ranges of Selected Metals to Aquatic Animals(a)

Element	Freshwater Invertebrates	Freshwater Fish	Marine Invertebrates	Marine Fish	Acute Toxicity Range(b) LC_{50} (< 96 hr) mg/l	Coal-Pile Effluent Concentration Treated(c) (mg/l)	Coal-Pile Effluent Concentration Untreated(d) (mg/l)
Arsenic	333	333	333	333	1-60	0.05	0.20 - 0.15
Cadmium	2,000	200	250,000	3,000	0.11 - 8.4	NA(e)	BDL(f)
Chromium	20	40	2,000	400	0.32 - 195	NA	0.006
Copper	1,000	200	1,670	667	0.02 - 1.7	0.03	0.0 - 0.9
Lead	100	300	1,000	300	0.3 - 23.8	NA	BDL
Mercury	100,000	1,000	33,300	1,670	5.0	NA	0.0021
Nickel	100	100	250	100	0.51 - 33.5	0.05	0.30 - 2.60
Selenium	107	107	1,000	4,000	2.9 - 40	NA	NA
Vanadium	3,000	10	50	10	-	NA	NA
Zinc	10,000	1,000	100,000	2,000	0.1 - 6.44	0.15	2.42 - 6.46

(a) Adapted from Vaughan et al. 1975. Concentration ratios = concentration in organism divided by the Concentration in water.

(b) Adopted from Dvorak et al. 1978: LC_{50} (< 96 hours) = concentration in water that kills 50 percent of the test organisms in 96 hours.

(c) Source--Table 4.33.

(d)Source--Table 4.32.

(e) NA = not available.

(f) BDL = Below detection limits.

Discharge of untreated or treated coal-pile runoff would result in no detectable change in water quality in either the Patapsco River or *Saltpeter Creek*. Trace metals will ultimately precipitate or sorb to suspended particles and become incorporated into the sediments. The existing sediments in the Patapsco River estuary are moderately contaminated with trace metals, and any inputs to the sediments from treated coal-pile runoff would be insignificant.

Solid-Waste Leachates

Solid wastes resulting from coal conversion could include fly ash, bottom ash, coal-crushing wastes, wet-limestone FGD sludge, and dredge spoils.

An active, diked, disposal area (Marley Neck Disposal Site) for dredge spoils has been identified north of the Brandon Shores site (Figure 4.4). Existing dikes at the site were raised to increase the capacity of the site (Section 4.3.1). Swan Creek is located immediately to the southwest of the site. It and its associated marshes contain a diverse assemblage of freshwater aquatic organisms (USDT/MDT 1979). This area (about 65 acres) represents the largest remaining wetland area along the southwest shore of the Patapsco River. Runoff from the dredge-spoil pile will be contained by a dike system that isolates the site from Swan Creek. Runoff would be collected in a sedimentation basin and treated, if necessary, before discharge through a spillway to the Patapsco River. The runoff is expected to be of similar quality to Patapsco River water (Section 4.3.1). Leachates which enter the ground water are expected to move toward the Patapsco River. Because of the somewhat unique nature of the Swan Creek wetlands, potential ground-water seepage into Swan Creek from the disposal site should be periodically monitored to insure that contamination does not occur.

The Bishop and McKay disposal site principally drains into Cox Creek. Runoff in the southern portion of the property drains into Nabbs Creek. Cox Creek and Nabbs Creeks contain healthy populations of fish; species such as killifish, mummichog, alewife and blueback herring probably spawn in the area. Benthic organisms in these creeks are believed to be affected by moderate levels of contaminants in the sediments. The surface-water quality of Cox and Nabbs Creek, which are estuarine fingers of the Patapsco River estuary, are influenced by the generally poor water quality of the lower reaches of the Patapsco River estuary. The soils at the site are generally prone to erosion (DM 1980). Runoff from coal-combustion wastes may contain elevated levels of suspended solids; however, dissolution of trace metals in runoff is expected to be insignificant and is further reduced by state-of-the-art design and engineering for disposal sites. Water percolating through the waste ash could dissolve higher levels of trace metals. Maximum elemental concentrations of coal-combustion-waste leachates can be compared to measured levels of elements in Cox and Nabbs Creeks (Table 4.41).

These estimates do not take account of the retardation properties of soil. The uptake of metals by the soil should significantly reduce the potential for ground-water contamination by trace metals. The potential for ground-water contamination decreases greatly after the most available trace metals (i.e., surface-bound) have been leached from the waste material. Ecological impact to the creeks adjacent to the proposed disposal site could be minimal provided that the sites are properly managed.

TABLE 4.41. A Comparison of Trace-Metal Contaminants in Solid-Waste Leachates and Environmental Levels Found in Cox and Nabbs Creeks

	Solid Waste[a] Leachates	Sediments (mg/kg)[b]		Water (mg/l)[c]	
		Cox Creek	Nabbs Creek	Cox Creek	Nabbs Creek
Arsenic	0.002 - 0.30	4.42	2.11 - 10.75[d]	0.00.026	0.00026
Barium	0.002 - 3.0	< 88.9	< 88.9	< 0.37	0.41
Cadmium	0.0005 - 0.085	< 5.49	< 5.49	0.05	< 0.05
Chromium	0.001 - 0.25	25.22	23.06 - 56.27[d]	0.08	< 0.08
Copper	0.002 - 0.56	64.24	39.59 - 129.21[d]	0.05	0.04
Lead	0.003 - 0.20	83.1	51.11 - 146.11[d]	0.15	0.26
Mercury	0.0002 - 0.07	0.74	0.059 - 0.179[d]	< 0.0004	0.00054
Selenium	0.0005 - 0.54	< 0.91	0.91	< 0.0006	< 0.0006
Silver	NA[e]	< 1.74	1.74	< 0.0001	0.00038
Zinc	0.01 - 4.20	336.2	275.2 - 636.1[d]	0.04	0.60

(a) Range in fly ash ponds, bottom ash ponds, or untreated sludge leachate; Hart and DeLany 1978.
(b) DM 1980.
(c) Highest reported value from several surface and bottom samples.
(d) Range of two values.
(e) Not available.

4.5.2 Impacts of Cooling Systems

The impacts of thermal power plant cooling systems are caused by the discharge of heat to surface waters and by the loss of aquatic organisms through impingement on the cooling-water intake screens and entrainment in the condenser cooling water.

Thermal Discharges

Currently, the Crane units use a once-through cooling system, which results in maximum discharge temperatures of 14.0°F (78°C) above ambient temperatures. A slight increase in the thermal increments of the cooling-water effluents may occur at Crane. Plant capacity factors may increase to 66 percent at Brandon Shores *and 63 percent at Crane* after coal conversion. This increase in operation of the generating station results from the converted units assuming more of a baseload rather than a peaking mode of power generation. Increases in duration of thermal discharges can be expected, but they may not change greatly during the late summer months when station capacity factors are similar to preconversion capacity factors and when peak electrical demand coincides with high ambient-water temperatures. This time period has the potential for maximum impact on aquatic systems. The elevation of temperatures to levels that are lethal to aquatic organisms in the discharge plume is of primary concern. Secondary impacts may include temporal and spacial changes in populations of aquatic organisms resulting from non-lethal shifts in plume temperatures. Species that prefer warmer temperatures would tend to remain in the thermal plume and could undergo cold shock if the generating station abruptly shuts down during colder months.

Brandon Shores will use discharge water from the nearby Wagner Generating Station for cooling-tower makeup. When returned to the Wagner discharge canal, this cooling water is projected to be cooler than when it was removed because of the expected efficiency of the Brandon Shores cooling towers.

Temperature increases would most likely affect the populations of aquatic organisms by causing minor temporal and spatial shifts in resident populations. Hirshfield (1981) reported a possible thermal preference by certain resident finfish in an interim report to BG&E; however, his results are tentative.

The Crane generating station removes cooling water from Seneca Creek and discharges it to Saltpeter Creek. Thermal impacts associated with oil-fired operation at Crane are limited to the immediate discharge area (Sellner et al. 1980; Grant and Berkowitz 1979). In the late summer, temperatures in this area may exceed 100°F (38°C), which is acutely detrimental to endemic flora and fauna. As the thermal plume dissipates and temperatures drop, conditions become favorable for enhanced productivity of phytoplankton and shifts in the quantitative distribution of zooplankton. The thermal plume at Crane has been reported to have minor effects on submerged aquatic vegetation (Nichols et al. 1980). These effects are evident outside of the immediate discharge area and may extend into the Gunpowder River.

Impingement and Entrainment

Impingement is the physical process whereby aquatic organisms are drawn against the intake screens by the force of the cooling water flowing through the intake screens. Impingement may result in mortality or injury depending upon the intake velocity and the organisms' tolerance to stress. Low velocities and constant screen washing may reduce mortalities and injury significantly. Organisms small enough to pass through the screens may be exposed to thermal, mechanical (e.g., pumps) and chemical (e.g., chlorination) stresses prior to being discharged in the effluent.

Small, diseased, or injured organisms are generally too weak to avoid entrainment. Impacts are seasonal depending on the species' life histories and relative abundance. The Patapsco River and *Seneca and Saltpeter Creeks* are nursery areas for resident fish, and the ichthyoplankton (fish eggs and larvae) from these waters may be subjected to impingement or entrainment in the generating-station cooling-water systems.

The Patapsco River is not a major spawning ground for finfish (Section 3.5.2), but the river does serve as a nursery area for a number of fish species, as indicated by impingement and entrainment studies (EA 1980c; LM&SE 1979). It is not possible to estimate an "acceptable" level of impingement and entrainment, because current estimates of existing fish populations in the Patapsco River are not available.

Cooling water for Brandon Shores will be removed from the Wagner discharge canal. Fish entering the discharge canal may be subjected to entrainment at the Brandon Shores cooling-water intake. It is not possible to predict additional losses due to entrainment. (The Brandon Shores intake will not use traveling screens.) When cooling water demands at Brandon Shores exceed the discharge rate from Wagner, the flow in the discharge canal could entrain aquatic organisms directly from the Patapsco River.

The minimum rate at which the pumps would operate at Brandon Shores is 6,300 gpm; the predicted demands of makeup water during normal station operation ranges from 13,365 to 14,792 gpm (JHU 1972a). From December 1978 to July 1979, average cooling water demand at Wagner ranged fom 313,440 to 674,112 gpm (LM&ES 1979). The only time that discharges from Wagner would be less than the demands of Brandon Shores are when the Wagner units are completely shut down or retired. In either event, the flow requirements of Brandon Shores are so small in comparison to those of Wagner that a net decrease in entrainment and in impingement would be expected when both plants are considered together.

The water-intake structures at the Crane generating station are equipped with 3/8-in. mesh traveling screens. Intake velocities across the screens are not projected to increase upon conversion, but post-conversion capacity factors for these units are expected to increase.

The projected increase in capacity factor for Crane after conversion is 63 percent. Present capacity factors are 62 percent and 58 percent for Units 1 and 2, respectively. Consequently, little if any change in impingement or entrainment losses are projected at the Crane Generating Station.

4.5.3 Impacts of Dredging and Dredge Spoils

Dredging was required to construct a new channel at Brandon Shores. The ecological effects from dredging include: 1) physical disruption of existing aquatic habitat during channel construction and/or maintenance dredging; 2) resuspension and/or solubilization of toxic contaminants during channel construction and/or maintenance; and 3) land-use and associated habitat loss from spoils disposal (Section 4.2).

Physical Disruption of Aquatic Habitat

Clamshell dredging techniques were used at the barge channel (Section 4.3.1). Concentrations of suspended solids would have been highest at the dredging site and would have decreased downstream rapidly, due to the dilution and settling of the heaviest particles. Populations of benthic organisms within the boundaries of the channel and in the immediate vicinity of the dredging operation would have been removed with the spoils or smothered by heavy resedimentation of suspended sediments. Suspended solids in the water column may exert a direct physical impact on free-swimming organisms. The sediment plume that results from clamshell dredging is predicted to form a 250 mg/l (including background level) isopleth of total suspended solids (TSS) extending up to 240 meters downstream of the dredging operation (EA 1980a).

Generally, suspended solids concentrations resulting from dredging operations range from less than 100 mg/l to a maximum of 500 mg/l outside of the immediate area of disturbance (Peddicord 1980). For the purposes of this analysis, a TSS concentration of 500 mg/l will be assumed to exist in a plume covering 10 percent of the cross-sectional area of the Patapsco River, extending 240 meters downstream of the dredging site. The duration of the dredging operation is taken to be 9 months, with actual dredging occurring 10 hours/day, 5 days/week. These conditions establish an estimated worst-case condition of exposure to TSS by aquatic organisms in the water column.

Generally, aquatic organisms exhibit a remarkable tolerance to high concentrations of suspended solids. Benthic organisms which normally encounter varying levels of suspended sediments are the most tolerant. Free-swimming species such as open water fish appear to be the most sensitive to elevated levels of suspended solids.

'.ı a recent review of dredging impacts on the upper Chesapeake Bay, Schubel and Williams (1977) conclude from a number of research projects that high concentrations of suspended sediments in the water column associated with overboard spoil disposal or dredging do not represent a demonstrable threat to the upper Chesapeake Bay. They cite several studies that suggest an overall lack of effects on fish eggs and larvae, gills of fish held in pens in open-water disposal areas, phytoplankton, zooplankton, and dissolved oxygen depletion in the plume.

Laboratory studies support Schubel and Williams' (1977) field observations. Concentrations of kaolin[a] that produce 10 percent mortality in more-than-200-hour exposures for a selected group of marine invertebrates ranged from 9,000 to 26,000 mg/l TSS (McFarland and Peddicord 1980). The most sensitive species tested was the shiner perch *(Cymatogaster aggregata)*, which exhibited a 100-hour, 10 percent mortality rate at 1000 mg/l. Schubel and Williams conclude that benthic species which normally encounter high turbidity are the most resistant to elevated concentrations of suspended solids.

Benthic (bottom-dwelling) organisms would be subject to the greatest impact as their habitat within the boundaries of the channel are completely destroyed during initial channel construction and/or maintenance dredging. The area adjacent to the channel may receive increased burdens of sediments from the dredge bucket dislodging and resuspending sediments which would move laterally away from the channel. The adjacent areas affected by this disturbance would be small and the extent that invading sediments would smother the adjacent habitat is minimal. Recolonization estimates of habitats impacted in this manner range from 3 months (Peddicord 1980) to 18 months (Schubel and Williams 1977).

Benthic populations in the lower Patapsco River have been characterized as "severly impacted" by high levels of urban and industrial contamination found in the sediments. Channel dredging within this area may remove the more contaminated surface sediments and expose relatively uncontaminated substrata for future colonization. This possible beneficial impact may be negated by maintenance dredging or the gradual refilling of the channel by suspended contaminated sediments from adjacent areas.

(a) A clay with a median particle size of 4.5 μm.

Free-swimming organisms within the water column would be exposed to 10-hour daily pulses of suspended solids (500 mg/l) under the worst-case conditions. Concentrations of suspended solids would return to background levels within a few hours after dredging ceases (Schubel and Williams 1977; Peddicord 1980). Fish species may leave the plume area temporarily. It is unlikely that there would be significant decreases in pH or dissolved oxygen resulting from these dredging activities. When dredge spoils were disposed of in the Patapsco River, the sediment plume dissipated quickly (within 2 hours), and there was only a minor reduction in dissolved oxygen (about 1 ppm) and pH (Schubel and Williams 1977). The amount of resuspended solids resulting from clamshell dredging is much less than would be expected from open-water dredge-spoil disposal.

Consequently, it is very unlikely that any long-term impacts will result from the dredging operations to make coal delivery possible at Brandon Shores. Benthic populations would be the most severely affected, but the long-term ecological impacts would be insignificant. The laboratory-derived dose responses of aquatic organisms to suspended solids indicate that free-swimming species would suffer few adverse impacts.

Resuspension and/or Resolubilization of Toxic Contaminants in Patapsco River Sediments

Laboratory studies readily demonstrate that aquatic organisms are more severely affected by continuous exposure to contaminated suspended sediments than to noncontaminated suspended sediments. Patapsco River sediments have been contaminated by years of urban- and industrial-waste discharges from the Baltimore area. A gradient of pollution is evident in the sediments in Baltimore Harbor where the pollution is the highest, all the way to the mouth of the Patapsco River where the pollution is the lowest. Sediments sampled from areas next to the Brandon Shores site contain moderate to high levels of contamination (Table 4.42). Toxicity tests employing continuous exposure of resuspended sediments from this area indicate that the sediments at Brandon Shores are less toxic than the sediments collected at Bear Creek, which is located near BG&E's Riverside Station (across the Patapsco River from Bradon Shores; Table 4.43, Tsai et al. 1979). Relative to control

TABLE 4.42. Concentrations of Contaminants in Sediments from the Patapsco River and San Franciso Bay

	Baltimore Harbor Sediments(a)			
Parameter	Bear Creek(b)	Stations(c) 7 and 8	Channel(d) Site Surface Sediments	San Francisco Bay Sediments(e)
Arsenic	71	29 - 44	-	128 ± 33.6
Cadmium	45	2	0.9 - 1.1	2.3 ± 0.74
Copper	580	140 - 200	40 - 95	158 ± 73.6
Chromium	4,300	490	61 - 143	-
Lead	5,500	120 - 310	38 - 106	-
Mercury	1.15	0.32 - 0.47	0.12 - 0.43	1.47 ± 0.93
Nickel	93.0	60 - 82	-	104 ± 18.5
Zinc	5,500	470 - 1,080	49 - 158	381 ± 301
Total PCBs	2.10	0.05 - 0.16	-	1.30
Total DDT	-	-	-	0.750

(a) Source: Tsai et al. 1979.
(b) Most-toxic sediments tested by Tsai et al. 1979.
(c) Sample sites closest to the proposed barge channel; Stony Point (8) and Hawkins Point (7).
(d) Source: Ecological Analysts 1980b.
(e) Source: Peddicord 1980.

TABLE 4.43 Comparison of the Toxic Effects of Resuspended Uncontaminated and Contaminated Sediments on Selected Aquatic Organisms

Species	Baltimore Harbor Sediments: Bear Creek[a] 48-hour LC_{50}	Range (Station 7 and 8)[b] 48-hour LC_{50}	Range (Station 7 and 8)[b] 96-hour LC_{50}	Control[c]
Mummichog (*Fundulus heteroclitus*)	0.58 g/liter	20.6 - 66.8 g/liter	—[d]	103.3 g/liter 48-hour LC_{50}
Spot (*Leiostomus xanthurus*)	0.60	18.0 - 29.1 g/liter	—	50.6 g/liter 48-hour LC_{50}
Soft-Shell Clam (*Mya arenaria*)	—	111.1 g/liter	96.9 g/liter	137.2 g/liter 96-hour LC_{50}

Species	San Francisco Bay Contaminated Sediments[e] 240-hour LC_{50}	San Francisco Bay Contaminated Sediments[e] 480-hour LC_{50}	Control[f]
Coast mussels (*Mytilus californianus*)	—	6 g/liter	100 g/liter 264-hour LC_{50}
Tunicates (*Ascidia ceratades*)	20 g/liter	13 g/liter	38 g/liter 100-hour LC_{50}
Dungeness Crabs (*Cancer magister*)	20 g/liter	14 g/liter	32 g/liter 200-hour LC_{50}

(a) Source of most toxic sediment tested from Tsai et al. 1979.
(b) Patapsco River in areas adjacent to the proposed Brandon Shores channel (Tsai et al. 1979).
(c) Fuller's earth (Tsai et al. 1979).
(d) — = No value given.
(e) Peddicord 1980.
(f) Kaolin (McFarland and Peddicord 1980).

values (i.e., values obtained during continuous exposure to noncontaminated Fuller's earth), sediments from the Brandon Shores area were evaluated as having low toxicity. Further analysis of these data failed to identify a single toxic contaminant in the sediments that could individually be related to (correlated with) the toxicities of the different sediments tested from the Patapsco River.

Peddicord (1980) made similar observations on tests of suspended contaminated sediments from San Francisco Bay. Contaminants in these sediments appear comparable to the Baltimore Harbor sediments (Table 4.42). However, different species were tested and chronic exposures (greater than 96 hour) were used in the Peddicord (1980) study. Kaolin, a commercial clay, was used as a control sediment in these studies. Uptake of contaminants in the tissue of three marine invertebrates exposed to contaminated sediments rarely exceeded a factor of two over control (i.e., kaolin-exposed) organisms. PCBs, DDT, and most trace metals fell into this category. Iron, manganese, and nickel were the only metals that accumulated to higher levels. Nickel, the most toxic of the three, accumulated to levels 52 times higher than control organisms for a species of sand shrimp, *Crangon nigromaculata* (tissue concentrations were 0.52 µg/g wet, a tissue concentration which is considered to be nontoxic). The low degree of bioaccumulation of contaminants from the subject sediments suggests that the toxic contaminants that were assayed in the study were not contributing in an independent manner to the toxicity attributed to the sediments overall. Generally, these contaminants are bound to the sediment particles, making them biologically unavailable. The higher toxicity of contaminated sediments may be attributed to a synergistic (or additive) relationship among contaminants or to a direct response to a contaminant that was not assayed in these two studies.

Concentrations of contaminated sediments that produced low toxic effects in laboratory studies (Table 4.43) are greater than the concentrations of suspended solids from Brandon Shores dredging operations (500 mg/l) by one to two orders of magnitude. Based on a dredging operation of nine months, and recurrent exposures to contaminated sediment (about 10 hours/day), some adverse effects on resident species may result. These impacts would have been minor and would have persisted only as long as the dredging operation was underway.

4.5.4 Threatened and Endangered Species

No threatened or endangered aquatic species are found within a five-mile radius of Brandon Shores *or Crane*. The Maryland darter, the big turtle, the eastern tiger salamander, and the eastern narrow-mouth toad inhabit freshwater lakes and streams located within a 50-mile radius of both generating stations.

4.6 NOISE IMPACTS

The noise impacts associated with fuel conversion are evaluated here with respect to effects of noise on human populations and wildlife within the immediate vicinity of the generating stations. Construction and operational noise impacts for Brandon Shores are discussed. *The noise impacts at Crane are based on the increased noise level over baseline (i.e., oil-fired) operations and associated construction activities.* The measurement and expression of noise are discussed in Appendix I.

4.6.1 Effects of Noise

High-level noise (greater than 100 dBA) is capable of directly damaging the inner ear in animals and man. Responses to noise depend upon individual susceptibility, duration of exposure, type and intensity of noise.

Impacts on Plant Workers

Plant employees may be exposed to either acute or chronic levels of noise that may necessitate the use of ear protection devices. Levels in excess of 70 dBA can cause shifts in the hearing threshold. The Occupational Safety and Health Administration (OSHA) requires ear protection for employees exposed to 90 dBA or more during an 8-hour work period. Employees are encouraged or required (depending upon existing noise levels) to wear protective devices. Consequently, the plant working force is not identified as an affected segment of the population.

Community Response

Members of a community might complain about noise levels even though the noise levels meet State regulations. At some times the magnitude of the noise relative to the average ambient noise level might seem excessive. Areas of high ambient noise (i.e., near highways or industrial zones) may be less subject to complaints. Additional problems arise from the incidence of audible pure tones, fluctuations in sound level (5 dB or more), and extended duration of a noise (i.e., noise of a short duration may be more acceptable than noise of a chronic nature at a lower sound level). The time of year and time of day are other important factors.

The Maryland Department of Health and Mental Hygiene has jurisdiction over and is responsible for the enforcement of noise regulations. Existing State regulations for maximum allowable noise levels are based upon land use categories (Table 3.20). These maximum limits are promulgated to ensure that Environmental Noise Standards (ENS) are not exceeded. The ENS for industrial zones are expressed as the "equivalent sound level (L_{eq} 24)," an integrated average level of constant sound that represents the actual time-varying sound observed during a specified time period. The day-night average sound level (L_{dn}) is used for commercial and residential zones. It incorporates a 10 decibel penalty into the 24-hour average for sound generated during a 9-hour nighttime period.

