Trip B-10

Engineering and Environmental Geology of the Hudson Valley Power Sites

William D. Lilley*

and

Claudia Assini**

I. Introduction

The four main types of electric generation facilities that will be available in the next 25 years are coal, oil, nuclear and hydro. Each type has significant environmental impacts requiring detailed geologic and environmental studies. The purpose of this field trip is to identify some of the geologic and environmental considerations involved with siting various types of facilities.

II. Siting Controls

(1) The responsibility for licensing of nuclear plants is shared by both the Federal and State governments. At the Federal level the major responsibility for nuclear health and safety is in the Nuclear Regulatory Commission (NRC) under the terms of Section 161 of the Atomic Energy Act of 1954 and the Energy Reorganization Act of 1974. The individual States discharge their responsibilities in a variety of ways.

Figure 1 shows the steps associated with obtaining approval of the NRC for a nuclear plant. The NRC application (PSAR and ER) requires at least one year to prepare and the hearings usually take at least another year. The geologic and seismic analysis required of nuclear sites is outlined in 10 CFR, Part 100, Appendix A - Seismic and Geologic Siting Criteria for Nuclear Plants.

* Associate Generating Facilities Analyst (Geology), Office of Environmental Planning, NYS Department of Public Service, Empire State Plaza, Albany, New York 12223.
**Geologic Consultant to the NYS Geological Survey for the Indian Point Project.

(2) Federal licensing of hydroelectric facilities and associated transmission lines is the responsibility of the United States Federal Power Commission (FPC) pursuant to the Federal Power Act. The FPC process is outlined in the flow chart in Figure 2. Application requires at least a year of studies. Hearings last at least a year. In the Storm King case the hearings have lasted ten years and will start again this fall.

(3) In addition to traditional licensing requirements, Federal agencies are required to submit environmental impact statements under the National Environmental Policy Act of 1969 (NEPA). On July 23, 1971, the United States Court of Appeals rendered a historic decision in two suits jointly filed against the Atomic Energy Commission (AEC) (predecessor of the Nuclear Regulatory Commission) by the Calvert Cliff's Coordinating Committee, Inc., the National Wildlife Federation and the Sierra Club. The suits sought review of regulations adopted by the AEC for implementation of NEPA in AEC licensing proceedings and the application of those regulations to the Calvert Cliff's Nuclear Power Project, a Maryland facility licensed for construction prior to NEPA enactment. The court's decision upheld the petitioner's contentions in each respect and ruled the following:

> "1. The AEC was wrong in providing that in uncontested licensing proceedings consideration need not be given to non-radiological environmental issues. The Court held that environmental issues must be considered at every important decisionmaking stage; and that at each stage of the process there must be a case-by-case balancing (through a cost-benefit assessment) of environmental and non-environmental factors with alterations made in the facility which would minimize environmental costs. In uncontested cases the licensing board must examine the staff's environmental statement to determine whether the latter's review was adequate and the board must independently consider the final balance among conflicting factors that is struck in the ultimate staff recommendation.
>
> 2. In its implementation of NEPA, AEC must make an independent assessment of water quality and other non-radiological environmental factors. The Commission cannot rely on certification by Federal or State agencies of compliance with water quality standards established under the Federal Water Pollution Control Act or on Federal or State standards in other environmental areas. The Commission

must be prepared to set more stringent requirements of its own in light of the overall balance of project benefits and environmental costs resulting from the NEPA cost-benefit assessment.

3. The AEC was tardy in its implementation of NEPA following the statute's enactment. Even if a delay in implementing the statute was necessary for administrative reasons, the AEC was not relieved of responsibility to consider, and hold public hearings on, the environmental consequences of licensing actions taken between January 1, 1970, and the final adoption of the Commission's NEPA regulations. AEC must thus give prompt NEPA consideration to facilities for which permits and licenses were issued after January 1, 1970, where NEPA matters were not substantively considered in the original licensing determination.

4. With respect to construction permits issued before January 1, 1970 (e.g., the Calvert Cliffs Nuclear Power Plant), AEC must promptly consider, on its own initiative, any significant non-radiological environmental impact and order such facility alterations as may be indicated thereby. This NEPA consideration, including a hearing thereon, may not be deferred until the operating license review."[5]

The NEPA procedures followed by the NRC are lined in Figure 3.