Special provisions are made for construction sites. Noise levels must not exceed 90 dBA during daytime hours or the zones' nighttime maximum (Table 3.20). Prominent discrete tones or periodic noises must not exceed a level which is 5 dBA less than the applicable standard. Railroads are exempt from these regulations.

Impacts on Wildlife

The major effects of noise on wildlife are behavioral in nature. Noise may interfere with breeding patterns (territoriality), recognition of young, feeding, and predator-prey relations by masking auditory communications. Song birds are perhaps the most sensitive to these effects. Modification of the spatial distribution and composition of terrestrial biomes by noise has not been rigorously studied. Noise effects may exacerbate a broader spectrum of ecological effects related to the construction and operation of powerplants.

4.6.2 Conversion Impacts

Conversion to coal would result in two distinct sources of noise. One of these is construction and the other is the operation of the generating stations. Major noise producing activities would include the expansion of existing coal piles or installation of new coal piles, addition of water treatment facilities for coal-pile runoff, installation of coal- and solid waste-handling equipment, and retrofitting of boilers to burn coal. The extent and duration of construction-related sources of noise are different for each generating station. Noise levels resulting from construction activities may range up to 101 dBA (Appendix I). Special provisions apply to noise levels associated with construction activities. During daytime hours (7:00 a.m. to 10:00 p.m.), noise levels must not exceed 90 dBA. However, noise levels below this standard may still result in complaints.

Once a generating station has been converted to a coal-firing mode, the operational sources of noise which did not exist under oil-fired operation become a major concern. Coal-handling equipment, such as railroad car unloaders, stacker-reclaimers, coal crushers and transfer towers, produce the highest noise levels (Table 4.44). Intermittent sources, such as the public address system and the backup warning signals on coal-moving equipment, may be particularly offensive because of their need to be audible over existing sound levels.

Argonne National Laboratory (ANL) has developed a computer code for modeling and predicting noise emissions from powerplants (Dunn et al. 1981). The model is based on the Edison Electric Institute's (EEI 1978) Electric Power Plant Environment Noise Guide. At its present stage of development, the model does not include barrier and terrain effects; consequently, predictions made with this model should be viewed as tentative and conservative (i.e., an overestimate of actual sound levels that may result from coal conversions). The computer program was used for the noise analyses of the Crane generating station. Noise emissions from Brandon Shores have been estimated previously (Cwiklewski 1980).

TABLE 4.44. Potential Sources of Noise Resulting From Conversion to Coal-Based Fuel Scenarios[a]

Source	dBA	Temporal Characteristic
Coal-Car Shaker	132	Intermittent
Coal Crusher	118	Intermittent
Conveyors and Transfer Towers	116	Intermittent
Coal Yard Mobile Equipment	107 - 119[b]	Intermittent
Stacker-Reclaimer	106	Intermittent
Pulverizers	105 - 107[c]	Continuous
Electrostatic Precipitators		
Rapper	111	Periodic
Vibrator	114	Periodic
Trucking of Solid Waste	91	Periodic

(a) Derived from Edison Electric Institute (EEI 1978).
(b) Dependent upon rated engine power; does not include backup warning signal.
(c) Range of 13-55 MT/hour.

Crane

Unit 1 has been converted to a coal-firing mode and has undergone test firings on coal. The coal-handling equipment has been renovated or installed; consequently, the remaining construction activity relevant to noise propagation is the retrofitting of the Unit 2 boiler. Because of the relatively long distances from the generating station to the closest residences (1600 feet or more), it is unlikely that any construction-related activities would result in noise levels that exceed State guidelines.

Operational noise impacts were estimated with the ANL computer model (Dunn et al. 1981). The acoustical center of the plant was determined according to EEI (1978) methods and it serves as the center for a Cartesian coordinate grid system. The locations of all major sources of noise and principle receptors were located on this grid system (Figure 4.9) from an aerial photograph of the site (Baltimore County Wetlands Photo No. BAI-?5?L). Two generating station boundaries were modeled as receptor points. Background noise levels (i.e., oil-fired mode of operations) at the receptor sites were estimated by moving the acoustical center of the plant to the boiler area and assuming a 6 dBA (i.e., 75 percent sound energy level) reduction in noise emissions due to enclosure of the principle oil-fired noise sources. This estimate of ambient (oil-fired) noise level is appropriate because the Crane Generating Station is the major source of noise in the area. Noise emissions from coil-fired operations were added to these background levels to determine the predicted noise levels at that receptor point. All sources and receptors were assumed to be at 1 meter in elevation. Meteorological conditions assumed 70 percent relative humidity, 59°F (15°C), and no wind.

Two modes of operations were considered. A maximum-impact mode (designated daytime mode) was modeled assuming continuous operation of every piece of coal-handling equipment for 1 hour. A second mode, representing nighttime operation, excludes sources of noise required for coal delivery (i.e., coal-car shaker and bulldozer). The second mode of operation assumes that delivery of coal would cause sufficiently high emissions of noise to violate State nighttime standards (50 dBA). These predictions are summarized in Table 4.45. The modeling effort does not include intermittent sources of noise such as soot blowers, public address systems, backup-warning devices on coal-yard equipment and venting of steam.

This modeling exercise suggests that the 50 dBA nighttime standard may be violated at the three closest residences used in the analysis. Additionally, noise emissions at all residential receptors may exceed the daytime standard of 60 dBA. Predicted noise levels at the generating station boundary are also in potential violation of State guidelines.

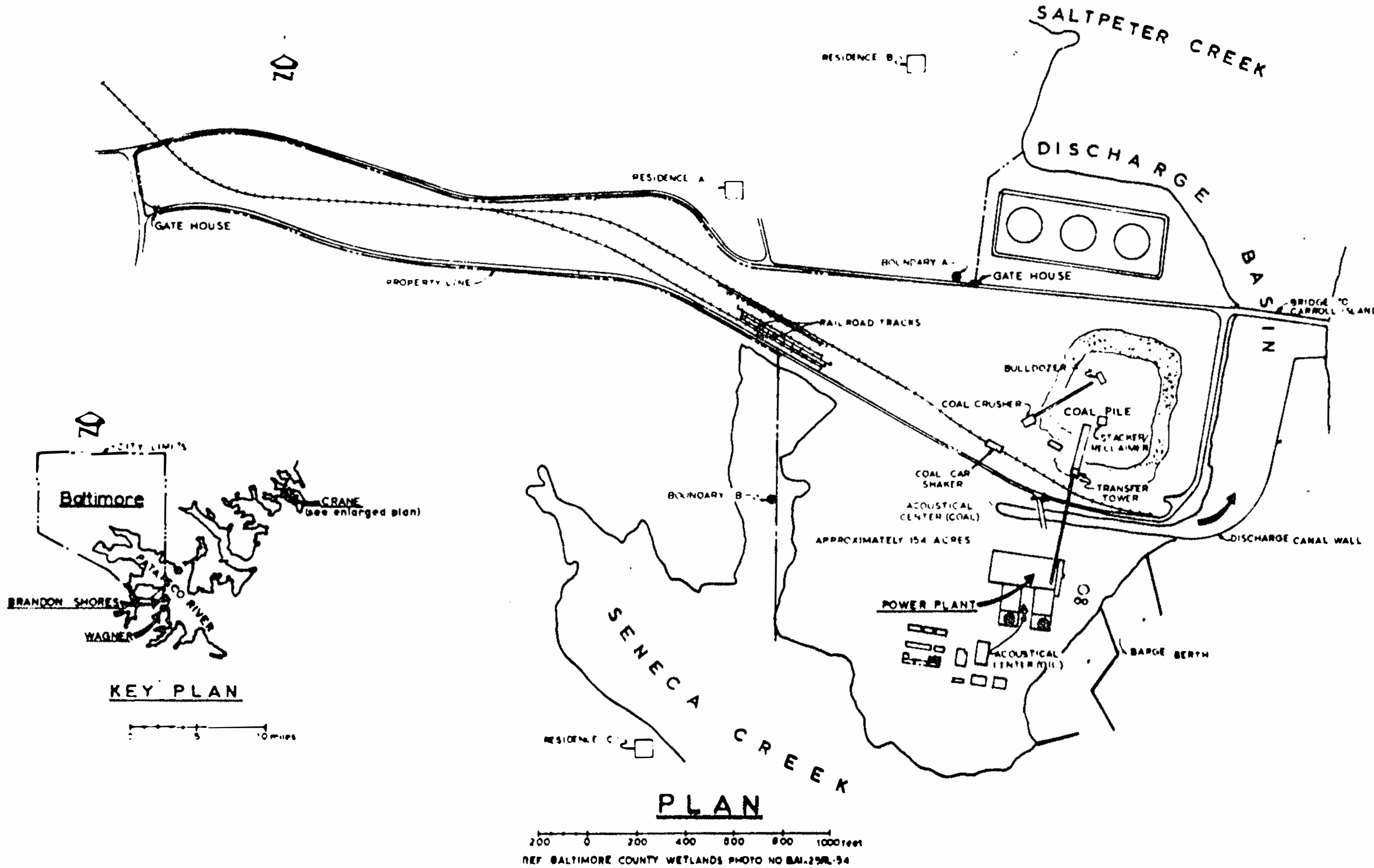


Figure 4.9. Location of Noise Sources Associated with Conversion to Coal and Receptor Locations Used in Noise Predictions at the Crane Generating Station

TABLE 4.45. Predicted Noise Levels (dBA) Associated with Coal-Fired Operation of the Crane Generating Station

Receptor[a]	Ambient[b]	Daytime Mode: Contribution Due to Coal Firing	Daytime Mode: Total[c]	Nighttime Mode: Contribution Due to Coal Firing	Nighttime Mode: Total[c]
Residence A	43	66	66	52	53
Residence B	41	65	65	53	53
Residence C	46	64	65	50	51
Boundary A	49	73	73	61	61
Boundary B	52	72	73	56	58

(a) See Figure 4.9 for locations.
(b) Predicted noise level on oil-base operation.
(c) Contribution plus ambient.

These predictions are tentative. The noise spectrum (standard octave band frequencies) of coal-handling equipment is generally characterized by high noise levels in the lower frequencies. All residences are separated by the generating station by varying areas of woods and fields. This type of terrain (Appendix I) would account for a significant reduction in environmental sound levels at the residential and boundary receptors. Additionally, the coal-handling sources were modeled as if they were operating in an unenclosed fashion. Noise levels produced by these sources at the Crane generating station may be lower than the levels used in the model, particularly if they are enclosed or insulated. A field survey would be needed to determine if coal firing at the generating station would result in violations of State noise standards.

There may be a high potential for complaints due to intrusive noise because of the rural quality of the area. Additionally, adjacent wetlands and the wildlife sanctuary on Carroll Island may harbor many species of birds which exhibit territorial breeding behavior. It is not possible to predict what the impacts associated with intrusive noise would be on these communities. Because the effects of noise are limited to areas relatively close to the source, research on the potential responses of wildlife to intrusive noise has not been conducted.

Brandon Shores

Because their station boundaries are contiguous, Brandon Shores and Wagner were considered as one source of noise for analytical purposes. Noise levels resulting from the coal-fired operation of Brandon Shores were estimated by Lewis S. Goodfriend & Associates, an acoustical engineering firm. Sound-level spectra for each major source of noise were derived from either the manufacturers' specifications or the literature such as the EEI (1978) manual and relevant acoustical journals. Contributions from each noise source were estimated at selected receptors and added to determine the predicted environmental noise levels that would result from operation on coal of the Brandon Shores generating station. Goodfriend and Associates also measured noise levels at the Wagner generating station with Units 3 and 4 in operation. Predicted noise levels are below both State daytime and nighttime standards.

The Goodfriend analysis (as referred to in Cwiklewski 1980), however, did not incorporate intermittent-noise sources in its predictions. Sources such as steam venting, soot blowers, backup-warning devices on coal-moving equipment, and public address systems generally exceed the ambient level of plant noise and may be annoying to nearby communities, particularly at night. The communities in proximity to the Brandon Shores site may be somewhat conditioned to intermittent-noise intrusions from the ongoing construction of Brandon Shores and from existing operations (including coal handling) at Wagner.

Construction noise most likely would exceed operational noise levels at Brandon Shores. Present scheduling calls for Unit 2 completion by 1988; hence, the natural environs within the plant boundaries and nearby communities could be subjected to sporadic episodes of noise as high as 90 dBA for some time. These levels may be disruptive to resident wildlife in the forests surrounding Brandon Shores and in nearby wetlands and rivershore areas.

4.7 SOCIOECONOMIC IMPACTS

The severity of any impacts that may occur due to the conversion of one or more of the four units at Brandon Shores *and Crane* depends upon the degree of new construction required, the availability of a local work force, the project schedule, and the ability of the surrounding region to provide a necessary service. Converting these units would create less socioeconomic impact than if new facilities were constructed, because the time and capital and laboi costs of converting a unit are much less than those associated with building a new unit. In the case of the Brandon Shores station, the units are currently under construction and the impact of converting and operating the units on an alternate fuel would represent a small incremental change.

4.7.1 Employment

Any labor and economic activity associated with the unit under consideration would be highly interrelated with the rest of the Baltimore-Washington area, which currently has a reserve of skilled labor (Section 3.8.2). Any additional labor requirements due to conversion may therefore be expected to be met in large part by this labor pool, although some specialists may have to be brought in from other areas.

Conversion

The additional labor needed to convert the four units at Brandon Shores *and Crane* is expected to be larger than that needed to operate the converted facilities. Assuming a worst-case situation of all units being converted at once, and the need for a labor force during conversion of 30 to 60 workers per generating station about 60 to 120 additional jobs would be created over the two and one-half to three-year duration of conversion operations. This is less than one-half of one percent of the total available construction labor force in the Baltimore Metropolitan area (Section 3.8.2). The maximum number of workers probably would not be employed during the entire construction period; their numbers would fluctuate as the need for different skills arose. Given the current and projected availability of housing and services in the area (Section 3.8.2), these additional workers could be accommodated with no significant impact. It is conceivable that local commercial establishments may experience a short-term increase in patronage from these workers.

Operation

The number of people working at the Crane generating station averages about 62 (DOE/EIA 1978). The number of people that would be employed at the Brandon Shores station is not known with certainty, but can be estimated by comparisons with other generating stations with operating characteristics similar to those anticipated at Brandon Shores. A similar station is Commonwealth Edison's 1064-Mw, 2-unit Collins station, which went into service in 1977 using oil. The average number of employees at that station was 142 in 1977 (DOE/EIA 1978). The number of people that would be employed at Brandon Shores can therefore be estimated to be 130 to 150 if the units burn oil.

Additions to the work force due to the operation of Brandon Shores *and Crane* on an alternate fuel would be negligible compared to the total work force in the area. Additional employees would be needed for operation of emission-control equipment, handling of solid waste for offsite disposal, and boiler maintainence. It has been estimated that conversion of a station to coal would add between 10 and 30 persons to the work force. If an FGD system were added to the system, approximately 25 additional people would be required. If RDF were burned, more people would be added for fuel handling; this analysis is based on the use of five additional people. These estimates agree with a comparison that may be made between similarly sized oil and coal-fired generating stations; Associated Electric Cooperative's two-unit, 1300-Mw New Madrid, Mo. station requires about 183 people when using coal without FGD, or about 40 more than the Collins oil-fired station (DOE/EIA 1978). Taking into account the fact that one New Madrid unit is older and requires about 50 more personnel than the other, similar-size New Madrid unit, an estimate of 30 additional personnel seems appropriate for a new converted station.

Table 4.46 gives the estimated number of additional operating personnel that may be expected for each scenario. As in the case of additional employment due to conversion activities, the approximately 100 to 150 additional people expected during operation of the stations would easily be accommodated in the community.

4.7.2 Community Impacts

A potential impact of fuel conversion at the community level would be the transport of fly ash and sludge from the generating stations to designated disposal areas. This is usually done with large 10-wheel, covered dump trucks, although a conveyor system might be used at Brandon Shores. Depending on how the trucks are scheduled, as many as 25 truck loads of waste (Scenario 4) may leave the Brandon Shores site per hour during daylight hours. However, because the proposed disposal site (Figure 4.4) is very close to the Brandon Shores station, impact on the community should be minimized until the near-site disposal area is filled.

As discussed in Section 4.8, some impacts due to traffic delays might occur if coal were delivered to the stations by rail. Transport by barge, the method currently being pursued by BG&E, would alleviate these impacts. According to DOE's fuel supply analysis, limestone would most likely be delivered by rail *and refuse-derived fuel probably would be hauled by truck. The probable routes of transporting RDF from production facilities would include sections of the Baltimore Beltway (I-695). Local traffic increases due to RDF transport would be less than 2 percent.* Generally transportation impacts can be reduced by using the most suitable transportation mode (barge, for instance), by limiting the hours of fuel and waste movements, and by minimizing route capacity conflicts by limiting truck and rail traffic to areas where access and activities are compatible.

4.8 ENERGY IMPACTS

The intent of FUA is to reduce or eliminate the use of petroleum fuels in certain generating station units and MFBIs. Conversion of the four units at Brandon Shores *and Crane* under consideration would displace fuel oil in the approximate amounts listed in Table 4.47 (ERA 1980b).

The consumption of coal varies slightly with each conversion scenario (Tables 2.1 and 4.48). The most oil is displaced in Scenario 3 and the worst-case scenario; these scenarios also consume the greatest quantities of coal.

Scenario 2, 3, 4, and 5 (Table 2.1) envision the use of a 90 percent coal, 10 percent RDF mixture for unit 1 of Crane. This would result in RDF requirements of about 85,000 tons/yr. This amount of RDF may be difficult to obtain from the Baltimore area; to the extent that RDF could be used in the BG&E units, however, the requirements for disposal of municipal solid waste would be reduced.

TABLE 4.46. Approximate Number of Additional Operating Personnel Needed Under Each Conversion Scenario

	1 (Base Case)	2	3	4	5
Brandon Shores	130 - 150	130 - 150	160 - 180	185 - 205	185 - 205
Crane	60	95	95	95	95
Total	190 - 210	215 - 245	255 - 275	280 - 300	280 - 300
Increase Over Base Case	No change	35	65	90	90

TABLE 4.47. Potential Oil Use Displaced by Conversion[(a)]

Plant	Units	Barrels/day
Brandon Shores	1	13,400
	2	13,600
Crane	1	5,320
	2	5,850
TOTAL		38,170

(a) Source: ERA 1980b.

TABLE 4.48. Fuel Quantities Required for Each Scenario (100 Percent Capacity)[(a)]

	Scenario									
	1	2			3		4		5	
	Oil, Gal/hr	Oil, Gal/hr	Coal, Ton/hr	RDF, Ton/hr	Coal, Ton/hr	RDF, Ton/hr	Coal, Ton/hr	RDF, Ton/hr	Coal, Ton/hr	RDF, Ton/hr
Brandon Shores Unit 1	41,700	41,700	-	-	248	-	257	-	248	-
Brandon Shores Unit 2	41,700	41,700	-	-	248	-	257	-	257	-
Crane Unit 1	15,500	-	70	22	70	22	70	22	70	22
Crane Unit 2	15,200	-	69	-	69	-	69	-	69	-
TOTAL	114,100	83,400	139	22	635	22	653	22	644	22

(a) Parameters for calculating fuel are those listed in Table 2.1.

TABLE 4.49. Limestone Requirements, Tons/Day

Scenario 4	78-wt Percent $CaCO_3$	95-wt Percent $CaCO_3$
Brandon Shores Unit 1	635	521
Brandon Shores Unit 2	635	521
TOTAL	1270	1042
Scenario 5		
Brandon Shores Unit 2	635	521

Although not a fuel, limestone would be consumed in the wet FGD systems described in Scenarios 4 and 5. The utility would have the option of using locally available (and possibly less expensive) 78-wt percent $CaCO_3$ limestone, or the more commonly used 95-wt percent $CaCO_3$ limestone. Limestone requirements for the two scenarios are given in Table 4.49.

Additional considerations include the energy cost of transportation of fuels and FGD reagents to the sites and transportation of solid wastes to disposal sites. Coal is projected to be delivered to the stations by barge, with rail as a back-up mode. Limestone (Scenarios 4 and 5) would be trucked to stations using wet FGD systems. *Refuse-derived fuel would also be brought in by truck; since there is no practical way to stockpile RDF, it would have to be supplied daily to Crane.* These uses of energy are insignificant in terms of the amount of energy (coal) that would be consumed to generate steam in the units, but they do add a small increment to the cost of generating electricity.

4.9 COAL-DELIVERY IMPACTS

Delivery of coal to the Brandon Shores generating station has been discussed and reviewed in a number of reports and letters (FBD 1980; ICF 1980). The principal alternatives for transporting coal to the site are by rail or by combined rail-barge delivery.[a,b]

4.9.1 All-Rail Delivery

Existing rail branch lines run to the adjacent Wagner generating station from the Curtis Bay coal pier facility in Baltimore Harbor. This line (about 7 miles long), connects with a rail network to coal mines in Northern Appalachia, and could be used for coal delivery.

All-rail transport poses several problems. For optimum efficiency, unit trains would be used to make the coal delivery. These trains are made up of about 100 cars each, and their efficiency lies in their use as a unit. The length of these trains is over 5000 feet (about 1 mile). The Curtis Bay branch line has seven grade crossings; five of these are on roads that are primarily used for access to industrial plants and have low traffic volumes except at shift changes. Two of the crossings are on State Routes 710 (Ordinance Road) and 713 (Pennington Avenue), and carry a greater volume of traffic. Unless otherwise regulated, it is accepted policy that trains should not block road crossings for more than 10 minutes. This limit would apply to the Ordinance Road crossing. The Pennington Avenue crossing is within the City of Baltimore, and a city ordinance limits delays at road crossings to 5 minutes. The estimated time for a unit train to clear a crossing is from 5.4 to 7 minutes. Trains

(a) Letter to J. Polasek, ERA, from S. A. Link, BG&E, dated March 23, 1981.
(b) Letter to W. Muir, EPA, from G. Keizur, PNL, dated April 15, 1981 confirming telephone conversation regarding status of Chessie Systems property.

that are delayed by an opening of the drawbridge over Curtis Creek would block the Ordinance crossing for 11.4 minutes. It is evident that unit trains would have difficulty in clearing road crossings within the specified time limits. An alternative would be to deliver coal in trains composed of less than 100 cars. This could increase the delivered cost by $1.64 to $3.66 per ton or $13,000 to $29,000 per day at a use rate of 12,000 tons per day (ICF 1980).

Four trains per day presently use this line. The addition of approximately one unit train per day would lead to problems in scheduling rail traffic so that there would be minimal interruption at road crossings and so that the blockage at crossings would not prevent the passage of emergency vehicles (e.g., ambulances and fire trucks).

According to DOE's internal analyses, the branch line would need upgrading in order to handle unit trains. The tracks can presently handle loads of about 7,000 tons; a unit train weights over 12,000 tons.

The feasibility of bringing unit trains to Brandon Shores would be limited by the space available for turning the trains around. BG&E attempted to obtain land immediately north of the site for unit-train delivery of coal. An agreement to use the land was not reached with the owner, the Chessie System.[a] Turning a unit train at the Brandon Shores site would require tracks that encircle most of the site, plus the construction of three over- and underpasses to prevent the isolation of the site at times when trains are unloading coal. These tracks and the necessary relocation of the coal piles would occupy space that could be used for a third generating unit at Brandon Shores.

The noise and fugitive dust from unloading coal trains would probably be greater than that from barge delivery of coal. Although trains are exempt from noise regulations, additional noise would be produced by the passage of unit trains to and from Brandon Shores.

The Chessie System and SOROS, a consortium of coal companies, are considering constructing a coal-export facility on the property north of Brandon Shores. Because this project is still in the planning stage, there is no assurance that it would be a coal-supply outlet for Brandon Shores.[b]

4.9.2 Rail-Barge Delivery

There are four coal-loading piers on Chesapeake Bay; two at Baltimore, MD, and two at Norfolk, VA. These piers receive coal by rail and ship it by barge. In addition, five other coal facilities are planned in the Baltimore, Norfolk, and Newport News areas.

Coal is presently delivered by barge to Wagner Unit 3. The greater fuel capacity of Brandon Shores required the dredging of a channel for larger, deeper-draft barges. A channel covering about 70 acres of Patapsco River bottom, including the existing Wagner channel, is required for 7,000-ton barges. About 462,000 yd^3 was removed from this channel and transferred to a spoils-disposal area. The Marley Neck site is located on the Chessie System's property north of Brandon Shores for spoil disposal.

The estimated impacts of the barge channel dredging and dredge-spoil disposal on water quality and ecology have been discussed in Sections 4.3.1, 4.4.2, and 4.5.3.

Clamshell dredges were used to remove the bottom material from the channel and load it on barges, which transport the spoils to the Marley Neck site. About 5 percent (about 23,000 yd^3) of the

(a) Letter from S. A. Link, BG&E, to J. Polasek, ERA, March 23, 1981.
(b) Letter from G. Keizur, PNL, to W. Muir, EPA, April 15, 1981.

material lifted by the dredge was lost to the water. This created a zone of increased turbidity (80 mg suspended solids/l) at distances to approximately 700 meters. Little change would occur in the concentration of trace metals in the river due to the dissolution of materials in the disturbed sediments. Concentrations of the toxicants eluted from Patapsco River sediments are usually below water-quality standards. Some reduction in the amount of dissolved oxygen in the water was measured in laboratory elutions of Patapsco River sediments. A reduction in dissolved oxygen was less evident in actual dredging operations in the upper Chesapeake Bay. Little change in water quality will occur outside the mixing zone, and the water quality that may be degraded within the mixing zone will return to normal when the dredging is complete.

Benthic organisms disturbed by dredging are destroyed, and some benthic organism mortality may occur in the areas adjacent to the channel. The reestablishment of bottom organisms in this zone occurs rapidly after dredging is completed. Fish and other organisms that live in the water column of the river are tolerant of suspended sediments and toxic materials that are introduced into the water by the dredged sediments. Laboratory exposure of marine fish and shellfish to sediments from Bear Creek, which flows into the Patapsco River near BG&E's Riverside Generating Station (across the river from Brandon Shores), did not produce toxic effects at pollutant concentrations predicted to occur during channel dredging.

The management of the dredge spoils will be the responsibility of the site operators. The site is diked to retain water that drains from the dredge spoils, plus runoff due to precipitation. This water will not be discharged to surface waters if it fails to meet water-quality standards. Uncontrolled infiltration of the drainage from the spoils-disposal site could contaminate ground waters. Controls as a condition of site operation would prevent this from occurring.

It is expected that maintenance dredging of the barge channel will be required every 4 to 6 years. The quantity of dredge spoil removed and the associated impacts would be less than those experienced when the original channel was constructed. Disposal of dredge spoils from maintenance dredging may not be possible at the Marley Neck disposal site. This location has a total capacity of about 1.5 million yd^3. About 400,000 yd^3 of this capacity has already been used. With the disposal of 462,000 yd^3 from the Brandon Shores barge channel, only about 638,000 yd^3 of capacity would remain. This capacity could be consumed by the time maintenance dredging of the channel becomes necessary.

Land use of the spoils-disposal site would not change due to the development of the Brandon Shores channel, because the spoils site is already established.

The potential impacts of barge delivery of coal are mainly degradation of water quality and destruction of aquatic life within the mixing zone during actual dredging. Impacts from rail delivery center around the difficulties from tying up automobile traffic at road crossings and problems with turning unit trains in the limited space at the Brandon Shores site. In the absence of identifiable long-term impacts from barge delivery, it appears that barge delivery of coal to Brandon Shores is preferable to rail delivery via the Curtis Bay branch line.

4.10 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Some unavoidable impacts to the human environment will occur if one or more of the four units at the Brandon Shores *and Crane* generating stations is converted to the use of an alternate fuel.

The impacts related to possible conversion activities can be considered to be minor or negligible except as noted below.

4.10.1 Air Resources

Most potential impacts from conversion of the four units can be mitigated through the use of more effective emission-control measures. It is likely, however, that the total atmospheric loading of SO_2, NO_x, and particulate matter from the units will increase. The most significant concentration change would be an increase in SO_2 over areas immediately surrounding Brandon Shores *and Crane*

With the exception of Scenario 4, conversion of the units would consume most of the available PSD increment for 24-hour and 3-hour SO_2 emissions. This would occur mainly in the vicinity of the Brandon Shores station under Summer daytime conditions.

4.10.2 Water Resources

Unavoidable adverse impacts on water resources due to construction activities will be minimal. Dredging of a portion of the Patapsco River at Brandon Shores for construction of a coal-unloading facility increased suspended sediments and decrease dissolved oxygen around the point of bottom disturbance. Similar effects will occur during maintainance dredging operations. Such effects occur during the period of dredging and no permanent effect is projected.

The surface- and ground-water quality impacts of operation of the units after they have been converted to an alternate fuel are limited primarily to the potential for contamination from surface runoff or leaching of coal piles, ash ponds, ash-disposal areas, dredge spoils, and FGD sludge-disposal piles. Measures designed to treat runoff water (including oxidizing reduced metals, neutralizing the acidic effluent with lime, and clarifying and filtering of the solution) would mitigate in large part any chance of water-quality impact.

BG&E's plan to install impermeable liners or underdrain collection systems will minimize this possible contamination of ground water and surface water by coal-pile leachate at the Brandon Shores site. *At Crane, leachate could move into the Seneca-Saltpeter Creek and Patapsco River estuaries.*

4.10.3 Land Resources

Operation of the units on coal or another alternate fuel would greatly increase ash production. The disposal of this ash and, possibly, FGD sludge would require more land than is available at existing disposal sites. The utility is considering the purchase of a 282-acre site adjacent to the Brandon Shores generating station for use as an ash disposal site. A study by Dames and Moore (DM 1980) concluded that the site would be suitable for such use.

Construction of a barge channel for coal delivery to Brandon Shores led to the need for disposal of about 462,000 yd^3 of spoils material. This material was disposed of in a permitted dredge-spoils disposal site on Marley Neck.

4.10.4 Biological Resources

Disposal of coal ash and scrubber sludge by landfill would result in the loss of habitat for some terrestrial animals. The extent of habitat loss depends on the site selected and the amount of solid waste produced.

Toxicological hazards associated with coal-pile runoff and solid-waste leachates are expected to be controlled by proper waste management. During dredging operations, resuspension or dissolution of toxic components in the sediment may pose a temporary hazard to aquatic life.

4.10.5 Social and Cultural Impacts

The influx of construction workers at the Crane Generating Station may have some minor impacts on nearby communities. Vehicular traffic will increase, and ambient noise levels will be somewhat higher at certain times than noise levels are at present.

Brandon Shores, which is presently under construction, should not experience any significant change in social and cultural impacts due to fuel conversion.

During operations, the most significant impact of conversion at the community level is expected to be traffic problems created by transporting the fly ash and/or sludge from the powerplant sites to designated disposal areas.

4.10.6 Fuel, Limestone and Other Resources

The conversion of the four units to alternate fuels would, of course, result in the use of those fuels in place of oil. If FGD systems are installed, limestone would also be consumed.

Coal and limestone are nonrenewable resources, although the domestic supply of each is substantial. Because oil is in shorter supply domestically than coal, these conversions would reduce the severity of impact on fuel supplies.

Refuse-derived fuel is a renewable resource; its use as a fuel also reduces problems associated with municipal solid-waste disposal.

Other resources in the form of construction materials and equipment would be used as a result of conversion activities; the total impact in terms of resource use of this consumption is negligible. The construction activities associated with conversion would have a positive impact on the local economy.

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APPENDIX A

Health Effects of Exposure to Agents Produced by Coal Combustion

Taken directly from the Northeast Regional Environmental Impact Statement (DOE/EIS-0083)

HEALTH EFFECTS OF EXPOSURE TO AGENTS PRODUCED BY COAL COMBUSTION[a]

SULFUR DIOXIDE

Acute

Sulfur dioxide is a colorless gas with a pungent, irritating odor. Human sensory detection occurs between 1.3 and 2.6 mg/m^3 (0.5 to 1 ppm) (Walsh et al. 1981). SO_2 is a potent, pulmonary irritant at concentrations above 26 to 52 mg/m^3 (10 to 20 ppm). At lower levels, changes in pulmonary function have been observed in the laboratory (National Research Council 1978). Acute studies with a variety of animals generally indicate that SO_2 concentrations >2.6 mg/m^3 (1 ppm) are necessary to produce changes in pulmonary function (National Research Council 1978). However, Amdur et al. (1978) have observed an increase in pulmonary flow resistance in guinea pigs exposed to only 0.84 mg/m^3 (0.32 ppm) SO_2 for 1 hour.

Clinical research with human subjects has indicated a wide range of sensitivity to SO_2 and the interdependence of factors including activity level, route of breathing (oral or nasal), timing of exposure and health status (National Research Council 1978). Exposures of normal, healthy, resting subjects to SO_2 concentrations of 13 mg/m^3 (5 ppm) or more for 2 hours have decreased pulmonary function and nasal mucus flow. Experimental results from exposures of healthy persons to SO_2 concentrations <13 mg/m^3 (5 ppm) are more variable. Several investigators have detected decreased lung function in normal subjects while breathing through a variety of regimes and equipment of concentrations as low as 1.95 mg/m^3 (0.75 ppm). Exercise and mouth breathing have generally enhanced the severity of response in these experiments. Asthmatics have reacted to lower concentrations of SO_2 than healthy subjects in many of these tests. In a series of recent experiments, mild asthmatics exposed to concentrations as low as 260 μg/m^3 (0.1 ppm) SO_2 experienced reduced airway resistance and increased symptoms such as wheezing (Sheppard et al. 1980, 1981). Several researchers have not detected adverse effects on pulmonary function at levels of SO_2 <13 mg/m^3 (5 ppm), however (National Research Council 1978). It must also be noted that at lower exposure levels both normal and asthmatic subjects demonstrate considerable variability in sensitivity in SO_2. For example, Jaeger et al. (1979) in their studies of 80 healthy nonsmokers and asthmatics, found a single healthy teenager and two asthmatics affected by 1.3 mg/m^3 (0.5 ppm) SO_2 after 3 hours of mouth breathing. Amdur (1973, 1974) and Horvath and Folinsbee (1977) have suggested that 10 percent of the total population may be especially sensitive to SO_2.

Epidemiological studies of past air pollution episodes have repeatedly demonstrated an association between acute high levels of SO_2 and particulate matter (PM) and increases in morbidity and mortality (Walsh et al. 1981). Attempts to separate out the effects of one pollutant or the other have not been successful. Reviews by Higgins (1974), Holland et al. (1979), and Shy et al. (1978) conclude that during major pollution episodes in London during the late 1940s and early 1950s, increases in mortality were associated with SO_2 and PM (measured by the British smoke [BS] method) levels of 1000 μg/m^3 and above. Studies by Glasser and Greenberg (1971) and McCarroll and Bradley (1966) indicate that small increases in mortality among the elderly occurred in New York City in the early 1960s when SO_2 levels were in excess of 1000 μg/m^3 and PM was in the range of 5.0 to 7.0 coefficient of haze (CoH) units.

(a) This appendix is taken directly from Appendix C of the October 1982 "Final Northeast Regional Environmental Impact Statement, the Potential Conversion of Forty-Two Powerplants from Oil to Coal or Alternate Fuels," prepared by the U.S. Department of Energy, Washington, D.C. Citation to a specific table, figure, section, or source is in reference to the Northeast Regional Environmental Impact Statement.

Lawther (1963) associated increased daily mortality with PM levels >750 $\mu g/m^3$ (BS) and SO_2 in excess of 715 $\mu g/m^3$ (0.25 ppm) during a winter characterized by the presence of thick fog. Martin and Bradley (1960) found a readily identifiable increase in mortality when PM and SO_2 concentrations ranged from 500 to 1000 $\mu g/m^3$ (BS for PM). Martin (1964) again found a correlation between excess mortality during winter and PM levels of 500 to 600 $\mu g/m^3$ (BS) and above and SO_2 levels higher than 400 to 499 $\mu g/m^3$. Excess mortality was most dramatic at PM levels over 1200 $\mu g/m^3$ (BS) and SO_2 levels over 900 $\mu g/m^3$. Glasser and Greenberg (1971) identified substantial correlations between mortality and SO_2 levels over 786 to 1048 $\mu g/m^3$ with PM above 5.0 to 4.9 CoH. Based upon the analysis of these studies and others which show a qualitative relationship between PM, SO_2 and mortality, the World Health Organization adopted a figure of 500 $\mu g/m^3$ for each pollutant as the minima associated with short-term increase in mortality (Walsh et al. 1981). Excess deaths occurring during these episodes were primarily attributed to bronchitis, pneumonia and cardiac diseases and generally occurred among persons 45 yr of age and older. At lower pollutant concentrations attempts to detect increased mortality have been difficult because of confounding variables such as temperature ad influenza epidemics.

Other studies indicate no relationship between SO_2 concentrations and mortality but rather that PM plays the predominant role (Walsh et al. 1981). In any case, from the studies that have been conducted, it is impossible to relate adverse health effects of SO_2 alone.

Lawther et al. (National Research Council 1978) found SO_2 concentrations of 250 to 300 $\mu g/m^3$ and 350 $\mu g/m^3$ TSP (converted from BS data) to be minimal daily concentrations associated with symptoms in patients with chronic bronchitis. The authors indicated that shorter-term fluctuations in pollution levels may have been responsible for the adverse effects detected, however. Emerson only found a weak association between similar daily TSP levels in conjunction with SO_2 concentrations of 722 $\mu g/m^3$ and decreased pulmonary function in chronic obstructive pulmonary disease patients (National Research Council 1978). Based upon these and other epidemiological studies in this country, Great Britain and Europe, the National Academy of Sciences Committee on Sulfur Oxides (National Research Council 1977) concluded that 24-hr concentrations of 300 $\mu g/m^3$ SO_2 and PM (as TSP) appear as the levels above which acute morbidity apparently increases and that 180 $\mu g/m^3$ (0.07 ppm) SO_2 and 180 $\mu g/m^3$ PM (as TSP) should not be exceeded if the most sensitive asthmatic subjects are to be protected from increases in symptoms.

Chronic

No acceptable epidemiological studies quantitatively relate respiratory disease mortality to chronic (long-term) exposures to SO_2 or PM. Several researchers have reported correlations between annual 24-hr average SO_2 and PM concentrations in the range of 100 to 300 $\mu g/m^3$ (PM as TSP) and decreased phlegm production, prevalence of chronic nonspecific respiratory disease and decreased pulmonary function in adults, and respiratory symptoms, decreased pulmonary function and increased lower respiratory tract involvement in children (National Research Council 1978). Ferris et al. found an association between 180 $\mu g/m^3$ of PM (as TSP) and ~56 $\mu g/m^3$ SO_2 and decreased respiratory function accompanied by symptoms in adults (National Research Council 1978). In a followup study no association was found between pulmonary function or symptoms and 131 $\mu g/m^3$ PM (as TSP) in combination with ~66 $\mu g/m^3$ of SO_2. Lambert and Reid (1970) found an association between the prevalence of cough and phlegm and PM concentrations in excess of 100 $\mu g/m^3$ (BS) and SO_2 concentrations over 150 $\mu g/m^3$ in postal workers in England. Becklake et al. (1979) reported significant differences in lung closing volume function test results associated with annual SO_2 levels up to 123 $\mu g/m^3$ and annual PM levels of 131 $\mu g/m^3$ (TSP).

In summary, chronic exposure to SO_2 as low as 150 to 275 $\mu g/m^3$ concurrent with PM levels between 100 and 300 $\mu g/m^3$ (BS) have been strongly associated with a greater prevalence of respiratory symptoms in adults and a likely increased frequency of lower respiratory symptoms and decreased lung function in children. 180 $\mu g/m^3$ of PM (measured as TSP) with very low levels of SO_2 has been related to decreased pulmonary function in adults. Several other studies indicate effects from chronic exposure to particulate matter and SO_2 at lower levels than those cited above, but due to inadequacies in methodology little confidence can be placed in their results at this time.

PARTICULATE MATTER

Ambient particulate matter is often composed of sulfur compounds, and identification of the effects of ambient aerosols and particles independent of sulfur compounds may be impossible. Atmospheric particles are also comprised of heavy metals as oxides or salts and a wide range of volatile organic compounds.

Information from occupational exposures indicates that health effects are highly dependent upon the physical and chemical characteristics of the particles. Mineral dusts are generally not fibrogenic and accumulate in the reticulum framework of the lung without provoking any inflammatory responses. These inert dusts generally only present adverse health impacts after excessive exposure to concentrations several-fold over those which occur in the ambient environment (Hamilton and Hardy 1974). Other particles such as silica are capable of inducing a variety of pneumoconiosis-type diseases at lower levels of exposure, while metal particles can produce respiratory and systemic disease (Hamilton and Hardy 1974).

Few toxicological studies have been conducted on the complex particles that occur in ambient air. Since a large proportion of ambient aerosols are comprised of sulfur compound, the research that has been done has focused on sulfur-containing particles and aerosols. The following discussion of acute and chronic effects of atmospheric particles and aerosols will address sulfuric acid (H_2SO_4), sulfates (sulfur oxides), nitrates (nitrogen oxides), and respirable particles. Hydrocarbons and other organic particles and trace metals are discussed separately.

SULFURIC ACID

Acute

Amdur (1952, 1971) identified that acute lethal toxicity in laboratory animals varies with species, age (being more toxic in the young), particle size (~2 μm being the most toxic size), and temperature (toxicity increases with extreme cold). The acute toxicity of H_2SO_4 aerosols is more a function of concentration than length of exposure. Cockrell and Busey exposed guinea pigs to 25 mg/m^3 H_2SO_4 (MMD of 1 μm) for two days and reported segmented alveolar hemorrhage, Type 1 pneumocyte hyperplasia and proliferation of pulmonary macrophages. Extensive experimentation by Amdur and cohorts has revealed pulmonary functional effects at H_2SO_4 concentrations ranging from 0.11 to 43.6 mg/m^3, with particle size generally <2.5 μm MMD (National Research Council 1978). Recently, Amdur et al. (1978) reported a rectilinear relationship between H_2SO_4 concentrations and pulmonary flow resistance in guinea pigs at concentrations as low as 50 to 150 $\mu g/m^3$ (National Research Council 1978). Amdur et al. (1978) described H_2SO_4 as producing six to eight times the pulmonary response as SO_2 did in other work conducted by this same author using similar experimental methodology.

Human respiratory effects from laboratory exposure to sulfuric acid mist in concentrations ranging from 0.35 to 5.0 mg/m^3 include increased respiratory rate and decreased maximum inspiratory and expiratory flow rates and tidal volumes (Amdur et al. 1952). Sim and Pattle (1957) determined that respiratory response to H_2SO_4 is directly proportional to relative humidity. Except for the work of Amdur cited above, acute exposures of healthy subjects have shown no effects on the pulmonary function at H_2SO_4 concentrations up to 1000 $\mu g/m^3$, even during exercise (National Research Council 1978). Lippman et al. (1980) found increased mucociliary clearance in nonsmokers at H_2SO_4 levels of 100 $\mu g/m^3$ and above and decreased clearance distal to the trachea at 1 mg/m^3 and above. Utell et al. (1981) found exposure to H_2SO_4 at 1 mg/m^3 potentiated the bronchoconstrictor action of carbachol in healthy and asthmatic subjects. Asthmatic subjects have not shown changes in airway function after exposures up to 1 mg/m^3 of H_2SO_4 (Sackner et al. 1978).

Fairchild et al. (1975) revealed that concentrations of H_2SO_4 as low as 30 $\mu g/m^3$ shifted the deposition pattern of nonviable bacteria in the respiratory tracts of guinea pigs towards the upper respiratory tract. Schlesinger et al. (1978) demonstrated that 1-hour exposures to 0.3 to 0.6 μm H_2SO_4 aerosols at concentrations ranging from 0.19 to 1.36 mg/m^3 slowed particle clearance in the bronchi of donkeys.

Chronic

As with acute studies, chronic lethal toxicity investigations with animals reveal that the concentration of H_2SO_4 and not the duration of exposure is the most important parameter influencing toxicity. Subchronic continuous exposure to monkeys at concentrations between 0.38 and 4.79 mg/m^3 H_2SO_4 produced morphological changes in bronchiolar epithelia (Alaire et al. 1973). No changes were seen in dogs exposed to 0.89 mg/m^3 of predominantly 0.5 μm H_2SO_4 aerosols. Guinea pigs, highly sensitive to H_2SO_4 in acute experimentation, were not affected by 52 weeks of continuous exposure to up to 100 $\mu g/m^3$ H_2SO_4 (Alaire et al. 1973). Schlesinger (1978) showed development of persistently slowed bronchial clearance of particles after about 6 exposures to H_2SO_4 at 0.19 to 1.36 mg/m^3 in two of the four donkeys tested. Followup experiments using repeated 1-hour exposures to 0.1 mg/m^3 H_2SO_4 produced erratic bronchial clearance rates, again in donkeys (Schlesinger 1978). Sustained and progressive slowing of clearance was again produced in two of four test donkeys. Studies with dogs found similar results while studies with sheep found no alterations in lung clearance rates at H_2SO_4 concentrations of 14 mg/m^3 (Wolff et al. 1979, Sackner et al. 1978).

No information is available on chronic exposures to H_2SO_4 in humans but it has been hypothesized based upon both acute and chronic animal test results and acute studies with humans that chronic exposure to 100 $\mu g/m^3$ H_2SO_4 could produce persistent changes in mucociliary clearance in previously healthy individuals and exacerbate conditions in those with existing respiratory disease (Walsh et al. 1981).

SULFATES

Acute

The effects on pulmonary function produced by sulfate aerosols are similar to those produced by sulfuric acid (National Research Council 1978). Amdur has ranked the relative irritancy of a number of sulfate aerosols administered to guinea pigs using similar experimental methodology and found zinc ammonia sulfate [$Zn(NH_4)_2(SO_4)_2$] to be most toxic (National Research Council 1978). Its irritant effects on pulmonary function were stated to be approximately one-third of those detected with H_2SO_4 using aerosols in a similar size range. Table A.1 lists the relative irritancy of other sulfates tested by Amdur et al. (1978).

Based on Amdur's work it is difficult to assess the relative irritancy of sulfur compounds in ambient air because of the importance of particle size. For example, if ferric sulfate is present in the atmosphere in particles with diameters <1 μm while H_2SO_4 is associated with particles having diameters >1 μm, ferric sulfate would be more toxic to exposed animals because of greater penetration of this compound. On the basis of sulfur equivalents, the same amount of sulfur as zinc ammonium sulfate is 16 times as toxic as it would be in H_2SO_4, which in turn is four times as toxic as the same amount of sulfur would be if it existed as SO_2.