(4) In 1972 New York State enacted a one-stop power plant siting law in which all laws, codes, and permits had formerly been the responsibility of separate State and local agencies. The purpose of the "one-stop" siting law was to both expedite power plant siting decisions and provide for a full exposition of all issues. A certificate of environmental compatibility and public need must be issued by the New York State Board on Electric Generation Siting and the Environment prior to the construction of any steam-electric generating facility 50 MW and greater. The procedure for siting a major steam-electric generating facility in New York State under Article VIII of the Public Service Law is outlined in Figure 4.

III. Future Power Generation

At least one fossil plant, two nuclear plants, and one pumped storage facility are being proposed for the Hudson Valley (Figure 5). One new 700 MW coal unit is being considered for alternative Athens, Quarry or Arthur Kill sites by the Power Authority of the State of New York (PASNY). Consolidated Edison's proposed pumped storage at Cornwall-Storm King is still in hearings. PASNY has filed an Article VIII application for its Cementon nuclear site and New York State Electric and Gas Corporation is studying the Stuyvesant site for two nuclear units.

IV. Major Siting Considerations

(1) Coal

The impacts of coal facilities relate to the combustion of the fuel and the control and disposal of the combustion waste produces. The sulfur content of the fuel is critical in determining the SO_2 impact on the region. Present air quality regulations require low-sulfur fuels or SO_2 stack gas scrubber equipment on all new plants. Most coal contains about ten percent ash, after the coal is burned there are several hundred thousand tons of ash waste per year for disposal. As a result of the amendments to the Clear Air Act of 1970 requiring the reduction of SO_2 from new plants the SO_2 gas scrubbers produces millions of tons of toothpaste-like SO_2 sludge for disposal. Although there are means of stabilizing the SO_2 sludge, the cost will be millions of dollars per year.

(2) Pumped Storage

A pumped storage facility has a reservoir that is pumped full during off-peak hours and then released during peak load periods. Pumped storage requires three units of energy for every two units it returns, but it is still considered the most economical method, now available, for storing energy.

Pumped storage facilities cause no air pollution in the vicinity of the facility or heat to the water bodies utilized. Heaviest impacts are on terrestrial habitats, land use, and the general aquatic ecology of affected water bodies. The fossil or nuclear steam-electric units which provide off-peak power impact the environment in which they are located.

(3) Nuclear

Nuclear plants play a large role in New York Power Pool's future generation plans. Nuclear plants do not approach

the major air quality impacts of fossil plants, but have a greater heat discharge than fossil plants. Long-term nuclear waste disposal has not yet been resolved. Even with the recent rise in construction costs and uranium fuel prices, experts say that the historical price advantage of nuclear over coal will remain. Finally, the nuclear safety question has been discussed and debated by experts. For geologists, the seismic safety is the key question.

Stop 1 - Danskammer and Roseton, Marlboro, New York

(1) Danskammer - Central Hudson Gas & Electric Corp. Plant - Oil Fired - 531.9 MW - 66.3 Acres Plant Site

Units 3 and 4 of the Danskammer Point Generating Station are the subject of a notice of intention by the Federal Energy Administration to issue a prohibitive order that would require conversion of those units from residual oil to coal.

Unit 3 was first placed in commercial service in October 1959 and Unit 4 in September 1967. Central Hudson currently has $57,000,000 invested in the two units; $5,000,000 represents the cost of converting these units from coal-firing to oil-firing in 1970 and 1971.

These units were originally designed with coal as their primary energy source. In the late 1960s, however, because of the rapidly rising cost of coal, the deteriorating quality of the coal economically available, coal delivery problems, increasing costs associated with coal unloading and handling and ash disposal, increasing concern about the environmental impact of coal burning, and the very attractive prices for fuel oil being offered by some of the major oil companies, the decision was made to convert these units to oil-firing. At that time the oil companies indicated to the company that oil prices would be stable for a long time and that ample oil supplies would be available. Indeed, after competitive bidding, the company entered into an advantageous contract for fuel oil at a fixed price; that price prevailed from 1968 to the oil embargo in 1973.