Hackney (1978) reported pulmonary function effects in monkeys after 1-hour exposure to $(NH_4)_2SO_4$, $ZnSO_4$, and NH_4HCO_4 at concentrations of 2.5 mg/m³, but not from NH_4SO_4 or NH_4NO_3 at the same concentrations. Ehrlich et al. (1978, 1979) found no significant alterations of host defense mechanisms in mice after 3-hour exposures to ammonium sulfate, ammonium bisulfate, NO_2SO_4, $Fe(SO_4)_2$ or $Fe(NH_4)_2SO_4$ at concentrations ranging from 2.5 to 6.7 mg/m³ SO_4. Similar exposure to generally lower levels of cadmium sulfate, copper sulfate, aluminum sulfate, zinc ammonium sulfate, and magnesium sulfate between 0.2 and 3.6 mg/m³ SO_4 enhanced bacterial induced mortality over controls by 20 percent. These results suggest that the ammonium ion decreases sulfate toxicity to mice respiratory tract defense mechanisms while toxicity is associated with the cation.

Utell et al. (1981) exposed 16 normal subjects and 17 asymptomatic asthmatics to $NaHSO_4$ $(NH_4)_2SO_4$ and NH_4HSO_4 and then to the bronchoconstrictive agent carbachol. Concentrations of 1 mg/m³ NH_4HSO_4 potentiated the effects of carbachol in asthmatics. Lower sulfate exposures produced no effect. Kleinman and Hackney (1978) and Avol et al. (1979) evaluated the effects of a variety of sulfates on normal subjects, those identified as ozone-sensitive and asthmatics. The subjects exercised during their 2-1/2 hour exposure periods and the test conditions were 88°F and 40 percent or 85 percent relative humidity. Pulmonary function was unaffected in the subject pool after NH_4HSO_4 exposures of 100 μg/m³ and ammonium sulfate concentrations of 85 μg/m³. Asthmatics exposed at 40 percent RH to 372 μg/m³ $(NH_4)_2SO_4$ similarly showed no reaction.

General conclusions from human acute experimentation indicate that concentrations <1 mg/m³ sulfate produce only infrequent, slight, or transient changes in pulmonary function (National Research Council 1978).

Ispen and coworkers could find no correlation between sulfate levels and absences due to illness in working populations at ambient concentrations reaching 35 μg/m³ (National Research Council 1978). Investigations by Lave and Seskin, Winkelstein et al. and Winkelstein and Kantor have associated ambient sulfate concentrations to excess mortality (National Research Council 1978). A series of CHESS studies conducted in the U.S. in the late 1960s and early 1970s similarly associate ambient sulfates with excess mortality and a variety of morbidity endpoints (USEPA 1974). However, the limitations of these studies reduce their usefulness beyond providing qualitative evidence of an association between air pollution and adverse health effects and identifying the many difficulties in conducting community air pollution health effects research (National Research Council 1978, USEPA 1980).

NITRATES

Acute

No significant pulmonary effects were found in healthy and asthmatic volunteers after laboratory exposure to 7 mg/m³ $NaNO_3$ for 16 minutes. The particles had a MMD of 0.49 μm (Walsh et al. 1981). Epidemiological studies have demonstrated an association between atmospheric nitrate levels and exacerbation of pulmonary symptoms in elderly and asthmatic persons at nitrate levels of 2 to 7.2 μg/m³ (Walsh et al. 1981). As with sulfate epidemiological research, these results may suffer from interference of confounding environmental variables. No information on the effects of chronic exposure to nitrates in animals or humans has been found.

NITROGEN DIOXIDE (NO_2)

Acute

Respiratory illness from acute exposure to low levels of nitrogen dioxide (NO_2) ranges in severity from slight irritation to burning and pain in the chest to violent coughing and dyspnea. Exposure to higher levels can produce chronic lung disease and death (Walsh et al. 1981). Laboratory research has shown that pre-exposure to NO_2 reduces the resistance to respiratory infection in laboratory animals (Walsh et al. 1981). This effect has occurred after exposures to 3.6 mg/m³ (2.0 ppm) NO_2 (National Research Council 1977). Reduced resistance to bacterial infection is thought to result from interference to alveolar macrophage activity and may occur in humans (Walsh et al. 1981).

Clinical studies with human volunteers by von Neiding, and Rokaw and Suzaki indicate that reversible increases in airway resistance occur after 15 to 45 minute exposures to NO_2 at concentrations of 2.8 to 3.8 mg/m³ (1.5 to 2 ppm) (National Research Council 1977). Orehek et al. reported increased airway resistance in 3 of 20 asthmatic subjects and increased sensitivity to carbachol, a bronchoconstrictor, in 13 of 20 asthmatics exposed to 200 μg/m³ (0.11 ppm) NO_2 for 1 hour (Walsh et al. 1981). This has been the only adverse health effect reported in humans clinically exposed to NO_2 concentrations <2.82 mg/m³ (1.5 ppm).

Chronic

The chronic health effects of NO_2 are less well documented (National Research Council 1977). Continuous or prolonged intermittent exposure for 3 or 6 months to 940 μg/m³ (0.5 ppm) NO_2 reduced the resistance to bacterial infection of laboratory animals. Pathological and physiological abnormalities of increasing severity have been seen in animals exposed to higher concentrations. Epidemiological studies indicate the presence of excess acute infectious respiratory disease in healthy human populations after exposure to 100 to 580 μg/m³ (0.053 to 0.31 ppm) NO_2. Other epidemiological studies found changes in ventilatory function in populations exposed to >150 μg/m³ (0.08 ppm). The results from these epidemiological studies must be interpreted with caution, however, because other air pollutants capable of inducing the observed effects were also present.

OZONE AND PHOTOCHEMICAL OXIDANTS

Acute

Ozone is the major component of photochemical oxidant mixtures and has recently been recognized as a reliable indicator of the adverse health effects due to this group of pollutants (USEPA 1978). Ozone and the other constituents in photochemical smog generally cause biological effects in animals and humans similar to those associated with nitrogen dioxide. While the toxicological and health endpoints are similar, ozone (O_3) is considerably more toxic than NO_2.

Acute experiments with animals indicate a range of effects from exposure to O_3 concentrations of 392 to 1960 μg/m³ (0.2 to 1 ppm) including altered pulmonary function, morphological changes in pulmonary tissue, biochemical effects and alterations of genetic material (USEPA 1978). Increased susceptibility to bacterial infection has been detected in a number of investigations with animals upon short-term exposure to 196 μg/m³ (0.10 ppm) O_3 and lower (USEPA 1978, National Research Council 1977).

Data from clinical experimentation with humans is highly suggestive that alterations in pulmonary function occur upon acute exposure (hours) to 1.47 μg/m³ (0.75 ppm) O_3 in lightly exercising subjects. Experimental results are more variable at lower levels of exposure. Several researchers have identified changes in pulmonary function after 2-hr exposures to 730 μg/m³ (0.37 ppm) in subjects exercising intermittently (USEPA 1978). Another researcher detected changes only in known O_3-sensitive subjects (persons who have demonstrated an abnormally high susceptibility to the irritating properties of O_3) at this level. This same researcher, in another study, found Canadian subjects to react to 730 μg/m³ (0.37 ppm) O_3 while Californian subjects similarly exposed were not affected (USEPA 1978). This result indicates development of tolerance to O_3-induced physiological changes which are detected by pulmonary function. De Lucia and Adams observed changes in lung function and respiratory patterns in two of six healthy adults undergoing strenuous physical exercise after 1-hour exposures to O_3 levels of 590 $\mu g/m^3$ (0.30 ppm) and again at 290 $\mu g/m^3$ (0.15 ppm); two other researchers have detected alterations in pulmonary function in a portion of subjects tested at 200 $\mu g/m^3$ (0.1 ppm) O_3 (USEPA 1978). Hackney et al., however, were unable to detect any effects at 490 $\mu g/m^3$ (0.25 ppm) O_3, even in "reactive subjects" (USEPA 1978). All changes in lung function detected in the above research have been reversible. These laboratory experiments have also detected self-reported symptoms including throat tickle, substernal tightness, pain upon deep inspiration and cough in exposed subjects at levels associated with altered pulmonary function (USEPA 1978). The symptoms are proportional to dose. During strenuous exercise, symptoms occasionally prevented subjects from completing the tests. Ozone irritates the major bronchi of test subjects at 490 $\mu g/m^3$ (0.25 ppm) (USEPA 1978).

Researchers have detected increased lysis of blood erythrocytes in healthy human subjects following O_3 exposure to concentrations as low as 730 $\mu g/m^3$ (0.37 ppm). There is conflicting evidence whether or not acute exposure at this level produces chromosome abnormalities in lymphocytes of healthy subjects. Other biochemical changes in the blood of human subjects exposed to O_3 at levels <980 $\mu g/m^3$ (0.5 ppm) have been determined, but the clinical significance of these effects is unknown (USEPA 1978).

Epidemiological research has associated total oxidant exposures in the range of 200 to 290 $\mu g/m^3$ (0.10 to 0.15 ppm) and greater with failure of high school cross country runners to improve running performance (Wayne et al. reported in USEPA 1978). These results have been verified by re-analysis. Hammer et al. found an association in students between chest discomfort and maximum hourly oxidant levels of 490 to 570 $\mu g/m^3$ (0.25 to 0.29 ppm), cough and oxidant levels of 590 to 760 $\mu g/m^3$ (0.3 to 0.39 ppm) (USEPA 1978). These findings correlate well with clinical research results. Japanese researchers found higher rates of respiratory symptoms and headaches in students exposed to oxidants at concentrations >200 to 290 $\mu g/m^3$ (0.1 to 0.15 ppm) (USEPA 1978). These results are difficult to interpret because of the possible presence of confounding variables and the potential for oxidant pollution in Japan to be characteristically different from that which occurs in the U.S. Epidemiological investigations that link oxidant exposure above 200 to 880 $\mu g/m^3$ (0.10 to 0.45 ppm) to eye irritation. The quantities of O_3 present in these epidemiological studies is difficult to determine, but results from clinical studies indicate that O_3 is not responsible for eye irritation. Peroxyacetyl nitrate (PAN) and peroxybenzoyl nitrate (PB_2N) are probably responsible for the eye irritation effects observed (Walsh et al. 1981). No research has conclusively associated daily oxidant levels to increased mortality (USEPA 1978).

Chronic

Chronic exposure of animals to O_3 has produced a variety of morphological changes at levels <1970 $\mu g/m^3$ (1 ppm) (USEPA 1978). Emphysematous changes and damage to terminal bronchioles and alveoli have been detected after repeated, intermittent exposure to 784 to 1058 $\mu g/m^3$ (0.4 to 0.541 ppm) O_3 for as little as three months. No experiments have assessed the long-term effects of ozone/oxidant exposure in humans. Epidemiological results showing associations with respiratory mortality and increased incidence of chronic obstructive pulmonary disease are inconclusive (USEPA 1981).

RESPIRABLE PARTICLES

It has become increasingly apparent that particles in the smallest size range are at least partially responsible for the adverse health effects associated with atmospheric particulate matter (Walsh et al. 1981). Particles <2.5 μm in diameter easily penetrate into the distal portions of the respiratory tract where they contact relatively unprotected tissue and can remain for long periods of time.

Particles <2.5 μm in diameter also contain a larger percentage of the sulfates, nitrates, sulfuric acid, heavy metals and organic species that occur in ambient air.

Amdur (1952, 1971) has identified the importance of particle size in human and animal toxicity research indicating that particles with ~2 μm mass mean diameter (MMD) are the most toxic to rodents. Experiments with inert dusts and powders <1 μm in diameter produced pulmonary functional changes and impaired gas exchange after brief exposure in both healthy and asthmatic human subjects (Walsh et al. 1981). The groups of subjects responded at different times with the time lag between exposure and respiratory response being greater in healthy subjects.

Epidemiological research to date has been largely insensitive to the potential role played by respirable particles in causing adverse effects on human health. The British data are probably more indicative of the impact of respirable particles than are American results since the BS monitoring method primarily detects particles in a smaller size range. The only conclusion that can be reached with available evidence is that inhalation of fine particles may be responsible for at least a portion of the adverse respiratory-related effects that occur in animals and humans, but that no quantitative relationship can be established at this time.

HYDROCARBONS AND ORGANIC MATTER

Hydrocarbons and other organic matter present in the ambient atmosphere include a variety of potentially harmful agents. The two classes of compounds of most concern on the basis of health are polynuclear aromatic hydrocarbons (PNAs) and their neutral nitrogen analogues. These classes of compounds contain several carcinogenic agents, including the potential carcinogen benzo[a]-pyrene. Many studies indicate that PNAs and other polycyclic organic matter are primarily associated with particles in the respirable size range (Walsh et al. 1981). Information on the health impacts of these substances is derived primarily from occupational data. Extrapolation of this information to the public is difficult because of known differences in sensitivities to effect between working populations and the general public and variations in type and degree of exposure.

Acute

The large number of PNAs released during coal combustion and/or present in the atmosphere produce a wide variety of biological effects. The primary focus of past and current research into these effects has been their mutagenicity, cytotoxicity and carcinogenicity (Walsh et al. 1981). These effects have been studied in subcellular and cellular investigations with animals and correlated with occupational and community exposures in humans. A variety of PNAs are capable of inducing mutations in an number of accepted *in vitro* test systems (Walsh et al. 1981). Mutagenic effects may occur directly or indirectly after metabolic activation. Metabolic activation subjects the initial test compound to enzyme action which degrades the chemical into biologically more useful forms. Oftentimes, the metabolites, and not the original compound, induce the mutagenic effects. Perylene, benzo-[a]-pyrene, dibenz-[a,c]-antracene, cyclopenta-[c,d]-pyrene, 3-methylchlo-anthrene, chrysens and 7, 12-dimethylbenz[a]-anthracene are amongst the strongest mutagens identified in studies conducted to date (Walsh et al. 1981). Cytotoxicity testing may also require metabolic activation for certain compounds. Tests for cytotoxic effects are generally conducted in cultures of rodentor occasionally human cells. In general, 7, 12-dimethylbenz-[a]-anthracene, 3-methylcholanthrene, benzo[a]-pyrene, and dimethyl and diethylnitrosamine are among the most cytotoxic polynuclear aromatic hydrocarbons identified thus far (Walsh et al. 1981).

The ability of PNAs to produce morphological transformations in mammalian cells has been suggested to indicate carcinogenic potential (Walsh et al. 1981). Several acute investigations in rodent cell systems have identified cellular transformations with the same compounds as have been positively correlated with mutagenicity and cytotoxicity as discussed above (Walsh et al. 1981).

Acute exposures to high levels of PNAs and other polycyclic organic matter has produced non-neoplastic skin and eye responses in an number of clinical and occupational settings (Walsh et al. 1981). Skin application of coal tar and coal tar solutions in the laboratory has produced phototoxicity, erythema, decreased mitotic activity and induction of enzyme activity related to cancer initiation (Walsh et al. 1981). Occupational exposure to coal tar and coal tar products, pitch, creosote, asphalt and petroleum products has produced nonallergic and allergic dermatitis, phototoxicity and photoallergic reactions, folliculitis, acne, and pigment disturbances (Walsh et al. 1981).

Chronic

Skin carcinomas have been observed in working populations exposed to unquantified levels of high temperature coal tar products (Walsh et al. 1981). Several epidemiological investigations of working populations have correlated long-term exposure to products of coal distillation with elevated rates of lung cancer and occasionally cancer at other sites (Walsh et al. 1981). Because exposure data are generally not available from these studies, the only conclusion that can be made is that the risk of cancer increases with pollutant concentration and duration of exposure, hence total dose. An occupational study by Hammond et al. of roofers and waterproofers found excess lung, bladder and skin cancer and leukemia in these workers (Walsh et al. 1981). Calculations of exposures of these workers to organic matter using benzo-[a]-pyrene [B(a)P] as a surrogate were equivalent to ambient air concentrations of 2.088 $\mu g/m^3$. However, the incubation period of cancer is very long and exposure conditions may have been different (probably worse) during the period prior to this study. For example, B(a)P concentrations measured in the vicinity of coal pitch roofing operations in 1967 were 14 $\mu g/m^3$, seven times higher than those detected by Hammond et al. during the early 1970s. In summary, the range of B(a)P concentrations (used as an indicator of PNA exposure) associated with increased cancer risks in working populations is 1.2 to 200 $\mu g/m^3$ (Walsh et al. 1981). These data must be interpreted cautiously, however, because past exposures to B(a)P for these workers are likely to have been greater than the measurements taken at the time of excess cancer was detected actually indicate. Higher exposures at earlier times may have contributed disproportionately to the doses leading to cancer induction.

TRACE ELEMENTS

Several trace elements in ambient air represent potential hazards to public health. Human exposure to metals in the atmosphere may result from direct inhalation or indirectly from contact with or ingestion of contaminated surface waters. Ingestion of contaminated aquatic organisms or of crops grown on contaminated soils is also possible but of lesser importance. Walsh et al. (1981) have identified arsenic, beryllium, cadmium, chromium, mercury, nickel, selenium, and thallium as being the trace metals of primary concern which are released by coal combustion sources. Most of these are preferentially concentrated in coal fly ash or are discharged as vapors. Many have been found to be concentrated in coal fly ash or are discharged as vapors. Many have been found to be concentrated on the smallest particle in powerplant flue gas (Walsh et al. 1981). In general, environmental trace metals are associated with, or suspected of causing, human illness through chronic, low-level exposures. Acutely toxic concentrations are not common, especially in association with coal combustion. A discussion of the trace elements of concern from coal combustion is presented in Walsh et al. (1981) and summarized below.

Arsenic

Arsenic poisoning can result from inhalation, ingestion and absorption through the skin. Elemental and certain organic and inorganic forms are capable of producing toxic reactions. Trivalent arsenite is more toxic than pentavalent forms of the element. The estimate of the maximum tolerable daily intake for humans is 14 to 20 mg. Arsenic has been associated with genotoxic effects in humans. Workers exposed to high levels of arsenic had an abnormally high frequency of chromosomal aberrations in their lymphocytes. Arsenic exposure to levels between 254 and 696 $\mu g/m^3$ has been weakly associated with cancer in sheep dip workers. Orchard sprayers exposed to 140 $\mu g/m^3$, and other groups of workers exposed to approximately 100 $\mu g/m^3$ for under 25 years, showed no increased risk of cancer, however. Other adverse health effects associated with arsenic occur at higher exposures than those associated with cancer. The daily intake for humans has been calculated to be from 0.137 to 0.40 mg/person. The "acceptable air concentration" of arsenic III established by the panel of health experts chaired by Morrow is 1×10^{-5} $\mu g/m^3$. The Estimated Permissible Concentration for ambient air based on health protection calculated by Cleland and Kingsbury as part of their Multimedia Environmental Goals is 5×10^{-3} $\mu g/m^3$ for both arsenic III and V (USEPA 1977).

Beryllium

Beryllium is a highly toxic metal which upon inhalation is retained by the lungs. Industrial exposures of 0.31 to 1310 $\mu g/m^3$ have caused chronic lung disease (berylliosis) in a portion of exposed workers. Many of these victims also developed hypoxia. Animals exposed to 50 to 100 $\mu g/m^3$ experienced acute lung distress and lung damage. Beryllium produces cancer in animals upon exposure to air concentrations of 10 $\mu g/m^3$ and higher but this disease has not been associated with humans. Skeletal damage can result from ingestion.

The National Institute of Occupational Safety and Health (NIOSH) recommended an atmospheric standard of 0.01 $\mu g/m^3$ to protect community health in neighborhoods near beryllium-using industries. The "acceptable air concentration" identified by Morrow et al. is 5.0×10^{-3} $\mu g/m^3$. The Estimated Permissible Concentration derived by Cleland and Kingsbury to protect public health is 1.0 $\mu g/m^3$ (USEPA 1977).

Cadmium

Cadmium occurs as a particulate in the atmosphere, with approximately 60 percent falling within the respirable size fraction. Subcellular, cellular and animal tests indicate that cadmium is cytotoxic, genotoxic and causes anemia, hypertension, cardiovascular disease and a variety of biochemical effects of uncertain consequence. Acute exposures in animals have also produced progressive and permanent lung damage. Certain of these effects have been verified to occur in humans. Human exposures to 3,000 to 15,000 $\mu g/m^3$ cadmium dusts over 20 years may result in some chronic lung damage. Acute exposures to dusts in the range of 30 to 690 $\mu g/m^3$ were not associated with any adverse effects. Estimates for the minimum atmospheric exposures necessary to produce renal damage in humans in 20 years range from 1.6 to 21 $\mu g/m^3$ and 0.8 to 2 $\mu g/m^3$ for 50 years of exposure. Epidemiological studies linking cadmium concentrations in air to hypertension and arteriosclerotic heart disease are suggestive but not conclusive. Several occupational studies have associated cadmium exposure with increased scrotal and/or respiratory cancer. Average adults intake 50 to 75 $\mu g/m^3$/day of cadmium, less than 25 percent of which is inhaled. Morrow et al. set the "acceptable air concentration" for cadmium at 0.05 $\mu g/m^3$, while the atmospheric Estimated

Permissible Concentration calculated by Cleland and Kingsbury to protect health is 0.12 $\mu g/m^3$ (USEPA 1977).

Chromium

Atmospheric chromium is in particulate form. Subcellular, cellular and animal experimentation have found chromium to induce biochemical, mutagenic and carcinogenic effects. Occupational evidence indicates that relatively high exposures (0.5 to 1.5 mg/m^3) to chromium for 6 to 9 years increase the risk of lung cancer while even higher exposures cause severe acute irritation of nasal tissue. Chromium IV is thought to be more toxic than chromium III (the form that predominates in the atmosphere). Most of chromium uptake by humans occurs via ingestion. The "acceptable air concentration" set by Morrow et al. is 0.05 $\mu g/m^3$. The Estimated Permissible Concentration for air to protect health is 0.12 $\mu g/m^3$ (USEPA 1977).

Mercury

Mercury is capable of accumulation and passage through the food chain. Environmental human exposure may either be direct or through contaminated food sources. Inhalation of elemental mercury vapor can be harmful to humans, and inhalation of alkyl mercurial compounds at levels of 1 mg/m^3 for several months has reportedly caused human fatalities. Some symptoms of organic mercury poisoning have been reported to occur after exposures to air levels between 0.1 and 1 mg/m^3. Monthly average exposures to 0.03 to 0.1 mg/m^3 produced no significant effects.

Inorganic mercurials from powerplant emissions are not expected to be an inhalation risk, however. Occupational data reveal that exposure to inorganic mercury in atmospheres containing less than 10 $\mu g/m^3$ have not been associated with significant adverse health effects. Increasing levels of exposure are directly associated with effects on the central nervous system. Ingestion of organic mercury can produce nervous and other symptoms and death. The U.S. Environmental Protection Agency has established a maximum allowable concentration for ambient air of 1 $\mu g/m^3$ for mercury. "Acceptable air concentrations" set by Morrow et al. are 0.1 $\mu g/m^3$ for inorganic mercury and 0.01 $\mu g/m^3$ for organic mercury. The Estimated Permissible Concentration for air is 0.024 $\mu g/m^3$ (USEPA 1977).

Nickel

As with several other trace elements, the chemical species of nickel affects its toxicity. Subcellular, cellular and animal experimentation has revealed nickel to be cytotoxic, mutagenic and genotoxic. Direct contact with human skin produces skin reactions in certain individuals. Other effects of nickel particles have been reported in both mammals and humans. Nickel carbonyl is the most toxic of all nickel compounds in humans and is generally acknowledged as a potential carcinogen. It has been correlated with nasal and respiratory cancers. Nickel oxide and sulfide are considered potential carcinogens.

Inhalation accounts for approximately 1 to 2% of nickel intake by humans. Amounts adsorbed into the body via this and other pathways are not known. Morrow et al. set the "acceptable air concentration" at 0.01 $\mu g/m^3$ for nickel and 1×10^{-6} $\mu g/m^3$ for nickel carbonyl. The Estimated Permissible Concentration for air is 0.24 $\mu g/m^3$ for nickel and 0.8 $\mu g/m^3$ for nickel carbonyl.

Selenium

Selenium is associated with respirable particles in the atmosphere. Chronic industrial exposures at relatively high concentrations cause nasal bleeding, loss of smell, dermatitis, headache and irritation of mucous membranes. The effects of chronic exposure to selenium are unknown. Although little is known about the toxicology of the element, the respiratory pathway is not seen as a major route of entry into the body with normal daily dietary uptake ranging from 15 to 50 $\mu g/m^3$. Morrow et al. estimated an "acceptable air concentration" for selenium of 0.1 $\mu g/m^3$ while the Estimated Permissible Concentration for air is 0.5 $\mu g/m^3$ (USEPA 1977).

Thallium

Thallium is highly toxic upon acute administration to animals. Occupational exposures have led to thallium poisoning after inhalation, ingestion, or skin contact. It accumulates in tissue. Like mercury, the passage of thallium through the food chain in humans is of concern. Morrow's acceptable air concentration is 0.01 $\mu g/m^3$. Cleland and Kingsbury's Estimated Permissible Concentration for air is 0.24 $\mu g/m^3$ (USEPA 1977).

COMBINED EXPOSURES

Many residents of the northeast are simultaneously exposed to relatively high levels of several criteria air pollutants including various mixtures of SO_2, TSP, NO_2, O_3, and CO. In addition, they are exposed to several noncriteria air pollutants such as sulfates, nitrates, sulfuric acid, trace metals and polynuclear aromatic hydrocarbons. Atmospheric concentrations for many of these substances will increase as a result of coal conversion. The interaction of these substances in the atmosphere and in human tissue may result in additive, synergistic or antagonistic effects upon human health. Besides the extensive epidemiological data base for particulate matter and SO_2, little research has been conducted on the health effects of exposure to multiple atmospheric contaminants. The available information is discussed below.

Acute

Amdur (1961), Amdur and Underhill (1968), Amdur (1971) and Amdur et al. (1978) reported results from experiments with animals that indicated simultaneous exposure to SO_2 and aerosols capable of converting SO_2 to H_2SO_4 had a greater effect on respiration than did either SO_2 or the aerosol alone. Since simultaneous exposure to SO_2 and solid aerosols not capable of interacting with SO_2 did not exhibit potentiation (Amdur and Underhill 1968), the theory developed that increased effects were not due to potentiation but to H_2SO_4 aerosols. These results have been reported in studies with human volunteers (Nakamura 1964, Toyama 1962, Snell and Luchsinger 1969). Snell and Luchsinger (1969) found simultaneous exposure of human subjects to 5 ppm SO_2 and NaCl aerosol (7 μm average diameter) to be the lowest level of SO_2 at which decrements in pulmonary function were noted. Significant effects on pulmonary function were observed after exposure to 0.5 ppm SO_2 in combination with distilled water aerosol (0.3 μm diameter).

Toxicological exposures of H_2SO_4 and O_3 have produced equivocal results. Last and Cross (1978) reported synergistic effects upon histopathological examination of rats simultaneously exposed to 0.78 to 0.98 mg/m^3 O_3 and 1 mg/m^3 H_2SO_4. Grose et al. (1980), on the other hand, reported antagonistic effects upon ciliary beating frequency in hamster trachea after sequential exposure to first 0.196 mg/m^3 O_3 and then 0.88 mg/m^3 H_2SO_4. Gardner et al. (1977) reported an additive effect between H_2SO_4 and O_3 in test of susceptibility to bacterial infection with mice. When 0.1996 mg/m^3 O_3 was administered immediately followed by 0.9 mg/m^3 H_2SO_4, increased susceptibility to infection was noted. This effect did not occur after a reversal of the sequence of pollutant administration was made.

Bates and Hazucha (1973) reported a synergistic effect upon pulmonary function in human subjects acutely and simultaneously exposed to 0.37 ppm O_3 and SO_2. Kagawa and Tsuru (1979) reported a similar synergy in exercising humans after simultaneous exposure to 0.15 ppm O_3 and SO_2. Bell et al. (1977) and Horvath and Folinsbee (1977) could not replicate these results and suggested that the effects noted by Bates and Hazucha may have been due to H_2SO_4 aerosol formation in the exposure chamber. Von Nieding et al. (1979) did not find evidence of pollutant interaction in human subjects exposed to 5 ppm SO_2, 5 ppm NO_2 and 0.1 ppm O_3.

Simultaneous ozone and NO_2 exposure resulted in an additive effect by reducing the resistance to bacterial infection in mice (National Research Council 1977a). A combination of O_3, 0.3 ppm NO_2, and 30 ppm CO produced no effects on male volunteers beyond those attributed to O_3 alone (National Research Council 1977b).

Chronic

Subchronic exposure to SO_2, H_2SO_4 and fly ash either singularly or in various combinations in guinea pigs resulted in no potentiation of the effect of fly ash on either pulmonary function or lung morphology (Alaire et al. 1975). Morphological changes were observed in monkeys exposed to 2.6 mg/m^3 SO_2 plus 0.88 mg/m^3 H_2SO_4, however. Chronic experiments with beagle dogs revealed that mixtures of 1.1 mg/m^3 SO_2 and 0.09 mg/m^3 H_2SO_4 produced anatomic alterations after 61 months of exposure (Hyde et al. 1978). These effects occurred at levels lower than necessary for either SO_2 or H_2SO_4 to produce the change alone. Stara et al. (1980) reported on this same series of experiments and concluded that simultaneous exposure to irradiated and nonirradiated auto exhaust (containing CO, HC, NO_2 and O_3) in conjunction with SO_2 and/or H_2SO_4 did not reveal potentiation upon pulmonary function for any combinations of the pollutants studied.

Zarkower (1972) found greater effects in the pulmonary and systemic immune systems of mice after simultaneous exposure to SO_2 and carbon than were attributable to either pollutant alone. These results were similar to those of Fenters et al. (1979) who exposed mice to 1.5 mg/m^3 H_2SO_4 and 1.5 mg/m^3 carbon. Schiff et al. (1979) found more epithelial damage in the trachea of hamsters after exposure to 1.1 mg/m^3 H_2SO_4 and 1.5 mg/m^3 carbon than was due to either chemical alone.

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APPENDIX B

Sulfur Dioxide Sensitivity of Various Plants

TABLE B.1. Sulfur Dioxide Sensitivity of Garden and Commercial Crops[(a)]

Common Name	Scientific Name
	Sensitive
Alfalfa	*Medicago sativa*
Barley	*Hordeum vulgare*
Bean, field	*Phaseolus* sp.
Bean, lima	*Phaseolus lunatus*
Beet	*Beta vulgaris*
Broccoli	*Brassica oleracea* var. *botrytis*
Brussel sprouts	*Brassica oleracea* var. *gemmifera*
Cabbage	*Brassica oleracea* var. *capitata*
Carrot	*Daucus carota*
Celery	*Apium graveolens*
Clover	*Trifolium* sp.
Cotton	*Gossypium hirsutum*
Cucumber	*Cucumis sativa*
Eggplant	*Solanum melongena*
Endive	*Cichorium endivia*
Kale	*Brassica oleracea* var. *acephala*
Leek	*Allium porrum*
Lettuce	*Lactuca sativa*
Oats	*Avena sativa*
Onion	*Allium cepa*
Parsley	*Petroselinum crispum*
Parsnip	*Pastinaca* sp.
Pea	*Pisum sativa*
Pepper (bell, chili)	*Capsicum frutescens*
Potato, sweet	*Ipomoea batatas*
Pumpkin	*Cucurbita pepo*
Radish	*Raphanus sativus*
Rhubarb	*Rheum rhaponticum*
Rubber tree	*Hevea brasiliensis*
Rye	*Secale cereale*
Safflower	*Carthamus tinctoria*
Soybean	*Glycine max*
Spinach	*Spinacea oleracea*
Squash	*Cucurbita maxima*
Sweet clover	*Meliotus* sp.
Swiss chard	*Beta vulgaris* var. *cicla*
Tobacco	*Nicotiana tabacum*
Turnip	*Brassica rapa*
Wheat	*Triticum aestivum*
	Intermediate
Castor bean	*Ricinus communis*
Clover	*Trifilium* sp.
Horse-radish	*Armoracia rusticana*
Pea	*Pisun* sp.
Potato, Irish	*Solanum tuberosum*
Sweet clover	*Meliotus* sp.
	Resistant
Cantaloupe	*Cucumis melo*
Corn	*Zea mays*
Sorghum	*Sorghum* sp.

(a) Adapted from Dvorak et al. 1978.

TABLE B.2. Plants of Known SO_2 Sensitivity Common to the Northern Chesapeake Bay Area[a]

Common Name	Scientific Name	Abundance	Sensitivity[b]
	Herbaceous Plants		
Bluegrass	*Poa* sp.	Abundant	S-I
Common Ragweed	*Ambrosia artemisiifolia*	Common	S
Cheat	*Bromus secalinus*	Common	S
Lambsquarters	*Chenopodiun albun*	Common	S
	Trees and Shrubs		
Oak	*Quercus* sp.	Common	I-R
American Elm	*Ulmus americana*	Common	I
Red Maple	*Acer rubrum*	Abundant	I
Sugar Maple	*Acer saccharum*	Common	R
Black Locust	*Robinia pseudoacacia*	Abundant	R
Sycamore	*Platanus occidentalis*	Common	R
Willow	*Salix* sp.	Uncommon	S-R
Dogwood	*Cornus florida*	Common	R
Ash	*Fraxinus* sp.	Common	S
Sumac	*Rhus* sp.	Abundant	S-R
Pine	*Pinus* sp.	Common	S-I
Blackberry	*Rubus* sp.	Common	S
Mountain Laurel	*Ceanothus sanguineus*	Common	I
Blueberry	*Vaccinium* sp.	Common	S
Poison Ivy	*Toxicodendrom radicans*	Common	R
River Bank Grape	*Vitis riparia*	Common	I
Virginia Creeper	*Parthenocissus quinque folia*	Common	S

(a) Adapted from Dvorak et al. 1978 and BCL 1976.
(b) S = sensitive, I = intermediate, R = resistant.

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APPENDIX C

Animals Native to the Northern Chesapeake Bay Area

TABLE C.1. Mammals Found in the Northern Chesapeake Bay Area(a)

Common Name	Scientific Name	Occurrence
Virginia Opossum	*Didelphis virginiana*	Common
Masked Shrew	*Sorex cinereous*	Uncommon
Least Shrew	*Crytotis parva*	Rare
Short-Tailed Shrew	*Blarina brevicaida*	Common
Star-nosed Mole	*Condylura cristata*	Rare
Eastern Mole	*Scalopus aquaticus*	Rare
Bats	Various species	Uncommon
Racoon	*Prcyon loor*	Common
Ermine	*Mustela erminea*	Rare
River Otter	*Loncra canadensis*	Rare
Striped Skunk	*Mephitis mephitis*	Common
Red Fox	*Vulpes vuloes*	Common
Gray Fox	*Urocvon cinereoargenteus*	Rare
Woodchuck	*Marmota monex*	Common
Eastern Chipmunk	*Tamias striatus*	Common
Fox Squirrel	*Sciurus niger*	Common
Gray Squirrel	*Sciurus carolinensis*	Common
Southern Flying Squirrel	*Glaucomys volans*	Uncommon
Beaver	*Castor candensis*	Uncommon
White-footed Mouse	*Peromyscus leucopus*	Abundant
Eastern Woodrat	*Neotoma floridana*	Rare
Marsh Rice Rat	*Oryzomys palustris*	Uncommon
Meadow Vole	*Microtus pennsylvanicus*	Abundant
Woodland Vole	*Microtus pinetorum*	Uncommon
Muskrat	*Ondatra zibethicus*	Abundant
Meadow Jumping Mouse	*Zapus hudsonius*	Common
Norway Rat	*Rattus norvegicus*	Rare
House Mouse	*Mus musculus*	Uncommon
Eastern Cottontail	*Sylvilagus floridanus*	Abundant
White-tailed Deer	*Odocoileus virginianus*	Abundant

(a) BCL 1976.

TABLE C.2 Reptiles and Amphibians Found in the Northern Chesapeake Bay Area[a]

Common Name	Scientific Name	Occurrence
Spotted Salamandar	*Ambystoma magulatum*	Common
Marbled Salamander	*Ambystoma opacum*	Uncommon
Red-backed Salamandar	*Plethodon c. cinercus*	Common
American Toad	*Bufo a. americanus*	Common
Fowler's Toad	*Bufo woodhousei fowleri*	Abundant
Northern Cricket Frog	*Acris crepitans crepitans*	Abundant
Green Treefrog	*Hyla cinerea*	Uncommon
Northern Spring Peeper	*Hyla crucifer*	Abundant
Eastern Gray Treefrog	*Hyla versicolor*	Abundant
Upland Chorus Frog	*Pseudacris triseriata ferianum*	Common
Bullfrog	*Rana contesbeina*	Abundant
Green Frog	*Rana clamitans melanota*	Abundant
Northern Leopard Frog	*Rana pipiens*	Rare
Southern Leopard Frog	*Rana vtricularia*	Abundant
Pickeral Frog	*Rana oslustris palustris*	Uncommon
Northern Fence Lizard	*Sceluporus undulatus hyacinthinus*	Rare
Five-lined Skunk	*Eumeces fasciatus*	Common
Eastern Worm Snake	*Carphophis amoenus*	Uncommon
Northern Fence Lizard	*Diadophis punctatus edwardsi*	Rare
Eastern Hognose Snake	*Heterodon platyrhinos*	Rare
Northern Black Racer	*Coluber constrictor*	Common
Black Rat Snake	*Elaphe obsoleta*	Common
Eastern Kingsnake	*Lampropeltis getulus*	Rare
Eastern Milk Snake	*Lampropeltis triangulum*	Common
Northern Water Snake	*Natrix sipedon*	Abundant
Queen Snake	*Natrix septemvittata*	Rare
Eastern Ribbon Snake	*Thamnophis sauritus*	Uncommon
Eastern Garter Snake	*Thamnophis sirralis*	Common
Eastern Mud Turtle	*Kinosternon subrubrum*	Abundant
Snapping Turtle	*Chelydra serpentina*	Abundant
Spotted Turtle	*Clermys guttata*	Abundant
Bog Turtle	*Clemmys muhlenbergi*	Unknown
Eastern Box Turtle	*Terrapene carolina*	Abundant
Northern Diamondback Terrapin	*Malaclemys terrapin*	Abundant
Eastern Painted Turtle	*Chrysemys picta*	Abundant
Red-bellied Turtle	*Chrysemys rubriventris*	Rare
Red-eared Turtle	*Chrysemys scripta clegans*	Uncommon

(a) BCL 1976.

TABLE C.3. Birds of the Northern Chesapeake Bay Area[a]

Common Name	Scientific Name	Occurrence
Common Loon	*Gavia inmer*	Uncommon
Horned Grebe	*Podicops auritus*	Rare
Pied-billed Grebe	*Podilymbus policeps*	Uncommon
Double-crested Cormorant	*Phalacrocorax auritus*	Rare
Great Blue Heron	*Ardea herodias*	Abundant
Little Blue Heron	*Florida caerulea*	Rare
Cattle Egret	*Rubulcus ibis*	Rare
Great Egret	*Casmerodius albus*	Rare
Snowy Egret	*Egretta thula*	Rare
Green Heron	*Butorides virescens*	Uncommon
Least Bittern	*Ixobrychus exilis*	Rare
American Bittern	*Botaurus lentiginosus*	Uncommon
Glossy Ibis	*Plegadis falcinellus*	Uncommon
White Ibis	*Eudocimus albus*	Rare
Whistling Swan	*Olor columbianus*	Abundant
Canada Goose	*Branta canadensis*	Abundant
Mallard	*Anas platychanchos*	Common
Black Duck	*Anas rubripas*	Common
Gadwall	*Anas streoera*	Common
Pintail	*Anas acuta*	Uncommon
Green-Winged Teal	*Anas crecca*	Common
Blue-Winged Teal	*Anas discors*	Uncommon
American Wigeon	*Mareca americana*	Common
Northern Shoveler	*Anas clypeata*	Rare
Wood Duck	*Aix sponsa*	Rare
Redhead	*Aythya americana*	Rare
Ring-necked Duck	*Aythya collaris*	Rare
Canvasback	*Aythya valisineria*	Rare
Greater Scaup	*Aythya marila*	Common
Common Goldeneye	*Bucephala clangula*	Rare
Bufflehead	*Bucaphala albeola*	Uncommon
Ruddy Duck	*Oxyura lamaicensis*	Uncommon
Hooded Merganser	*Lophodytes cucullatus*	Rare
Common Merganser	*Margus merganser*	Uncommon
Least Sandpiper	*Calidris minutilla*	Uncommon
Dunlin	*Calidris alpina*	Rare
Short-billed Dowitcher	*Limnodromus griseus*	Rare
Semipalnated Sandpiper	*Calidris pusillus*	Rare
Great Black-backed Gull	*Larus marinus*	Common
Herring Gull	*Larus argentatus*	Common
Ring-billed Gull	*Larus delawarensis*	Uncommon
Laughing Gull	*Larus atricilla*	Uncommon
Bonaparte's Gull	*Larus philadelphia*	Uncommon
Least Tern	*Sterna albifrons*	Rare
Caspian Tern	*Hydroprogne caspia*	Uncommon
Rock Dove	*Columba livia*	Rare
Mourning Dove	*Zenaida macroura*	Common
Yellow-billed Cuckoo	*Coccyzus americanus*	Uncommon
Great Horned Owl	*Bubo virginianus*	Rare
Short-eared Owl	*Asio Flammeus*	Rare
Barn Owl	*Tyto alba*	Rare
Barred Owl	*Strix varia*	Rare
Chuck-Will's Widow	*Caprimulgus carolinensis*	Rare

(a) BCL 1976.

TABLE C.3. (Contd)

Common Name	Scientific Name	Occurrence
Whip-Poor-Will	*Caprimulgus vociferus*	Uncommon
Chimney Swift	*Chaetura pelagica*	Uncommon
Ruby-Throated Hummingbird	*Archilochus colubris*	Rare
Belted Kingfisher	*Megaceryl alcyon*	Rare
Common Flicker	*Colaptes auratus*	Abundant
Yellow-bellied Sapsucker	*Sphyrapicus varius*	Rare
Red-bellied Woodpecker	*Centurus carolinus*	Uncommon
Hairy Woodpecker	*Dendrocopos villosus*	Uncommon
Downy Woodpecker	*Dendrocopos pubescens*	Common
Eastern Kingbird	*Tyrannus tyrannus*	Uncommon
Great Crested Flycatcher	*Myiarchus crinitus*	Uncommon
Eastern Phoebe	*Sayornis phoebe*	Uncommon
Acadian Flycatcher	*Empidonax virescens*	Rare
Eastern Wood Pewza	*Contopus virens*	Uncommon
Olive-sided Flycatcher	*Nuttallornis borealis*	Rare
Horned Lark	*Eremophila alpestris*	Uncommon
Tree Swallow	*Iridoprocne bicolor*	Abundant
Bank Swallow	*Riparia riparia*	Common
Rought-winged Swallow	*Stelgidopteryx ruficollis*	Uncommon
Red-breasted Merganser	*Mergus serrator*	Rare
Turkey Vulture	*Cathartes aura*	Uncommon
Black Vulture	*Coragyps atratus*	Rare
Sharp-Skinned Hawk	*Accipiter striatus*	Uncommon
Cooper's Hawk	*Accipiter cooperil*	Rare
Rough-legged Hawk	*Buteo lagopus*	Rare
Red-tailed Hawk	*Buteo jamaicensis*	Uncommon
Red-shouldered Hawk	*Buteo lineatus*	Rare
Broad-winged Hawk	*Buteo platypterus*	Rare
Golden Eagle	*Aquila chrysaetos*	Rare
Bald Eagle	*Haliaeetus laucocephalus*	Rare
Marsh Hawk	*Circus cyaneus*	Uncommon
Osprey	*Pandion haliaetus*	Uncommon
Merlin	*Falco columbarius*	Rare
American Kestrel	*Falco sparverius*	Uncommon
Turkey	*Meleagris gallopavo*	Uncommon
Bobwhite	*Colinus virginianus*	Common
Ring-necked Pheasant	*Phasianus colchicus*	Common
King Rail	*Rallus elegans*	Rare
Virginia Rail	*Rallus limicola*	Uncommon
Common Gallinule	*Gallinula chloropus*	Rare
Sora	*Porzana carolina*	Uncommon
Black Rail	*Laterallus jamaicensis*	Rare
American Coot	*Fulica americana*	Common
Wilson's Plover	*Charadrius wilsonia*	Rare
Killdeer	*Charadrius vociferus*	Common
Black-bellied Plover	*Pluvialis squatoraola*	Uncommon
American Woodcock	*Philohela minor*	Uncommon
Common Snipe	*Capella gallinago*	Uncommon
Spotted Sandpiper	*Actitis macularia*	Uncommon
Solitary Sandpiper	*Tringa solitaria*	Rare
Willet	*Catoptrophorus semipalmatus*	Rare
Greater Yellowlegs	*Tringa melanoleucus*	Common
Lesser Yellowlegs	*Tringa flavipes*	Common

TABLE C.3. (Contd)

Common Name	Scientific Name	Occurrence
Pectoral Sandpiper	*Calidris melanotos*	Uncommon
Barn Swallow	*Hirundo rustica*	Abundant
Purple Martin	*Progne subis*	Common
Blue Jay	*Cyanocitta cristata*	Abundant
Common Crow	*Corvus brachyrhynchos*	Common
Fish Crow	*Corvus ossifragus*	Uncommon
Carolina Chickadee	*Parus carolinensis*	Common
Tufted Titmouse	*Parus bicolor*	Common
White-breasted Nuthatch	*Sitta carolinensis*	Uncommon
Brown Creeper	*Certhia familiaris*	Uncommon
Winter Wren	*Troglodytes troglodytes*	Uncommon
Carolina Wren	*Thryothorus ludovicianus*	Common
Long-billed Marsh Wren	*Tolmatodytes palustris*	Common
Mockingbird	*Mimus polyglottos*	Common
Gray Catbird	*Dumetalla carolinensis*	Common
Brown Thrasher	*Toxostoma rufum*	Common
American Robin	*Turdus migratorius*	Common
Wood Thrush	*Hylocichla mustelina*	Common
Hermit Thrush	*Catharus guttata*	Common
Swainson's Thrush	*Catharus ustulata*	Common
Veery	*Catharus fuscesens*	Uncommon
Eastern Bluebird	*Sialia sialis*	Rare
Blue-gray Gnatcatcher	*Polioptila caerulea*	Uncommon
Golden-crowned Kinglet	*Regulus satrapa*	Common
Ruby-crowned Kinglet	*Regulus calendula*	Common
Cedar Waxwing	*Bombycilla cedrorus*	Rare
Starling	*Sturnus vulgaris*	Abundant
White-eyed Vireo	*Vireo griseus*	Uncommon
Red-eyed Vireo	*Vireo olivaceus*	Common
Black-and-white Warbler	*Mniotilta varia*	Rare
Blue-winged Warbler	*Vermivora pinus*	Rare
Tennessee Warbler	*Vermivora peregrina*	Rare
Northern Parula Warbler	*Parula americana*	Uncommon
Yellow Warbler	*Dendroica petechia*	Common
Magnolia Warbler	*Dendroica magnolia*	Common
Cape May Warbler	*Dendroica tigrina*	Rare
Black-throated Blue Warbler	*Dendroica caerulescens*	Common
Yellow-rumped Warbler	*Dendroica coronata*	Abundant
Black-throated Green Warbler	*Dendroica virens*	Uncommon
Blackburnian Warbler	*Dendroica fusca*	Uncommon
Chestnut-sided Warbler	*Dendroica pennsylvanica*	Uncommon
Bay-breasted Warbler	*Dendroica castanea*	Uncommon
Blackpoll Warbler	*Dendroica striata*	Common
Pine Warbler	*Dendroica pinus*	Rare
Prairie Warbler	*Dendroica discolor*	Rare
Palm Warbler	*Dendroica palmarus*	Uncommon
Ovenbird	*Seiurus aurocapillus*	Common
Northern Waterthrush	*Seiurus noveboracensis*	Uncommon
Louisiana Waterthrush	*Seiurus motacilla*	Uncommon
Common Yellowthroat	*Geothlypis trichas*	Abundant
Yellow-breasted Chat	*Icteria virens*	Common
Wilson's Warbler	*Wilsonia pusilla*	Uncommon
Canada Warbler	*Wilsonia canadensis*	Uncommon