Because of the foregoing factors and the severe space limitations at the station, the company decided that the conversion from coal to residual oil would be permanent, with no consideration for reconversion to coal-firing. Consequently, major modifications were made that resulted in these units becoming exclusively oil-fired.[6]

The major problems of air quality impact and waste disposal associated with conversion have not yet been resolved. At present there are air quality violations in the area of the plant, and conversion to coal could only worsen this situation. The Environmental Protection Agency has yet to make a decision on the FEA coal conversion notice.

(2) Roseton - Central Hudson Gas & Electric Corp. Plant - Oil Fired - 1242 MW - 133 Acres in Land Use

Environmental Impacts:

(a) Aquatic and Water Quality - The plant is under EPA orders requiring cooling towers. The company has requested a variance to prepare studies to prove the impact of cooling water intake and discharge location and operation is insignificant.

(b) Air Quality - Violations of the Federal primary ambient SO_2 standards have occurred in the vicinity of the plants. The New York State Department of Environmental Conservation has ordered Central Hudson to burn lower sulfur fuel costing $8 million more per year. Public Service Commission staff believes that the severe downwash problems due to the short stacks, compounded by the high terrain at these facilities, are creating the air quality problems. The stacks were designed in response to a State agency request to limit the aesthetic impact of the facility.

(c) Noise - Numerous complaints have been made about noise generated by the Roseton Station. The noise problem is a result of the short stacks. The company has attempted to increase exit velocity of the stack gas to improve air quality. The company has failed to solve the air problem, and now has a noise problem.

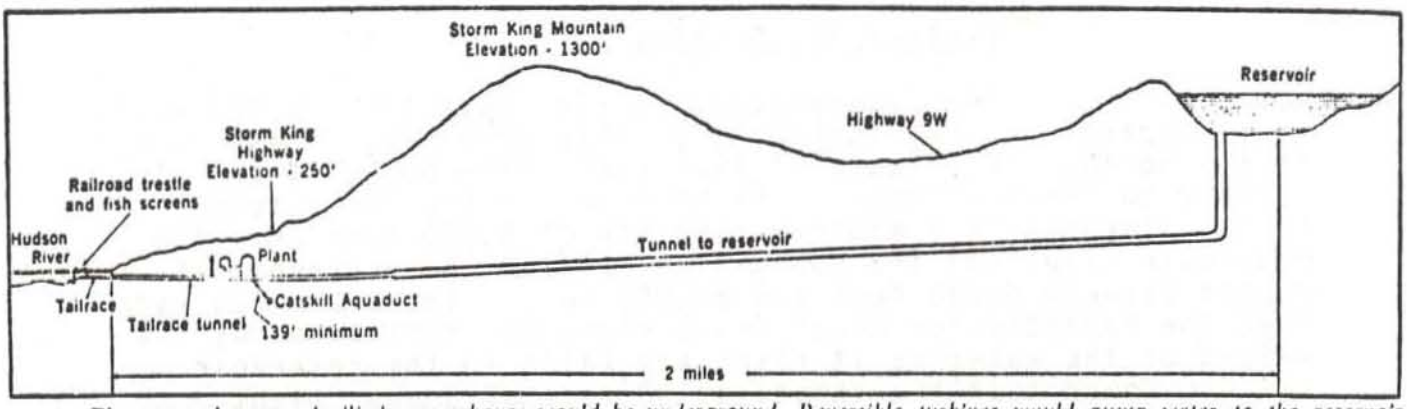
Stop 2 and 3 - Storm King-Cornwall Project, Cornwall, New York

(1) Storm King-Cornwall - Consolidated Edison Company of New York, Inc. - Pumped Storage - 2000 MW - Proposed 1965, Planned Operation 1988

History

The ten-year legal battle between the Scenic Hudson Preservation Conference and Consolidated Edison Company of New York, Inc. over the Storm King project anticipated the environmental litigation that developed in the late 1960s and early 1970s, resulting in NEPA and subsequent Federal and State

CROSS SECTION OF CORNWALL PROJECT



The pumped-storage facility's powerhouse would be underground. Reversible turbines would pump water to the reservoir during hours of low demand. Hydropower would be generated at hours of peak demand.

legislation governing air and water quality. It also highlighted a new area in the legal practice--environmental law.