TABLE C.3. (Contd)

Common Name	Scientific Name	Occurrence
American Redstart	*Sctophaga ruticilla*	Common
House Sparrow	*Passer domesticus*	Rare
Bobolink	*Dolichonyx oryzivorus*	Rare
Eastern Meadowlark	*Sturnella magna*	Common
Red-winged Blackbird	*Agelaius phoanlceus*	Abundant
Orchard Oriole	*Icterus spurius*	Rare
Northern Oriole	*Icterus galbula*	Uncommon
Rusty Blackbird	*Euphagus carolinus*	Uncommon
Common Crackle	*Quiscalus quiscula*	Common
Brown-headed Cowbird	*Molothrus ater*	Abundant
Scarlet Tanager	*Piranga olivacea*	Uncommon
Summer Tanager	*Piranga rubra*	Rare
Cardinal	*Cardinalis cardinalis*	Common
Rose-breasted Grosbeak	*Phaucticus ludovicianus*	Uncommon
Blue Grosbeak	*Gufraca caerulea*	Rare
Indigo Bunting	*Passerina cyanea*	Uncommon
American Goldfinch	*Spinus tristis*	Uncommon
Rufous-side Towhee	*Pipilo erythropthalmus*	Common
Savannah Sparrow	*Passerculus sanuichensis*	Uncommon
Grasshopper Sparrow	*Acrodramus savannarum*	Uncommon
Vesper Sparrow	*Pooecetes gramineus*	Rare
Dark-eyed Junco	*Junco hyemalis*	Common
Chipping Sparrow	*Spizella passerina*	Uncommon
Field Sparrow	*Spizella pusilla*	Uncommon
White-crowned Sparrow	*Zonotrichia leucophrys*	Rare
Fox Sparrow	*Passarella ilaca*	Rare
Swamp Sparrow	*Melospiza georgiana*	Common
Song Sparrow	*Melospiza melodia*	Common
Snow Bunting	*Plectrophenox nivalis*	Rare

TABLE C.4. Commercial and Recreational Fish and Shellfish in the Patapsco, Seneca and Saltpeter Rivers

Species	Scientific Name
Fish	
Menhaden	*Brevoortia tyrannus*
Alewife	*Alosa pseudoharengus*
Blueback Herring	*Alosa aestivalis*
Bay Anchovy	*Anchoa mitchilli*
White Perch	*Morone americanus*
Yellow Perch	*Perca flavescens*
Norfolk Spot	*Leiostomus xanthurus*
Striped Bass	*Morone saxatilis*
Winter Flounder	*Pseudopleuronectes americanus*
American Shad	*Alosa sapidissima*
Hickory Shad	*Alosa mediocris*
Gizzard Shad	*Dorsoma cepedianum*
Croaker	*Micropogon undulatus*
Bluefish	*Pomatomus saltatrix*
White Catfish	*Ictalurus catus*
Channel Catfish	*Ictalurus punctatus*
Brown Bullhead	*Ictalurus nebulosus*
American Eel	*Anguilla rostrata*
Largemouth Bass	*Micropterus salmoides*
Chain Pickerel	*Esox niger*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Carp	*Cyprinus carpio*
Shellfish	
Blue Crab	*Callinectes sapidus*

REFERENCE

Battelle Columbus Laboratories (BCL). 1976. *Environmental Impact Report: Riverside SNG Facility, Sollers Point, Maryland.* Prepared for Baltimore Gas and Electric.

APPENDIX D

Historic Sites

Historic Sites

Anne Arundel County	
National Historic Landmarks	
Chase - Lloyd House	(14)[a]
Hammond - Harwood House	(14)
Maryland State House	(14)
William Paca House	(14)
William Paca Gardens	(14)
National Register of Historic Places	
43 Pinkney Street	(15)
Baltimore City	
National Historic Landmarks	
Mount Clare Mansion	(9)
Shot Tower	(8)
Star-Spangled Banner Flag House	(8)
U.S. Frigate Constellation	(8)
National Register of Historic Places	
Battle Monument and Park	(8)
Carroll Mansion	(8)
Fort McHenry National Monument and Historic Site	(6)
Old Ottenbein United Methodist Church	(8)
Westminister Presbyterian Church and Cemetery	(9)
Baltimore County	
National Register of Historic Places	
Fort Carrison	(16)

(a) Numbers in parentheses are approximate distance (miles) to nearest BG&E Generation Station.

Maryland Historical Trust

June 6, 1983

Dr. Richard Craig
Battelle Northwest
P.O. Box 999
Richland, WA 99352

Re: Brandon Shores Power Plant
Anne Arundel County, Maryland

Dear Dr. Craig:

Thank you for contacting us regarding the proposal to convert the Brandon Shores Power Plant from an oil-fueled to a coal-fueled facility. We believe this action will have no effect on historic standing structures or archeological resources.

Sincerely,

Mark R. Edwards
Deputy
State Historic Preservation Officer

MRE/KEK/bjs

cc: Mr. Anthony F. Christhilf
Mrs. Keren D. Dement

Shaw House, 21 State Circle, Annapolis, Maryland 21401 (301)269-2212, 269-2438
Department of Economic and Community Development

APPENDIX E

Conversion Factors

Conversion Factors

MULTIPLY		BY	TO OBTAIN	
English Unit	(Abbreviation)	Conversion Factor	(Abbreviation)	Metric Unit
acre	ac	0.405	ha	hectares
board foot	bd. ft.	0.0023	cu. m.	cubic meters
British thermal unit/square foot	Btu/sq. ft.	2.71	kg cal/m²	kilogram-calories/ square meter
cubic feet	cu. ft.	0.028	cu. m.	cubic meters
cubic feet	cu. ft.	28.32	l	liters
cubic yards	cu. yd.	0.765	cu. m.	cubic meters
degree Fahrenheit	°F	(a)	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon per minute	gpm	3.79	l/m	liters per minute
horsepower	hp	0.7457	kW	kilowatts
inches	in.	2.54	cm	centimeters
pounds	lb	0.454	kg	kilograms
mile	mi	1.609	km	kilometer
square feet	ft²	0.0929	m²	square
meters				
tons (short)	t	0.907	kg	metric tons (100 kilograms)
yard	yd	0.9144	m	meters

(a) The conversion equation is

°C = (°F - 32) /1.8.

APPENDIX F

List of Acronyms

List of Acronyms

AAQS	Ambient Air Quality Standards
AQCR	Air Quality Control Region
BG&E	Baltimore Gas and Electric Company
COD	Chemical Oxidation Demand
DHS	Designated Hazardous Substance
DOE	Department of Energy
EPA	Environmental Protection Agency
ERA	Economic Regulatory Administration
ESECA	Energy Supply and Environmental Coordination Act
ESP	Electrostatic Precipitators
FEA	Federal Energy Administration
FGD	Flue Gas Desulfurization
FUA	Powerplant and Industrial Fuel Use Act
NAAQS	National Ambient Air Quality Control Standards
NPDES	National Pollutant Discharge Elimination System
NSPS	New Source Performance Standards
OFC	Office of Fuels Conversion
OSHA	Occupational Safety and Health Administration
PJM	Pennsylvania, New Jersey, Maryland Power Intertie
PSC	Primary Standard Conditions
PSD	Prevention of Significant Deterioration
PVD	Pore Volume Displacement
RDF	Refuse-Derived Fuel
SIP	State Implementation Plan
TSP	Total Suspended Particulates

APPENDIX G

Glossary

GLOSSARY

aggregate: A collection of soil grains or particles gathered into a mass so as to constitute a whole.

algorithm: A set of well-defined rules or procedures used for solving a mathematical problem.

ambient air: That portion of the atmosphere, external to buildings, to which the general public has access. The surrounding air.

anthropogenic: Caused by humans.

anticyclone: An extensive system of winds spiraling outward from a high-pressure center, circling clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere.

associations: A definite or characteristic assemblage of plants living together on an area of essentially uniform environmental characteristics.

attenuation: The reduction in level of a quantity, such as the concentration of pollutants, over an interval of a variable, such as the distance from a source.

baghouse: An air-pollution control device that uses fabric filters to remove particulate matter.

baseline: A base for measurement or comparison; as used here refers to the environment which would occur in the absence of the proposed action.

BAT: Best Available Technology; the level of treatment of best available technology economically achievable as determined by the Administrator of the EPA.

BOD: Biochemical or Biological Oxygen Demand; an indirect measure of the concentration of biologically degradable materials present in organic wastes. This is the amount of free oxygen used by aerobic organisms when allowed to attack the organic matter in any aerobically maintained environment at a specified temperature (20C) for a specific time (5 days). It is expressed in milligrams of oxygen used per liter (mg/l) of liquid waste volume or in milligrams of oxygen per kilogram of solids present (mg/kg = ppm = parts per million parts).

BPT: Best Practical Technology; also known as BPCTCA (Best Practical Control Technology Currently Available). This is based upon the average of the best existing performance by plants of various sizes, ages and unit processes within an industrial category or subcategory or both. BPT is based upon performance levels achieved by exemplary plants not industry average.

Btu: British thermal units; the majority of heat necessary to raise the temperature of 1 lb of water 1°F at or near 39.2°F.

cementitious material: any of various building materials which may be mixed with a liquid, such as water, to form a plastic paste, and to which an aggregate may be added; includes cements, limes, and mortar.

conventional pollutants: Those pollutants classified as biological oxygen demand (BOD), total suspended solids (TSS), fecal coliform and pH. Chemical oxygen demand (COD), phosphorus, and oil and grease were proposed on July 28, 1978 (43 CFR 328.57) to be considered as "conventional." On July 30, 1979 the following were designated as conventional pollutants: BOD, TSS, pH, fecal coliform, and oil and grease. For the purposes of this study BOD, TSS, fecal coliform and pH were considered to be the conventional pollutants.

criteria air pollutants: Pollutants for which air quality standards have been issued. These pollutants are those for which the emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare. Presently these are carbon monoxide, hydrocarbons, nitrogen oxides, particulate matter, photochemical oxidants, sulfur oxides and lead.

crystal lattice: A lattice from which the structure of a crystal may be obtained by associating with every lattice point an assembly of atoms identical in composition, arrangement, and orientation. Also known as lattice; space lattice.

deadhead: To begin a new cut without excavating the material from the previous cut.

deposit: Consolidated or unconsolidated material that has accumulated by a natural process or agent.

discharge: Waterborne pollutants released to a receiving stream directly or indirectly or to a sewage system.

edaphic: Of or pertaining to soil factors such as salinity and drainage, especially as they affect living organisms.

effluent: The liquid waste of sewage and industrial processing, usually containing chemical, physical, or biological materials. A liquid that is discharged from a containing space or a main waterway into navigable waters, the waters of the contiguous zone or the ocean.

elutriate: To separate or purify; for example, to separate ore by washing, decanting, and settling.

emission: Gasborne pollutants released to the atmosphere.

environment (human): Includes the natural and physical environment and the relationship of people with that environment. This includes ecological, aesthetic, historic, cultural, economic, social, and health values.

estuary: A semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water. Also known as a branching bay; drowned river mouth; firth.

fluoride: Any binary compound of fluorine with another element.

foliar deposition: The settling out of particles in the air onto foliage surfaces.

fossil fuel: Remains or traces of a prehistoric plant or animal found in the earth, rocks, etc., serving as a fuel (examples: coal, lignite, peat, oil, natural gas).

ha: (Abbreviation for hectare) A unit of area in the metric system equal to 2.47 acres or 10,000 square meters.

hydrocarbon: Any of numerous organic compounds that contain only carbon and hydrogen. Their importance as air pollutants rests almost entirely on their role as precursors of other compounds formed in the atmospheric photochemical system and not upon direct effects of hydrocarbons themselves.

impacts: Includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health effects whether direct, indirect, or cumulative.

innocuous: Having no adverse effects; harmless, innocent.

intermittent: Stopping and starting at intervals.

interpolation: To determine a value of (a function) between known values by a function or algorithms.

ionizing radiation: Radiation capable of producing ionization, including energetic charged particles such as alpha and beta rays and nonparticulate radiation such as X-rays and neutrons.

labile: Readily or continually undergoing chemical, physical, or biological change, breakdown or decomposition.

LC_{50}: A toxicological term indicating the concentration of a chemical which is lethal to 50% of a test population over a specific time period (i.e., 24, 48, or 96 hours).

leachate: The solution containing suspended or soluble material removed from the soil or waste.

mercaptan: Any sulfur-containing organic compound with the general formula RSH, R being any radical.

mitigated: To avoid, minimize, rectify, reduce, eliminate, or compensate for negative impacts.

nekton: Free-swimming aquatic animals, essentially independent of water movements.

nitrogen oxides (or oxides of nitrogen): All oxides of nitrogen except nitrous oxide as measured by test methods prescribed by EPA.

nonattainment area: A geographical region that does meet NAAQS for a specific air pollutant.

NSPS, water: New Source Performance Standards; regulations establishing Federal standards of performance for new sources which provide for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator (of the USEPA) determines to be achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives including, where practicable, a standard permitting no discharge of pollutants.

NSPS, air: New Source Performance Standards; a National emission standard for a hazardous air pollutant for any new stationary source, the construction or modification of which is commenced after the publication in the Federal Register of proposed national emission standards.

outcrops: An exposure of bedrock or strata projecting through the overlying cover of soil.

particulate matter: Any finely divided solid or liquid material, other than uncombined water, as measured by methods specified by the EPA.

percolation: Gravity flow of ground water through the pore spaces in rock or soil.

photochemical oxidant: Any of the chemicals which enter into oxidation reactions in the presence of light or other radiant energy. Products of atmospheric pollutants, nitrogen oxides (NO_x), oxygen, and sunlight. They consist mostly of ozone, NO, and peroxyacetylnitrate (PAN).

plankton: Small, mostly microscopic plants, and animals, which passively move in or on the water column.

promulgate: To make known (a decree, law, or doctrine) by public declaration; to announce officially; to put (a law) into effect by formal public announcement.

prototype: A type, form, or instance that serves as a model.

pyrolysis: Chemical change caused by heat.

radon: A colorless, radioactive, inert, gaseous element formed by the disintegration of radium.

residual coefficients: Quantity of a pollutant released by an industry or source per unit production (lb/unit).

scenario: A hypothesized set of circumstances or chain of events.

sorption: The taking up and holding of a substance, as by adsorption or absorption.

sulfur oxides: The oxides of sulfur, their acids, and acid salts. Sulfur oxides are common atmospheric pollutants which arise mainly from the combustion of fuels.

thixotrophy: A property exhibited by certain gels, which liquify when subjected to vibratory forces, such as ultrasonic waves or even simple shaking, and then solidify again when left standing.

ton: A unit of weight in the U.S. Customary System, an avoirdupois unit equal to 2000 lb.

total suspended particulate (TSP): Total mass of particulate matter suspended in a unit volume of air or water.

trophic: Pertaining to or functioning in nutrition.

water pollutant: Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal and agricultural waste discharged into water.

wind rose: A diagram in which statistical information concerning direction and speed of the wind at a location may be summarized; a line is drawn in each of perhaps eight compass directions from a common origin; the length of a particular segment is proportional to the frequency with which winds blow from that direction; thicknesses of a segment indicate frequencies of occurrence of various classes of wind speed.

APPENDIX H

Air Quality Modeling

AIR QUALITY MODELING

INTRODUCTION

Air quality impacts were quantified for this study using atmospheric dispersion models. The models employ release characteristics and local meteorological conditions to provide estimates of ground-level pollutants.

Computed changes in air quality are useful both to quantify potential impacts and to demonstrate the degree of compliance with air quality laws and regulations. This appendix gives the assumptions, models and detailed results of air quality modeling for the stack and fugitive dust releases. This analysis was conducted during 1980 and reflects the available monitoring data and regulations at that time.

Air-quality regulations are normally applied on a single-site basis. Since two sites are being evaluated in this document, the approach here is to evaluate separate site impacts and then a combination of air quality impacts for the fuel conversion scenarios. The same approach is used for the PSD increment consumption. Under current PSD rules, the combined SO_2 and TSP increment consumptions cannot exceed available increments or applicable NAAQS.

Computed highest and second highest air concentrations are used for comparison with NAAQS. Potential PSD increments are computed for attainment areas. Air quality impacts in non-attainment areas are required to be less than the level of modeled significance (*de minimis* level) as defined by EPA (1980). No PSD increment is allowed in areas in non-attainment for SO_2 and TSP.

The modeling assumptions of air-quality impacts and PSD increments differ in some cases. The PSD incorporates a defined modeling procedure that provides consistency between applications. For specific sites, a better estimate of actual impacts may be obtained using more detailed models and/or actual release parameters than specified for PSD increment modeling. This may result in higher or lower air concentrations depending on the applications.

The computed magnitudes of PSD consumption depend on PSD baseline definition. By current rules for PSD baseline, the impacts of prior operations (this includes planned operations for Brandon Shores) are included in the baseline. Failure by BG&E to make timely construction progress on Brandon Shores could conceivably change the status of these units.[a] This inclusion in baseline applies primarily to stack emissions since the coal and fly ash fugitive emissions are new sources with the exception of those from existing coal operations at Wagner.

The models and assumptions that were used for computing stack emission impacts are listed below:

Plant	EPA Model	Options	Meteorological Data Sources
Brandon Shores	CRSTER	Rural	Surface Observations - Baltimore Airport, 1964-1968. Upper Air Data - Dulles International Airport, 1964-1968.
Crane	*CRSTER*	*Rural*	

These surface meteorological data are summarized in Table H.1.

(a) Letter from Richard D. Wilson, Environmental Protection Agency, to Robert Davies, .omic Regulatory Administration, Dated March 3, 1980.

TABLE H.1. Annual Frequency Distribution of Wind Speed and Direction as a Function of Atmospheric Stability at Baltimore, Maryland

Wind Speed, Miles/hr	Atmospheric Stability	Wind Direction																	
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm	Total
0 to 3	Very Stable	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.2	0.3	0.1	0.1	0.1	0.6	2.2
	Moderately Stable	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.3	0.1	0.1	0.2	0.3	0.2	0.1	0.1	1.1	3.9
	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.6
	Unstable	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	1.5
4 to 7	Very Stable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Moderately Stable	1.2	0.6	0.8	0.8	1.4	0.7	1.0	1.2	4.2	1.1	1.4	1.8	5.6	2.1	0.8	0.7	0.0	23.6
	Neutral	0.3	0.2	0.3	0.3	0.6	0.3	0.4	0.4	0.5	0.3	0.3	0.3	0.9	0.3	0.2	0.2	0.0	5.6
	Unstable	0.4	0.2	0.3	0.4	0.7	0.3	0.4	0.3	0.5	0.4	0.4	0.5	0.7	0.4	0.3	0.3	0.0	6.6
8 to 12	Very Stable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Moderately Stable	0.4	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.4	0.3	0.4	0.6	2.4	1.4	0.9	0.5	0.0	8.3
	Neutral	0.8	0.6	1.0	0.9	1.6	0.5	0.8	0.9	1.2	0.7	0.8	0.8	1.7	1.1	1.2	0.8	0.0	15.2
	Unstable	0.6	0.3	0.4	0.6	1.3	0.4	0.7	0.6	1.0	0.6	0.9	0.8	1.3	0.8	0.7	0.6	0.0	11.6
13 to 18	Very Stable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Moderately Stable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	Neutral	0.7	0.4	0.6	0.5	0.7	0.1	0.4	0.5	0.6	0.6	1.0	0.6	2.4	2.9	2.3	1.1	0.0	15.4
	Unstable	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.2	0.2	0.1	0.0	1.7
19 to 24	Very Stable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Moderately Stable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Neutral	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.7	1.1	0.4	0.1	0.0	3.0
	Unstable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Over 24	Very Stable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Moderately Stable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
	Unstable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	Very Stable	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.2	0.3	0.1	0.1	0.1	0.6	2.2
	Moderately Stable	1.8	0.8	1.1	1.1	1.8	0.9	1.3	1.7	3.1	1.6	2.0	2.5	6.3	3.7	1.8	1.3	1.1	26.0
	Neutral	1.9	1.2	1.9	1.8	2.9	0.9	1.6	1.9	2.4	1.7	2.2	1.8	5.9	5.7	4.1	2.2	0.2	40.3
	Unstable	1.2	0.6	0.8	1.2	2.2	0.8	1.2	1.1	1.7	1.1	1.5	1.5	2.5	1.5	1.3	1.0	0.3	21.6

Note: Based on data from National Climatic Center - Years 1964 to 1969.

The CRSTER model is an EPA-approved model for these applications. It uses a Gaussian diffusion model with disperson parameters as a function of atmospheric stability and downwind distance. The use of the meterological data from the nearest airports is a standard application of this model.

The stack emissions for Brandon Shores *and Crane* based on load factors of 50%, 75%, and 100% were run for the meteorological conditions measured during 1964 to determine the worst-case loading factor. In previous stack emissions impact modeling, that year was clearly the worst year from a meteorological standpoint for the Brandon Shores (Brower 1980a) *and Crane facilities (Brower 1980b).*

Air concentrations were computed over 15 arcs for 36 directions. The following are the distances in kilometers used in each analysis:

Brandon Shores - Air Quality and PSD:
0.8, 1.0, 1.3, 1.7, 2.3, 3., 4., 6., 8., 12., 16., 23., 32., 41., 50.

Crane - Air Quality and PSD:
0.8, 1.0, 1.3, 1.7, 2.3, 3.0, 4., 6.,8., 12., 16., 23., 32., 41., 50.

Computations were made for all these distances for the year 1964. Then, based on these results, only an inner set of arcs were used to define maximum values for the other years.

Whether rural or urban dispersion coefficients are more appropriate for these facilities is a difficult question. The facilities' proximity to the Baltimore metropolitan area suggests the possibility of heat-island effects. On the other hand, the areas immediately surrounding the stacks (where the maximum concentrations occur) are characterized as relatively flat sites adjacent to large areas of water. Application of the applicable proposed guidelines (EPA 1980), based on land use, gave rural ratings to both facilities. Based on this result, all the units were modeled with rural dispersion coefficients.

Air-Quality Computations: Tables 4.1 and 4.2 contain the emission and stack data used in computations of potential air quality impacts. To demonstrate the range of concentration as a function of load factors, emissions for 100%, 75% and 50% load factors were modeled for one year (1964) for each of the units for Scenario 3. Slight variations in exit conditions may change the concentration distributions somewhat for the other scenarios, but the overall comparison of load factors should not change. All the concentrations reported in this Appendix for air qualities are the contributions from the stacks alone. These are added to background values to predict ambient concentrations given in the main text.

Brandon Shores Units 1 and 2: The air quality computations are based on the actual stack height and emission characteristics given in Table 4.1. The 100%-load factor produced the largest computed air concentrations (Table H.2) and was used in the more detailed five-year analysis reported in Table H.3 for SO_2 and Table H.4 for TSP. These tables show the changes in concentration from the operation of the units with no background component added.

Crane Units 1 and 2: The emission factors for Crane units in Table 4.2 were used to compute the predicted SO_2 and TSP concentration changes given in Tables H.5 and H.6. In Table H.2, Crane operations with 75% load factors produced slightly larger computed concentration than the 100% load factor. As a result, a detailed analysis is given for both the 100% and 75% cases in Table H.5. No background component has been added, nor has the current operations component been subtracted from these values.

Annual computed maximum NO_x concentrations are given in Table H.7. Three-hour predicted maximum NO_x concentrations in Table H.8 are presented for impact analysis in the absence of any current short-term standard for NO_x. NO_x concentrations are the sum of NO plus NO_2. Background estimates are not included in these values.

TABLE H.2. Comparison of Load Factors for 1964 of Predicted Changes in SO_2 Concentration for Brandon Shores and Crane[a]

Facility	Load Factor	Highest Annual	Highest 24-Hour	Second High 24-Hour	Highest 3-Hour	Second High 3-Hour
Brandon Shores[b]	100%	1.8(9,6)	79(10,1.7,181)	61(10,1.7,192)	634(10,1.7,181,4)	490(10,1.7,192,4)
	75%	0.6(9,4)	22(10,1.7,181)	16(10,1.7,192)	174(10,1.7,181,4)	130(10,1.7,192,4)
	50%	0.6(9,4)	19(10,1.3,181)	12(10,1.7,192)	152(10,1.3,181,4)	97(10,1.3,192,4)
Crane[c]	100%	6.3(10,4.0)	119(10,1.3,181)	90(27,3.0,125)	951(10,[illegible],4)	615(10,1.3,192,4)
	75%	6.9(9,3.0)	127(19,2.3,212)	96(27,2.3,125)	973(10,1.3,181,4)	628(16,1.3,192,4)
	50%	5.9(10,3.0)	116(10,1.0,181)	80(10,1.3,192)	922(10,1.0,181,4)	586(10,1.0,192,4)

(a) Values in μg/m³ for Scenario 3 with 1964 meterological data are followed by direction (tens of degrees from north), distance (km), Julian Day, and time period as appropriate.
(b) Units 1 and 2 using EPA CRSTER Model, rural option.
(c) Units 1 and 2 using EPA CRSTER Model, rural option.

TABLE H.3. Computed Maximum Changes in SO_2 Ground-Level Concentrations from Brandon Shores[a]

Scenario	Year	Highest Annual	Highest 24-Hour	Second High 24-Hour	Highest 3-Hour	Second High 3-Hour
1,2	1964	0.6(9,8)	18(26,1.7,123)	14(27,1.7,180)	121(7,1.0,128,5)	112(27,1.7,125,4)
	1965	0.5(10,8)	19(15,1.7,199)	12(10,8.0,214)	110(7,1.3,163,4)	80(7,1.7,228,5)
	1966	0.4(7,6)	20(28,1.7,218)	14(29,1.7,218)	125(5,1.7,174,5)	95(29,1.7,143,4)
	1967	0.4(10,8)	14(12,1.7,230)	10(12,1.7,150)	110(12,1.7,230,5)	82(12,1.7,150,4)
	1968	0.5(12,8)	25(9,1.7,184)	13(8,1.7,203)	154(27,1.7,187,4)	99(6,1.7,203,5)
3,5	1964	1.8(9,6)	79(10,1.7,181)	61(10,1.7,192)	634(10,1.7,181,4)	490(10,1.7,192,4)
	1965	1.4(9.6)	38(15,1.3,199)	22(7,1.3,228)	274(25,1.3,140,5)	172(7,1.3,228,5)
	1966	1.3(7,4)	38(5,1.3,174)	29(2,1.3,171)	306(5,1.3,174,5)	211(4,1.3,174,5)
	1967	1.2(4,6)	41(10,1.3,197)	25(10,1.3,156)	327(10,1.3,197,4)	201(10,1.3,156,4)
	1968	1.6(12,6)	64(25,1.3,170)	45(9,1.3,167)	337(7,1.3,203,5)	281(9,1.3,177,4)
4	1964	1.9(9,4)	61(10,1.7,181)	45(10,1.7,192)	483(10,1.7,181,4)	347(10,1.7,192,4)
	1965	1.3(10,4)	33(15,1.0,199)	27(9,4.0,225)	223(15,1.7,123,4)	174(14,1.0,226,4)
	1966	1.3(7,4)	55(15,3.0,175)	34(14,3.0,236)	290(5,1.3,174,5)	173(2,1.0,171,5)
	1967	1.2(4,4)	35(10,1.0,197)	23(25,[illegible]3.212)	280(10,1.0,197,4)	160(6,1.0,125,5)
	1968	1.3(12,4)	68(25,1.3,221)	47(25,1.3,170)	546(25,1.3,221,4)	261(21,1.3,177,4)

(a) Using EPA CRSTER Model, rural mode. All values are for 100% load factor. Each entry consists of concentration (μg/m³) with additional data as appropriate; direction (tens of degrees from north), distance (km), Julian Day, and time period.

Maximum concentrations of other pollutants listed in Tables 4.1 and 4.2 may generally be obtained by factoring emission rates with pollutants for which concentrations are presented above. These are based on passive dispersion with no chemical changes or settling. The particle controls result in releases consisting of primarily small particles that can be considered passively dispersed. Note, however, that performing this factoring for the particulate pollutants may give unrealistically high values. Particulate emissions other than TSP are based on current stack controls. Extension to conversion emissions requires the definition of the controls required to meet the regulatory maximum TSP emission. If the control equipment must be upgraded, then emissions and computed concentrations should be correspondingly reduced.

TABLE H.4. Computed Maximum Changes in TSP Concentrations from Brandon Shores[a]

Scenario	Year	Highest Annual	Highest 24-Hour	Second High 24-Hour
1,2	1964	0.04(9,8)	1.1(26,1.7,123)	0.[illegible](27,1.7,180)
	1965	0.03(10,8)	1.1(15,1.7,199)	0.7(10,8,214)
	1966	0.02(7,6)	1.2(28,1.7,218)	0.8(29,1.7,218)
	1967	0.02(10,8)	0.8(12,1.7,230)	0.6(12,1.7,150)
	1968	0.03(12,8)	1.5(9,1.7,184)	0.8(8,1.7,203)
3,5	1964	0.07(9,6)	3.1(10,1.7,181)	2.4(10,1.7,192)
	1965	0.05(9,6)	1.5(15,1.3,199)	0.9(7,1.3,22[illegible])
	1966	0.05(7,4)	1.5(5,1.3,174)	1.1(2,1.3,171)
	1967	0.05(4,6)	1.6(10,1.3,197)	0.8(10,1.3,156)
	1968	0.05(12,6)	2.5(25,1.3,170)	1.8(9,1.3,167)
4	1964	0.11(9,4)	3.6(10,1.7,181)	2.[illegible](10,1.7,192)
	1965	0.08(10,4)	1.9(15,1.0,199)	1.6(9,4.0,225)
	1966	0.08(7,4)	3.2(15,3.0,175)	2.0(14,3.0,236)
	1967	0.07(4,4)	2.4(10,1.0,197)	1.3(25,1.3,170)
	1968	0.08(12,4)	3.7(25,1.3,221)	2.7(25,1.3,170)

(a) Using EPA CRSTER Model, rural mode. All values are for 100% load factor. Each entry consists of concentration (μg/m³) with additional data as appropriate; direction (tens of degrees from north), distance (km) and Julian Day.

TABLE H.5. Predicted Maximum SO_2 Concentration Changes from Crane Units 1 and 2[a]

Scenario	Year	Highest Annual	Highest 24-Hour	Second High 24-Hour	Highest 3-Hour	Second High 3-Hour
(load factor)						
1 (100%)	1964	2.2(10,4.0)	40(10,1.3,181)	30(27,3.0,125)	324(10,1.3,181,4)	210(10,1.3,[illegible]2,4)
	1965	2.2(11,8.0)	36(9,3.0,251)	32(10,3.0,214)	149(19,2.3,112,4)	135(13,1.7,206,4)
	1966	1.8(11,8.0)	53(15,2.3,175)	35(14,2.3,236)	220(5,1.0,174,5)	129(18,4.0,225,3)
	1967	2.0(11,8.0)	39(20,3.0,223)	23(10,3.0,261)	214(10,1.0,197,4)	128(10,2.3,203,4)
	1968	[illegible].4(11,8.0)	56(20,1.3,157)	33(20,3.0,224)	448(20,1.3,157,4)	221(19,1.3,228,4)
2,3,4,5 (100%)	1964	6.3(10,4.0)	119(10,1.3,181)	90(27,3.0,125)	951(10,1.3,181,4)	615(10,1.3,192,4)
	1965	6.2(11,8.0)	105(9,3.0,251)	96(10,3.0,214)	439(13,2.3,112,4)	396(13,1.7,206,4)
	1966	5.2(11,8.0)	158(15,2.3,175)	103(14,2.3,236)	647(5,1.0,174,5)	378(18,4.0,225,3)
	1967	5.9(11,8.0)	114(20,3.0,223)	69(10,3.0,261)	628(10,1.0,197,4)	376(10,2.3,203,4)
	1968	6.9(11,6.0)	164(10,1.3,157)	98(20,3.0,224)	1312(20,1.3,157,4)	649(19,1.3,228,4)
2,3,4,5 (75%)	1964	6.9(9,3.0)	127(19,2.3,212)	96(27,2.3,125)	973(10,1.3,181,4)	629(16,1.[illegible],192,4)
	1965	6.6(11,6.0)	112(9,2.3,251)	100(10,2.3,130)	575(8,3.0,47,4)	445(33,2.3,185,5)
	1966	5.7(11,6.0)	173(15,1.7,175)	111([illegible],2.3,236)	626(5,1.0,174,5)	425(28,1.7,254,5)
	1967	6.3(11,6.0)	119(20,2.[illegible],22[illegible])	76(10,3.0,261)	655(10,0.8,197,4)	393(10,2.3,203,4)
	1968	7.4(11,4.0)	213(20,1.[illegible],157)	106(20,2.3,22[illegible])	1123(20,1.3,157)	580(20,1.3,157,3)

(a) Using EPA CRSTER Model, rural mode. All values are the 100% load factors except the scenarios noted as 75%. Each entry consists of concentration (μg/m³) with additional data as appropriate; direction (tens of degrees from north), distance (km), Julian Day, and time period.

TABLE H.6. Computed Maximum Changes in TSP Concentrations from Crane Units 1 and 2[a]

Scenarios	Year	Highest Annual	Highest 24-Hour	Second High 24-Hour
1	1964	0.06(10,4.0)	1.1(10,1.3,181)	0.8(27,3.0,125)
	1965	0.06(11,8.0)	1.0(9,3.0,251)	0.9(10,3.0,214)
	1966	0.05(11,8.0)	1.4(15,2.3,175)	0.9(14,2.3,236)
	1967	0.05(11,8.0)	1.1(20,3.0,223)	0.6(10,3.0,261)
	1968	0.07(11,8.0)	1.5(20,1.3,157)	0.9(20,3.0,224)
2,3,4,5	1964	0.09(13,4.0)	1.7(10,1.3,181)	1.3(27,3.0,125)
	1965	0.09(11,8.0)	1.5(9,3.0,251)	1.3(10,3.0,214)
	1966	0.07(11,8.0)	2.2(15,2.3,175)	1.4(14,2.3,236)
	1967	0.08(11,8.0)	1.6(20,3.0,223)	1.0(10,3.0,261)
	1968	0.10(11,6.0)	2.3(20,1.3,157)	1.4(20,3.0,224)

(a) Using EPA CRSTER Model, rural mode. All values are for 100% load factors. Each entry consists of concentration ($\mu g/m^3$) followed by the direction (tens of degrees from north) and distance (km); the Julian Day is given for the 24-hour values.

Table H.7. Computed Maximum Annual NO_x Concentration Changes

Scenario	Year	Brandon Shores[a] Units 1 and 2	Crane[a] Units 1 and 2
1	1964	0.2(9,8)	3(10,4)
	1965	0.2(10,8)	1.3(11,8)
	1966	0.2(7,6)	1.0(11,8)
	1967	0.2(10,8)	1.1(11,8)
	1968	0.2(12,8)	1.4(11,8)
2	1964	0.2(9,8)	3.9(10,4)
	1965	0.2(10,8)	3.9(11,8)
	1966	0.2(7,6)	3.3(11,8)
	1967	0.2(10,8)	3.7(11,8)
	1968	0.2(12,8)	4.3(11,6)
3,5	1964	1.0(9,6)	3.9(10,4)
	1965	0.8(9,6)	3.9(11,8)
	1966	0.8((7,4)	3.3(11,8)
	1967	0.7(4,6)	3.7(11,8)
	1968	0.9(12,6)	4.3(11,6)
4	1964	1.7(9,4)	3.9(10,4)
	1965	1.1(10,4)	3.9(11,8)
	1966	1.1(7,4)	3.3(11,8)
	1967	1.1(4,4)	3.7(11,8)
	1968	1.1(2,4)	4.3(11,6)

(a) Using EPA CRSTER Model, rural mode. All values are for 100% load factors. Each entry consists of concentration ($\mu g/m^3$) with direction (tens of degrees from North), distance (km), Julian Day, and time period.

TABLE H.8. Computed Maximum 3-Hour NO_x Concentration Changes

Scenario	Year	Brandon Shores[(a)] Units 1 and 2	Crane[(a)] Units 1 and 2
1	1964	45(7,1.3,128,5)	183(10,0.4,20,7)
	1965	41(7,1.3,163,4)	84(13,0.4,240,6)
	1966	47(5,1.7,230,5)	125(13,0.4,92,5)
	1967	41(12,1.7,230,4)	121(8,0.4,291,8)
	1968	58(27,1.7,187,4)	254(20,1.2,157,4)
2	1964	45(7,1.3,128,5)	594(10,0.6,20,7)
	1965	41(7,1.3,163,4)	274(13,0.4,240,6)
	1966	47(5,1.7,230,5)	404(16,0.4,129,7)
	1967	41(12,1.7,230,4)	392(8,0.4,291,8)
	1968	58(27,1.7,187,4)	819(20,1.2,157,4)
3,5	1964	371(10,1.7,181,4)	594(10,0.6,20,7)
	1965	160(23,1.3,140,5)	274(13,0.4,240,6)
	1966	178(5,1.3,175,5)	404(16,0.4,129,7)
	1967	191(10,1.3,197,4)	392(8,0.4,291,8)
	1968	197(7,1.3,203,5)	819(20,1.2,157,4)
4	1964	423(10,1.7,181,4)	594(10,0.6,20,7)
	1965	196(15,1.7,123,4)	274(13,0.4,240,6)
	1966	254(5,1.3,174,5)	404(16,0.4,129,7)
	1967	245(10,1.0,193,4)	392(8,0.4,291,8)
	1968	478(25,1.3,221,4)	819(20,1.2,157,4)

(a) *Using EPA CRSTER Model, rural mode. All values are the 100% load factors except the scenarios noted as 75%. Each entry consists of concentration ($\mu g/m^3$) with additional data as appropriate; direction (tens of degrees from North), distance (km), Julian Day, and time period.*

Combined Air-Quality Computations

This section presents maximum combined impacts for each scenario. The following description of the technique used applies also to the combined PSD computations discussed in a later section.

The analysis is based on a telescoping data retrieval method. The outputs of the individual plant air-quality impact computations are stored in a data base. Then the impacts of the operations of multiple units are summed over the time scales of interest on a variable-space scale to define maximum potential impacts.

More specifically, for the air-quality analysis, binary packed files of the 3-hour, 24-hour and annual air concentration for 1964 were created using CRSTER for the Brandon Shores and Crane units. Maximum values for each time period were summed over the annual cycle on a 10 x 10 square grid over the region with 10-km grid spacing. Then if necessary, grid areas with the high concentrations can be recomputed with a 1-km grid spacing. Then, as required, the maxima can be further recomputed with a 0.1-km grid spacing.

This approach allows the maxima from each facility to be modeled in detail on a grid appropriate to each facility, and then these computations can be overlayed in space and time to define maximum values. Fifteen arcs with 36 directions were used at each facility to define maxima as described in the preceding air-quality section. A finer spacing of computation distances is used where concentrations change rapidly close to the release, and a progressively wider spacing is used at greater distances where the concentrations do not change as rapidily. At grid points intermediate between computation points the closest value is adopted.

This method overcomes the problem of defining maximum values on detailed grids with reasonable computation time. The method provides conservative estimates of overlap on the larger grid spacings, and realistic estimates on the finer grid spacings.

Combined air-quality computations made for the SO_2 concentrations in the scenarios illustrate the extent of potential plume combinations. Although the coarse grid values are not necessarily limiting from an air-quality regulatory viewpoint, these numbers are useful for overall impact evaluation. The fine grid values derived below for the PSD increments are applicable for investigating compliance with regulations.

PSD Increment Computations: As noted above, the procedures for PSD increment (PI) computations were not identical in all cases to the air quality computation.

For Brandon Shores, the actual stack height exceeds the Good Engineering Practices (GEP) stack height. PSD increments are based on the more conservative use of GEP stack height. *For Crane, the air-quality and PSD assumptions are identical.* Although there appears to be no clearly defined rule, the current practice is not to use building effects when computing PI.

The availability of PI depends both on previous consumption by PSD permits and on the requirement that none of the computed concentrations can violate NAAQS.

Monitored data near the various units are used to define the PSD baselines. The sum of the baseline and the conversion increments are compared with NAAQS to determine available increments.

PSD increment consumptions cannot exceed available increments. In addition, the remaining increments indicate the future availability for consumption by other sources.

Fuel conversion Scenario 1 represents the oil-fired air quality impacts of the status quo. *For Crane, These are also, included in the PSD baseline.* For a fuel conversion at Brandon Shores, baseline PSD concentration is to be based on the original emission permit. Since this specified fossil fuel at 589K exit temperature from the boiler, EPA has indicated that coal emissions may be used to define the PSD baseline for stack emissions at the original exit temperature[a]. Since the stack emissions with the coal have a lower exit temperature, the change in location of maximum pollutant concentrations will result in PSD consumptions, even if total emissions are the same.

These definitions of PSD baselines are used to define the extent of potential PSD consumptions using the best and most current information. Applicable consumptions may differ. These represent an acceptable procedure for defining PSD increments based on current rules and practices.

The PSD increments (PI) for stack emissions are computed as the difference between air concentrations (at each point in space and time) with the plants converted and not converted.

(a) Letter from Richard D. Wilson, Environmental Protection Agency, to Robert Davies, Economic Regulatory Administration, Dated March 3, 1980.

For the individual plants;

$$PI_B = B_n - B_b$$
$$PI_C = C_n - C_b$$

and for the total consumption:

$$PI_{Total} = PI_B + PI_C$$

where all quantities are expressed in units of $\mu g/m^3$; n is the subscript for Scenarios 2 to 5; b is the subscript for the baseline value; and the letters B and C refer to ground-level concentrations of the regulatory pollutant concentrations from Brandon Shores *and Crane*, respectively. The largest value of PI that occurs at any time or location is the limiting value in terms of PSD compliance. No consumption occurs for the no-action Scenario 1, or for Brandon Shores in Scenario 2.

The total emissions at each site were modeled to check for compliance with NAAQS. As long as the modeled increment plus background is below NAAQS, full increment is assumed to be available.

Tables H.9 to H.11 give the computed single station PSD increments, locations, and times for Brandon Shores *and Crane*. For each case, the total concentrations (monitored plus computed) were compared with NAAQS. The amount of PI was not found to be limited by failures to meet NAAQS. The only cases of non-compliance were ones where the computed PI exceeded the available PI (or de minimis value in the non-attainment area).

PSD increments and the total maximum changes in air quality were computed for SO_2 emissions at 50%, 75%, and 100% load factors in Scenario 2 at each station using the 1964 meteorological data (Table H.2).

Brandon Shores had maximum PI at 100% load factors. The totals and increments were identical for Brandon Shores, with the exception of a slight displacement of the location of maximum annual values. This is because the baseline maximum impacts occurred about a factor of two further downwind than the conversion impacts; no significant overlays of plumes occurred under the maximum increment conditions. The five-year detailed PI at Brandon Shores were based on 100% load factors (Table H.10).

Crane had maximum increments for 75% load factors based on 1964 data for Scenario 3 for all values except one; highest annual SO_2 occurred for 100% load factors (Table H.9). Both 100% and 75% load factors were then used to compute maximum values for the four other years of meteorological data for the other secnarios. The differences between the results were small; 100% load factors were selected to compute typical maximums for the other scenarios at Crane (Table H.11).

Combinations of the PSD increments were studied using the technique described for the combination of air quality values in the preceding section. These are conservative estimates based on adding in each time step the maximum highest and second highest values from each conversion within 1-km^2 squares over the region. Since actual consumptions may be less depending on where the maximums occur within the 1-km^2 areas, a case study was conducted using 0.01-km^2 areas.

One set of assumptions and one year of data were used to study the potential plume combinations in the scenarios. Table H.12 based on 100% load factors for 1964 shows that none of the combinations of Brandon Shores *and Crane* plumes were very significant. Only the combined maximum annual values showed any overlap.

TABLE H.9. Computed PSD Increments and Total Concentratins of SO_2 as a Function of 50%, 75%, and 100% Load Factors Based on 1964 Meteorological Data for Scenario 3[a]

Station	Units	Load Factor	Highest Annual	Highest 24-Hour	Second High 24-Hour	Highest 3-Hour	Highest 3-Hour
Brandon Shores[b]	1,2	100%	2(11,4.0)	81(10,1.7,181)	63(10,1.7,192)	644(10,1.7,181,4)	496(10,1.7,192,4)
Increments	1,2	75%	1(11,4.0)	22(10,1.7,181)	17(10,1.7,192)	178(10,1.7,181,4)	132(10,1.7,192,4)
	1,2	50%	1(11,4.0)	20(10,1.3,181)	13(10,1.7,192)	158(10,1.3,181,4)	101(10,1.3,192,4)
Brandon Shores[b]	1,2	100%	2(9,6.0)	81(10,1.7,181)	63(10,1.7,192)	644(10,1.7,181,4)	496(10,1.7,192,4)
Total	1,2	75%	1(9,4.0)	22(10,1.7,181)	17(10,1.7,192)	178(10,1.7,181,4)	132(10,1.7,192,4)
	1,2	50%	1(11,4.0)	20(10,1.3,181)	13(10,1.7,192)	158(10,1.3,181,4)	101(10,1.3,192,4)
Crane[c]	1,2	*100%*	*4(10,4.0)*	*79(10,1.3,181)*	*59(27,3.0,125)*	*631(10,1.3,181,4)*	*404(10,1.3,192,4)*
Increment	1,2	*75%*	*5(9,3.0)*	*84(11,2.3,212)*	*64(27,2.3,125)*	*641(10,1.3,181,4)*	*426(19,1.3,192,4)*
	1,2	*50%*	*4(10,3.0)*	*76(10,1.0,181)*	*53(10,1.3,192)*	*608(10,1.0,181,4)*	*386(10,1.0,192,4)*
Crane[b]	1,2	*100%*	*6(10,4.0)*	*119(10,1.3,181)*	*90(27,3.0,125)*	*951(10,1.3,181,4)*	*615(10,1.3,192,4)*
Total	1,2	*75%*	*7(9,3.0)*	*127(19,2.3,212)*	*96(27,2.3,125)*	*973(10,1.3,181,4)*	*628(16,1.3,19.2,4)*
	1,3	*50%*	*6(10,3.0)*	*116(10,1.0,181)*	*80(10,1.3,192)*	*922(10,1.0,181,4)*	*586(10,1.0,1.92,4)*

(a) Based on computations with the EPA CRSTER Model, rural option. Entries are concentration followed by direction (tens of degrees from north) and distance (km) from the stations. Julian Day and three-hour time period follow these values, as appropriate.