The turning point in the Storm King case came in late 1965 when the United States Court of Appeals for the Second Circuit ordered the FPC to reopen proceedings after granting Consolidated Edison a license to build. The FPC was instructed to weigh aesthetic and other environmental values in the utility's proposal and to explore alternative means for meeting the project's objectives. In 1966 Consolidated Edison amended its plans to put the powerhouse entirely underground, thus eliminating the cut in the face of Storm King Mountain, and making the trail race less visible.[1]

Since licensing hearings before the FPC have been suspended until after October 1, 1976, it is not possible to accurately predict what constraints may arise from these hearings. Constraints could include possible reduction of biological impact of the plant. This may require fish protection devices or other mitigating measures, and continuation of present environmental studies or the addition of new studies to determine plant impact on aquatic population may be required.[4]

In March 1976, at the request of the New York State Public Service Commission, Consolidated Edison submitted a report of a restudy of the need for, and economic justification of, the Cornwall project. The report says the underground pumped storage plant's capital cost would be about $1 billion and alternatives to the project would require an investment of $1.4 billion to $3.2 billion.

Engineering Geology

The Pagenstecher Creek fault lies to the northwest, separating the Highland's granite from sedimentary rocks to the north. This fault strikes northeast-southwest and dips steeply to the southeast. The surface and the Pagenstecher fault intersect at a minimum distance of 8,000 feet from the reservoir site; and the fault dips beneath the reservoir at depths between 6,000 feet and 29,000 feet. The claim was made that the Pagenstecher Creek fault might be reactivated by the weight of the water as it rises and falls in the reservoir. The FPC found that the thousands of feet of sound, tight, granite rock and gneisses underlying the project are capable of sustaining any loading without movement of the Pagenstecher Creek fault.[9]

The hazards to the Catskill Aqueduct from powerhouse excavation and vibrations caused by blasting were raised by New York City and Scenic Hudson. Construction of the powerhouse would require removal of approximately 254,000 cubic yards of rock. After several geologic studies and witnesses were heard on the subject of rock stress, the FPC concluded that the evidence in the record indicates that the probability of damage to the Catskill Aqueduct is remote.[9]

Stop 4 - Ramapo Fault System, Stony Point, New York

The Ramapo Fault System, shown in Figure 7, extends for more than 50 miles northeast from Peapack, New Jersey to the Hudson River at Stony Point, New York, just west of Indian Point. Along this trend, to at least the New York State border, the Ramapo Fault System is a zone in the Newark Basin. The term Ramapo Fault has been applied to the structure north of the New York State line where the fault system continues northeastward, but is divided into several major splays trending subparallel to each other and passing into the Precambrian Hudson Highlands on both sides of the Hudson River.[7]

Stop 5 - Indian Point, Buchanan, New York

Nuclear Unit 1 - Operational 1962, 260 MW (the second commercial reactor in the United States) - Shutdown in 1974 due to inadequate emergency core cooling system.

Nuclear Unit 2 - Operational 1976, 873 MW, has applied for its full operational license. Owned by Consolidated Edison Company of New York, Inc.

Nuclear Unit 3 - Operational 1978, 965 MW, has applied for its testing operational license. Owned by PASNY.

Seismic Analysis

The hearings on seismic safety of Indian Point have been held before the Atomic Safety and Licensing Board. The New York State Atomic Energy Council, Citizens Committee for the Protection of the Environment, Consolidated Edison, and NRC were parties in the proceeding. The following issues are in controversy:

(1) Does the Cape Ann earthquake of 1975, or any other historic event, require the assumption, in accordance with 10 CFR, Part 100, Appendix A, of a Safe Shutdown Earthquake for the Indian Point site greater than a Modified Mercalli Intensity VII?

(2) Should the ground acceleration value used for the design of Indian Point Unit 1, 2 or 3 be increased?

(3) Is the Ramapo Fault a capable fault within the meaning of Appendix A, 10 CFR, Part 100?