(b) Total is based on the total of plumes from both units at each station. Background is not added.

(c) Increment is based on differences in time and space of the conversion and baseline.

TABLE H.10. PSD Increment Consumption for Brandon Shores[a]

Scenario	Year	Load Factor	SO_2 Highest Annual	SO_2 Second High 24-Hour	SO_2 Second High 3-Hour	TSP Highest Annual	TSP Second High 24-Hour	TSP High 24-Hour Non-Attainment Area
3,5	1964	100%	2,(9,3.)	63(10,1.7,192)	496(10,1.7,192,4)	0[b]	0[b]	0[b]
	1964	75%	1(11,4.)	13(10,1.7,192)	101(10,1.3,192,4)	0	0	0
	1964	50%	1(11,4.)	17(10,1.7,192)	132(10,1.7,192,4)	0	0	0
	1965	100%	1(36,41)	20(10,4.,214)	131(14,1.,226,4)	0	0	0
	1966	100%	1(14,41)	26(3,3.,165)	132(4,1.3,174,5)	0	0	C
	1967	100%	1(36,41)	25(17,1.7,230)	203(17.1.7,230,4)	0	0	0
	1968	100%	1(13,41)	43(25,1.3,221)	285(9,1.3,177,4)	0	0	0
4	1964	100%	2(10,3.)	47(10,1.7,192)	353(10,1.7,192,4)	0	0	0
	1965	100%	1(32,4.)	24(28,2.3,178)	219(14,1.,226,4)	0	0	0
	1966	100%	1(33,6.)	31(14,3.,236)	172(31,3.219,4)	0	0	0
	1967	100%	1(21,4.)	25(10,4.,261)	144(17,1.,230,4)	0	0	0
	1968	100%	2(12,3.)	44(20,1.3,228)	336(19,1.7,228,4)	0	0	0

(a) Based on the difference between baseline and conversion as explained in text. Computed for releases at GEP stack height using EPA CRSTER model, rural mode. Each entry gives the concentration ($\mu g/m^3$) followed by direction (tens of degrees from north), distance (km), Julian Day and 3-hour time period, as appropriate. No PSD increment consumption occurs in Scenarios 1 and 2.

(b) Less than *de minimis* value.

TABLE H.11. PSD Increment Consumption for Crane[a]

Scenario	Year	SO_2 Highest Annual	SO_2 Second High 24-Hour	SO_2 Second High 3-Hour	TSP Highest Annual	TSP Second High 24-Hour	TSP Highest 24-Hour	Non-Attainment Area Highest 24-Hour TSP
(load factor)								
2,3,4,5	1964	4.2(10,4.0)	59(27,3.0,125)	404(10,1.3,192,4)	0.06(10,4.0)[b]	0.9(27,3.0,125)[b]	1.1(10,1.3,181)[b]	(b)
(100%)	1965	4.1(11,8.0)	63(10,3.0,214)	260(13,1.7,206,4)	0.06(11,8.0)	0.9(10,3.0,214)	1.0(9,3.0,251)	(b)
	1966	3.4(11,8.0)	68(14,2.3,236)	243(18,4.0,225,3)	0.05(11,8.0)	0.9(14,2.3,236)	1.5(15,2.3,165)	(b)
	1967	3.9(11,8.0)	45(10,3.0,261)	248(10,2.3,203,4)	0.05(11,8.0)	0.7(10,3.0,261)	1.0(20,3.0,223)	(b)
	1968	4.5(11,6.0)	64(20,3.0,224)	426(19,1.3,228,4)	0.07(11,6.0)	0.9(20,3.0,224)	1.5(20,1.3,157)	(b)
2,3,4,5 (75%)	1964	4.5(9,3.0)	64(27,2.3,125)	416(16,1.3,192,4)	(c)	(c)	(c)	(c)
	1965	2.2(11,6.0)	66(10,2.3,130)	295(33,2.3,185,5)				
	1966	2.0(11,4.0)	74(14,2.3,236)	282(28,1.7,254,5)				
	1967	2.1(11,6.0)	50(10,3.0,261)	260(10,2.3,203,4)				
	1968	2.5(11,4.0)	70(20,2.3,224)	384(20,1.3,157,3)				
2,3,4,5 (50%)	1964	3.9(10,3.0)	53(10,1.0,192)	386(10,1.0,192,4)	(c)	(c)	(c)	(c)

(a) Based on the difference between baseline and conversion as explained in text. Computed for release at actual stack height using EPA CRSTER model, rural mode. Each entry gives the concentration ($\mu g/m^3$) followed by direction (tens of degrees from north), distance (km), Julian Day and 3-hour time period, as appropriate.

(b) Less than de minimis value at all locations; values given for Scenario 2 only.

(c) No value computed.

TABLE H.12. Combined Maximum SO_2 PSD Increments (PI) for Each Scenario[a]

Scenario	Highest Annual (PI)	24-Hour Second High (PI)	3-Hour Second High (PI)
2 C	4(C,10,4.0	59(C,27,3.0,125)	404(C,10,1.3,192,4)
3,5 All[b]	5(C,10,4.0)	63(B,10,1.7,192	496(B,10,1,1.7,192,4)
B	1	63	496
C	4	0	0
4 All	4(C,10,4.0)	54(C,27,3.0,125	404(C,10,1.3,192,4)
B	0	0	0
C	4	49	404

(a) Based on combined outputs from CRSTER runs for year 1964 based on 100% load factors at all stations. Values are sums of maximum and second high maximums occurring within a grid of areas of 1 km^2. Coverage in the analysis was 10^4 km^2. Actual consumptions may be less depending on plume overlaps on distances less than the 1-km grid used to generate this table.
B = Brandon Shores; C = Crane.

(b) All = maximum total for all units; contribution of Brandon Shores (B) and Crane (C).

(c) Locations relative to Brandon Shore (B) or Crane (C) followed by direction in tens of degrees from north and downwind distance (km). Julian day and 3-hour time periods are also listed.

These values (Table H.12) are not meant to represent the highest values that may occur. Clearly other years and/or load factors may result in higher values. Although values in Table H.12 represent maximums, these computed values could be slightly higher or lower if data on meteorological conditions from different years were used, or if different facility load factors were used. These values are conservative estimates because Table H.12 is based on a 1.0-km grid resolution; using a finer grid with this method will give the same or slightly smaller values.

As a case study, the 24-hour SO_2 combined concentrations were recomputed based on 100% load factors at Brandon Shores *and Crane*. These reflect the tendencies for local maxima noted in the PSD analysis.

Hence, the interpretation of Table H.12 should only be to illustrate the range of potential overlaps between the scenarios. Cases with near or over 100% consumption illustrate combinations of fuel conversions where combined PSD consumption may be limiting. *The Crane plume does not have significant overlaps with Brandon Shores.*

Capacity Factors

The average capacity factors for operation of the existing facilities are useful in evaluating actual current impacts, as opposed to maximum impacts considered in the previous sections. The following are the 1979 seasonal and annual capacity factors for Crane.[a]

	Crane	
	Unit 1	Unit 2
Spring	68.1	42.7
Summer	51.5	48.1
Fall	41.2	50.8
Winter	73.6	58.9
Annual Average	58.5	5ᐢ0

The air-quality analysis showed greatest impacts at 100% load factors. These capacity factors imply lower average concentrations. The low capacity factors are a combination of operations at lower load factors and for periods of no operation. These factors apply only to the historical operation of the units; operations under coal may differ. Depending on actual operations, the potential air-quality impacts are expected to range up to the maximum values presented in the preceding sections.

Comparison with Other Computations of Stack Air-Quality Impacts

The preceding analyses are based on interpretation of current regulations and guidelines for air-quality modeling. This approach has differed in the models selected and in some input assumptions from other recent modelings of the conversion of several of these units. The following is a comparison with these efforts.

The State of Maryland and BG&E modeled air quality for the Brandon Shores (Brower 1980a; Hattrup 1980) *and Crane (Brower 1980b)* conversions using CRSTER with the urban option. Tables H.13 and H.15 compare the State of Maryland results with PNL results using the CRSTER rural option. These results were nearly identical for cases with the same inputs. The State of Maryland source terms are listed in Table H.14 and H.16.

(a) Letter from D. P. Cameron, BG&E, to J. Poasek, ERA dated April 11, 1980

Table H.13. Comparison of SO_2 Air Quality Concentration Changes for Brandon Shores for 1964 to 1968

Model	Highest[(a)] Annual	Second High[(b)] 24-Hour	Second High[(c)] 3-Hour
Total SO_2			
Urban CRSTER[(d)]	2.0(9,5.,64)	58.1(10,2.,192.,64)	432.4(10,2.,192,4,64)
Rural CRSTER[(e)]	1.8(9,6.,64)	61(10,1.7,192,64)	490(10,1.7,192,4,64)
SO_2-PSD Increments			
Urban CRSTER[(d)]	1.2(9,4.)	48(10,2.)	350(10,2.)
Rural CRSTER[(f)]	2.0(9,3.)	63(10,1.7)	496(10,1.7)

(a) Concentration (μg/m³), direction (tens of degrees from North), distance (km) and year. Year and day not given for PSD increments.
(b) Concentration (μg/m³), direction (tens of degrees from North), distance (km), and (for total SO_2); Julian Day and year.
(c) Concentration (μg/m³) direction (tens of degrees from North), distance (km) and (for total SO_2); Julian Day, 3-hour time period.
(d) Brower, R. 1980a.
(e) From Table H.3; actual stack height used; Scenario 2.
(f) From Table H.10; note that the lower-than-actual GEP stack height is used to compute these values; Scenario 2.

TABLE H.14. Emission Characteristics Used for Alternative Brandon Shores Air Quality CRSTER Runs[(a)]

Unit	SO_2 (g/s)	TSP (g/s)	NO_2 (g/s)	Emission Rates Stack Height (m)	Stack Diameter (m)	Exit Velocity (m)	Exit Temperature (°K)
1	901.1	45.0	525.7	213.4	6.71	23.77	403.0
2	901.1	45.0	525.7	213.4	6.71	23.77	403.0

(a) Brower, R. 1980a

Fugitive Dust Screening Model

The following describes the screening model used to compare the relative maximum TSP impacts for the two facilities. The source terms and assumptions are generally conservative, and the results are suitable for comparative purposes. More detailed computations with site-specific assumptions and models can be expected to produce much lower estimated concentration, as was found in recently available studies for Brandon Shores *and Crane* referenced in the main text.

Twenty-four hour average TSP concentrations resulting from fugitive dust were estimated for each site at the nearest nonshoreline boundary. A Gaussian dispersion model (PEDCo 1978), employing source depletion to account for particle deposition, was used to estimate one-hour average

TABLE H.15. Comparison of SO_2 Air Quality Computation for Crane

Model	Year	Annual	Second High 24-Hour	Second High 3-Hour
CRSTER[a] (Urban)	1964	5.7(10,5)	80.0(10,2,197)	393.3(10,2,192,4)
	1965	5.6(11,7.5)	80.2(9,3,2[illegible])	350.9(33,3,202,6)
	1966	4.9(13,7.5)	82.8(14,3,236)	368.2(15,2,175,5)
	1967	5.5(11,7.5)	62.1(9,3,243)	317.0(8,2,194,5)
	1968	6.2(11,5)	77.8(4,3,181)	473.4(19,2,228,4)
CRSTER[b] (Rural)	1964	6.3(10,4.0)	90(27,3.0,125)	615(10,1.3,192,4)
	1965	6.2(11,8.0)	96(10,3.0,214)	396(13,1.7,206,4)
	1966	5.2(11,8.0)	103(14,2.3,236)	378(18,4.0,22.5,3)
	1967	5.9(11,8.0)	69(10,3.0,261)	376(10,2.3,203,4)
	1968	6.9(11,6.0)	98(20,3.0,224)	648(19,1.3,228,4)

(a) Brower, R. (1980b).
(b) From Table H.5, Scenario 2.

TABLE H.16. Exit and Emission Characteristics Used for Alternative Crane Air Quality CRSTER Runs[a]

Fuel	Unit	Emission Rates SO_2 (g/s)	Emission Rates TSP (g/s)	Emission Rates NO_2 (g/s)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m)	Exit Temperature (°K)
Oil	1	242	9	162	107.6	3.33	35	422
	2	242	9	162	107.6	3.33	35	422
Coal	1	755	13	450	107.6	3.33	35	422
	2	755	13	450	107.6	3.33	35	422

(a) Brower, R. (1980b).

concentrations. From these one-hour averages, 24-hour average values were estimated using an empirical scaling factor of 0.4 (Budney 1977).

The area of release (e.g., storage pile, construction area) was represented in the model as a virtual ground-level point source located upwind of the actual area source. The distance upwind was computed as a function of the width of the release area and the atmospheric stability. The meteorological inputs to the model were varied over a reasonable range of conditions. The source term for coal-storage areas varied with wind speed. Maximum hourly values occurred during higher wind speeds. The highest values occured at wind speeds of 5 m/s under neutral stability. Stable conditions during high winds are rare or nonexistent because of the mechanical mixing of the winds. Unstable conditions cause more rapid mixing downwind and produce lower concentrations for a ground-level release.

Emission factors listed in Table H.17 were used in the screening model to estimate fugitive dust releases from major sources. Dust releases from ash-handling activities were calculated using coal-handling emission factors. Emissions resulting from limestone storage were calculated using the emission factor for aggregate storage. The coal-storage, ash-storage, and construction emission factors can be considered conservative estimates for the Baltimore area. All three factors were developed for areas with drier and more severe climate than the Baltimore area.

TABLE H.17. Screening Model Fugitive Dust Emission Factors[a]

Activity	Emission Factor
Construction	1.2 tons/acre-month[b]
Coal Transport and Unloading	0.0097 lb/ton
Coal Loading	0.0034 lb/ton
Coal Storage	0.23 lb/acre[c]
Coal Processing	0.002 lb/ton
Limestone Transport and Loading	0.004 lb/ton
Limestone Unloading and Processing	0.002 lb/ton
Aggregate Storage	0.33 lb/ton[b]

(a) All factors are based on Blackwood and Peters (1976) except where noted.
(b) Factor is based on Cowherd et al. 1974.
(c) Factor is derived from PEDCO et al., 1978, and an average wind speed of 4.2 m/sec.

Specific emission factors are unavailable for fugitive releases from RDF. Regardless of the form, RDF would require covering during transport. Atmospheric releases would be minimal in routine boiler operation using RDF, and only minor fugitive emissions are anticipated from the routine onsite handling of RDF.

Emissions Estimates

Estimates were made of the maximum amount of fugitive dust that would be released under each scenario at the sites assuming a wind of 5.0 m/sec (Table H.18). The amount of dust generated was reported as an incremental increase over the no-action case (Scenario 1). *The burning of coal in Crane boilers would not produce dry fly ash; combustion residue would be in the form of slag.* The dry fly ash produced at Brandon Shores could be stored in covered silos, thus eliminating wind entrainment at the storage site.

Conversion of the BG&E generating stations to coal would necessitate the building of a coal-pile-runoff treatment facility at each site. In addition, scrubber systems would need to be installed at Brandon Shores under Scenarios 4 and 5. Except for the installation of scrubber systems, these activities are expected to last less than a year.

The computed 24-hour average incremental TSP concentrations for all stations and scenarios for which conversions are proposed are given in Table H.19. These show the relative maximum potential for impact between the sites and conversions. As explained in the main text, the recently available impact values based on detailed modeling for Brandon Shores *and Crane* better define the magnitudes of expected impacts for those facilities, and by implication of the other facilities.

Background Air-Quality Data

The maximum monitored ambient air pollutant values in the immediate vicinity of each of the facilities are summarized in Table H.20. The pollutant air concentration changes in Tables H.2 to H.6 are translated to potential ambient concentration by adding these values to the background air quality. The background air quality value is the sum of monitored (Table H.20) and modeled values for the projected operation of the plants. Although not included in the maximum air-quality estimates, the monitored values may include contributions from the current operations *for Crane* and Wagner. Capacity factors given above show how the actual operations compared with the full load no-action operations used in Scenario 1.

TABLE H.18. Screening Model Inputs of Fugitive Emissions from BG&E Plants

	Incremental Releases in lbs Dust/Day		
	Scenarios		
Brandon Shores	3	4	5
Coal Handling	163	181	181
Coal Storage	1610	1610	1610
Fly Ash Handling	16	16	16
Limestone Handling	0	13	0
Construction	1120	2480	1120
Crane			
Coal Handling	59	54	54
Coal Storage	520	520	520
Limestone Handling	0	1	0
Limestone Storage	0	6	0
Construction	160	560	160

TABLE H.19. Screening Model Computations of 24-Hour Average Incremental TSP Air Concentration[a] Due to Fugitive Emissions Assuming 5 m/sec Winds and a Neutral Atmosphere[b]

	Scenario			
Brandon Shores	3	4	5	Most Restrictive Plant Boundary
Coal S[c] (North Site)	112	112	112	North
Coal H[c] (North Site)	11	12	12	North
Coal S (South Site)	63	63	63	West
Coal H (South Site)	5	5	5	West
Limestone and Flyash H and S	1	5	5	North
Operations Total (North Site)	124	129	129	North
Operations Total (South Site)	68	68	68	West
Construction	29	51	29	North
Crane				
Coal Storage	32	32	32	*Northwest*
Coal Handling	3	3	3	*Northwest*
Limestone H and S	—(d)	—	—	*Northwest*
Operations Total	35	35	35	*Northwest*
Construction	8	20	8	*West*

(a) $\mu g/m^3$.
(b) Derived from most frequently occuring maximum condition.
(c) S = Storage; H = Handling.
(d) No significant increases.

TABLE H.20. Maximum Monitored Air-Pollution Values ($\mu g/m^3$)

Plants	SO_2 3-hour	SO_2 24-hour	TSP Annual	County 24 hour	County Annual	County Stations[a]
Brandon Shores	384[a]	139	28	215	69	1,6,9,11,16
Crane	235	126	20	146	57	11,12,15

(a) Numbers refer to Figure 3.4 and Table 3.6.

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APPENDIX I

Ear Sensitivity and Reference Noise Levels

Ear Sensitivity and Reference Noise Levels

Sound levels are usually expressed in decibels (dB). In technical terms, the decibel is equal to ten times the common logarithm of the ratio of a particular sound pressure squared to a reference pressure squared (20 micropascals squared).

Sound waves are characterized by frequency (hertz) and sound pressure levels. In field surveys, non-standard octave band center frequencies are measured by a sound level meter that meets the requirements of the American National Standard Institute S1.4-1971. The sound pressure is analyzed in terms of frequency (octave bands) to produce the A-weighted sound level (dBA). The A-weighted sound level approximates the frequency response of the human ear at moderate sound levels. However, the expression provides no indication of tonal frequency components or unusual frequency distributions that may be a source of annoyance at the community level (EEI 1978). A-weighted sound levels and derivations thereof (i.e., the day-night average sound level or equivalent sound level, Section 4.8.1) are usually used to establish noise level limits for regulatory purposes.

Sound pressure levels uniformly decrease at a rate of 6 dB per doubling of distance in an ideal atmosphere irrespective of frequency. Molecular absorption of sound by the air varies with frequency and is greatly influenced by temperature and humidity. Strong temperature gradients, wind, and precipitation may contribute to increased attenuation of sound pressure levels and deflection of sound waves. The physical environment may also alter the attenuation of sound. Sound propagation over or near the ground is greatly influenced by ground cover, trees, ground reflection and man-made barriers (Table I.1). All of these factors can influence the noise intrusion on communities or wildlife.

The human ear has varying sensitivities to different frequencies and intensity levels of sound. The lower limits of sensitivity and pain thresholds are exhibited in Figure I.1 with respect to sound level (dB) and frequency (hertz). Superimposed on the figure are the ranges of speech, industrial noise, and key sources of noise relating to coal handling (adapted from EEI 1978 and Margenau et al. 1949). Coal handling noise sources are determined at the source and will decrease away from the source with respect to the inverse square law. Table I.2 lists reference sound levels (dBA) of common sources of noise and industrial sources.

TABLE I.1. Attenuation of Sound Transmssion (dB for 10-m path) Above or Through Fields and Forests[a]

Octave Frequency Band (Hz)	Sound Path Over or Through Tall Thick Grass	Sound Path Through Medium-Dense Woods
31	—	0.3
63	0.1	0.4
125	0.7	0.5
250	1.2	0.6
500	1.8	0.8
1000	2.3	1.0
2000	2.8	1.3
4000	3.4	1.6
8000	3.9	2.0

(a) EEI 1978.

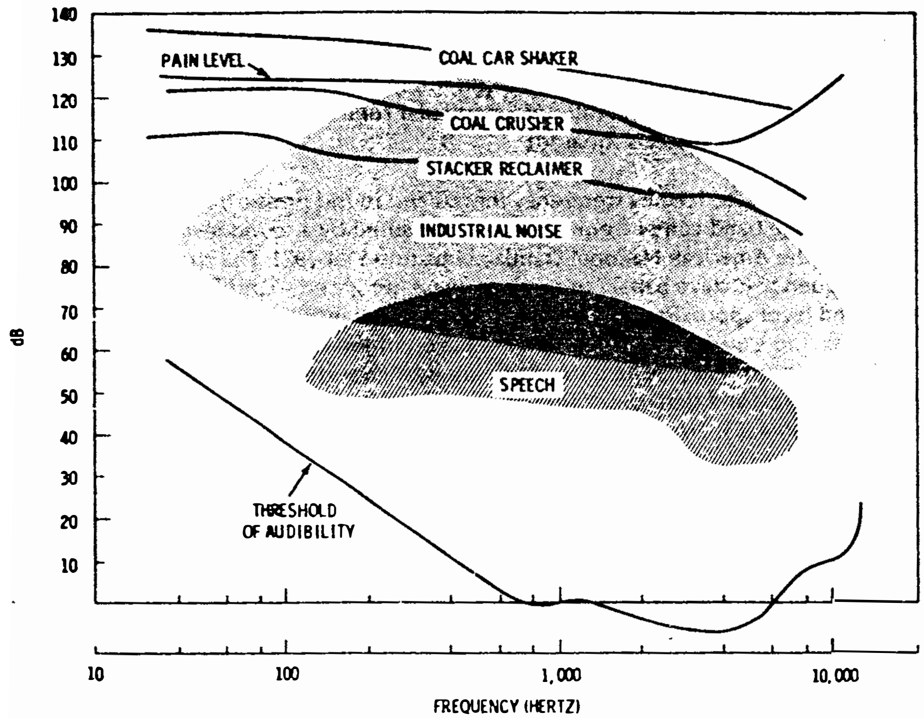

FIGURE I.1. Frequency and Sound Level Spectrum of the Human Ear (adapted from Edison Electrical Institute 1980 and Margenau 1949)

TABLE I.2. Intensity Levels (dBA) of Reference Noises and Industrial Equipment

Noise Source	dBA	Reference
Airplane, nearby	120	a
Pile Driver	101	b
Inside Subway Train	100	a
Rock Drill	98	b
Truck	91	b
Scraper, Jackhammer	88	b
Backhoe	85	b
Crane, mobile	83	b
Air Compressor		
Loader	79	b
Ordinary Conversation	70	a
Quiet Automobile	50	a
Purring Cat	25	a
Rustle of Leaves	10	a
Hearing Threshold	0	a

(a) Margenau et al. 1949; level at receiver in dB.
(b) EPA - NTID 300.1 b A-8, measured at 50 feet from the source.
(c) Edison Electric Institute 1978; measured at the source.

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