These hearings were completed this summer and decisions on these issues are expected this fall. The decision could effect the seismic analysis used in siting all nuclear plants.

At present, Consolidated Edison is undertaking extensive geologic and seismic studies of the Ramapo Fault System.

Environmental Impact

The major fishkills at Indian Point plants in the winter of 1964-1965 served to high-light the potential impacts of power plants on aquatic life. These fishkills added controversy to the Storm King hearings and the requirement for cooling towers at many power plants to protect aquatic life. At present, Consolidated Edison is under orders from NRC, at the request of EPA, to install cooling towers at Unit 2 by 1979 and at Unit 3 by 1981. Consolidated Edison has requested a variance on the tower requirement. The people of Buchanan, New York and local officials have opposed cooling towers due to the noise, visual impact and impacts on salt drift. Consolidated Edison has requested time to prepare impact studies.

Stop 6 - Quarry Site, Wappingers Falls, New York

Proposed Coal Plant - 700 MW - Power Authority of the State of New York

The quarry site is an alternative to the Arthur Kill site on Staten Island, New York. The plant would supply for the MTA. This would relieve some of the load carried by Consolidated Edison. This site is subject of an as-yet-to-be-docketed Article VIII application pending before the New York State Public Service Commission.

Engineering Geology

This site is located next to one of the largest limestone aggregate quarries in the United States. On June 7, 1974 an earthquake of magnitude 3.3 occurred at the quarry site. All available evidence indicates that this earthquake sequence, and possibly past earthquakes in the same area, may have been triggered by crustal unloading associated with quarrying operations in the presence of high horizontal stress.[8]

Environmental Geology

The coal plant proposed to be built will have SO_2 stack gas scrubbing equipment. The only type of SO_2 scrubbing equipment the engineers consider reliable enough to meet present air quality standards is a nonregenerable scrubber system, would produce over one million tons of toothpaste-like material requiring stabilization and disposal. The disposal options are quarries, the ocean or the Bahamas. The economic and environmental impacts of each option have yet to be fully explored.

References

(1) Mid-Hudson Pattern for Progress, Inc., Electrical Energy Facility Planning in the Mid-Hudson, prepared for the Mid-Hudson Inter-County Council, 61 Livingston Street, Poughkeepsie, New York, HUD Project No. CPA-NY-02-00-1039, August 1975.

(2) Talbot, Allan R., Power Along the Hudson, "The Storm King Case and the Birth of Environmentalism," E. P. DuHon and Company, Inc., New York, 1972.

(3) New York State Public Service Commission, Draft Report on the Hudson River Valley/Long Island Pilot Area Site Survey, Office of Environmental Planning, Empire State Plaza, Albany, New York, July 1, 1974.

(4) Report of Member Electric Systems of the New York Power Pool and the Empire State Electric Energy Research Corporation, Pursuant to Article VIII, Section 149-b of the Public Service Law, Volume 2, Albany, New York, April 1, 1976.

(5) Joint Committee on Atomic Energy Congress of the United States, Selected Materials on the Calvert Cliff's Decision, Its Origin and Aftermath, United States Government Printing Office, Washington, D.C., February 1972.

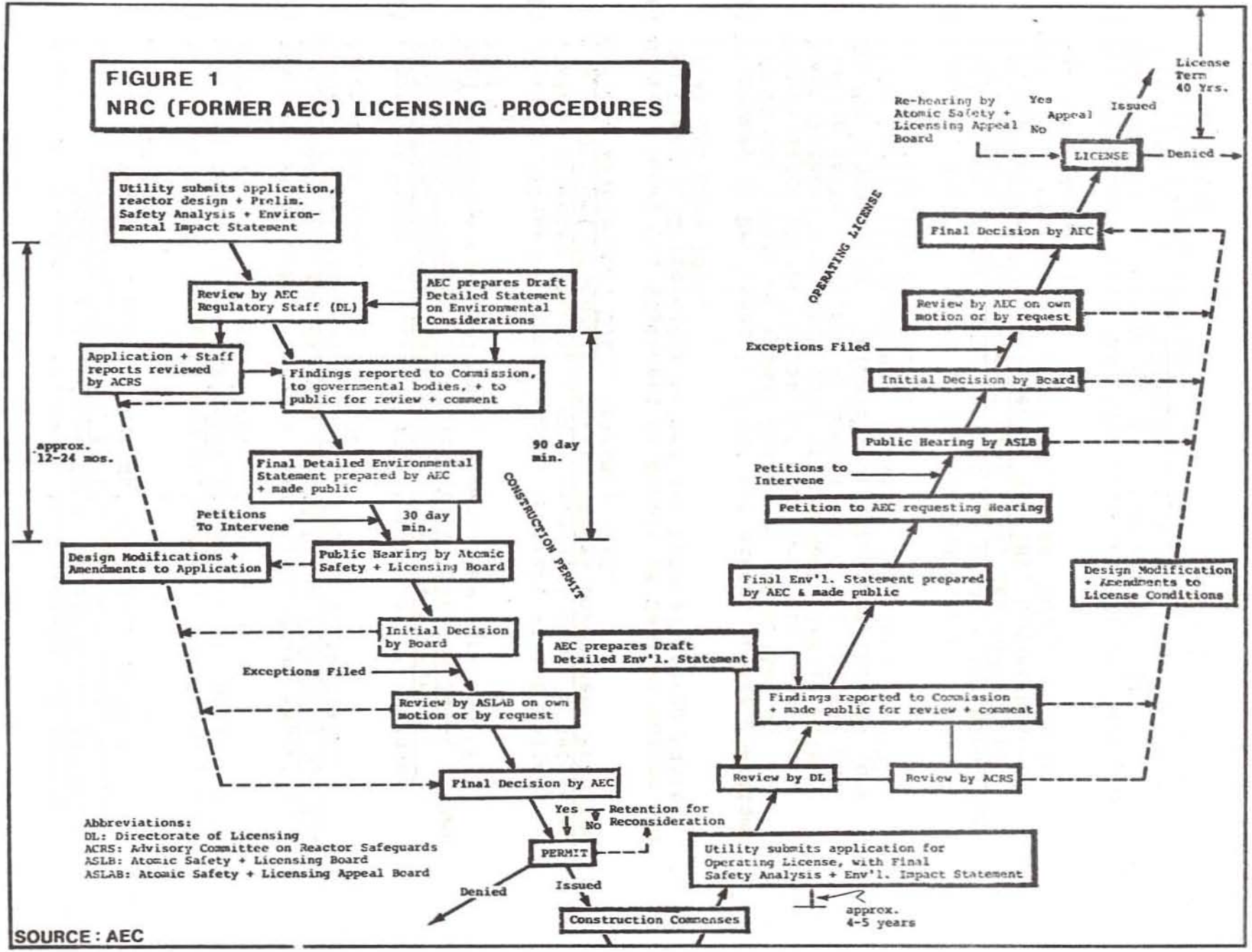
(6) Walker, Henry L., Statement on Behalf of Central Hudson Gas and Electric Corporation before the Federal Energy Administration, June 1975.

(7) Testimony of Dr. James F. Davis and others before the Atomic Safety and Licensing Appeal Board, in the matter of Consolidated Edison Company of New York, Inc. and the Power Authority of the State of New York, Indian Point Station Units 1, 2, and 3, Docket Nos. 50-3, 50-247 and 50-286 (Show-Cause - Seismic), on behalf of the New York State Atomic Energy Council on Issue III, June 18, 1976, pp. D1-2 and Exhibit No. 2.

(8) Pomeroy, Paul W., David W. Simpson and Marc L. Spar, Earthquakes Triggered by Surface Quarrying - The Wappinger Falls, New York Sequence of June 1974, New York State Science Service, Journal Series No. 189, LaMont-Doherty Geological Observatory Contribution No. 0000, Palisades, New York, August 1975.

(9) Federal Power Commission, "Consolidated Edison Company of New York, Inc., Opinion No. 584, Project No. 2338, August 19, 1970," Environmental Reporter Cases, The Bureau of National Affairs, Inc., 1970, Washington, D.C. pages 1ER 1526-1558.

FIGURE 1
NRC (FORMER AEC) LICENSING PROCEDURES



SOURCE: AEC

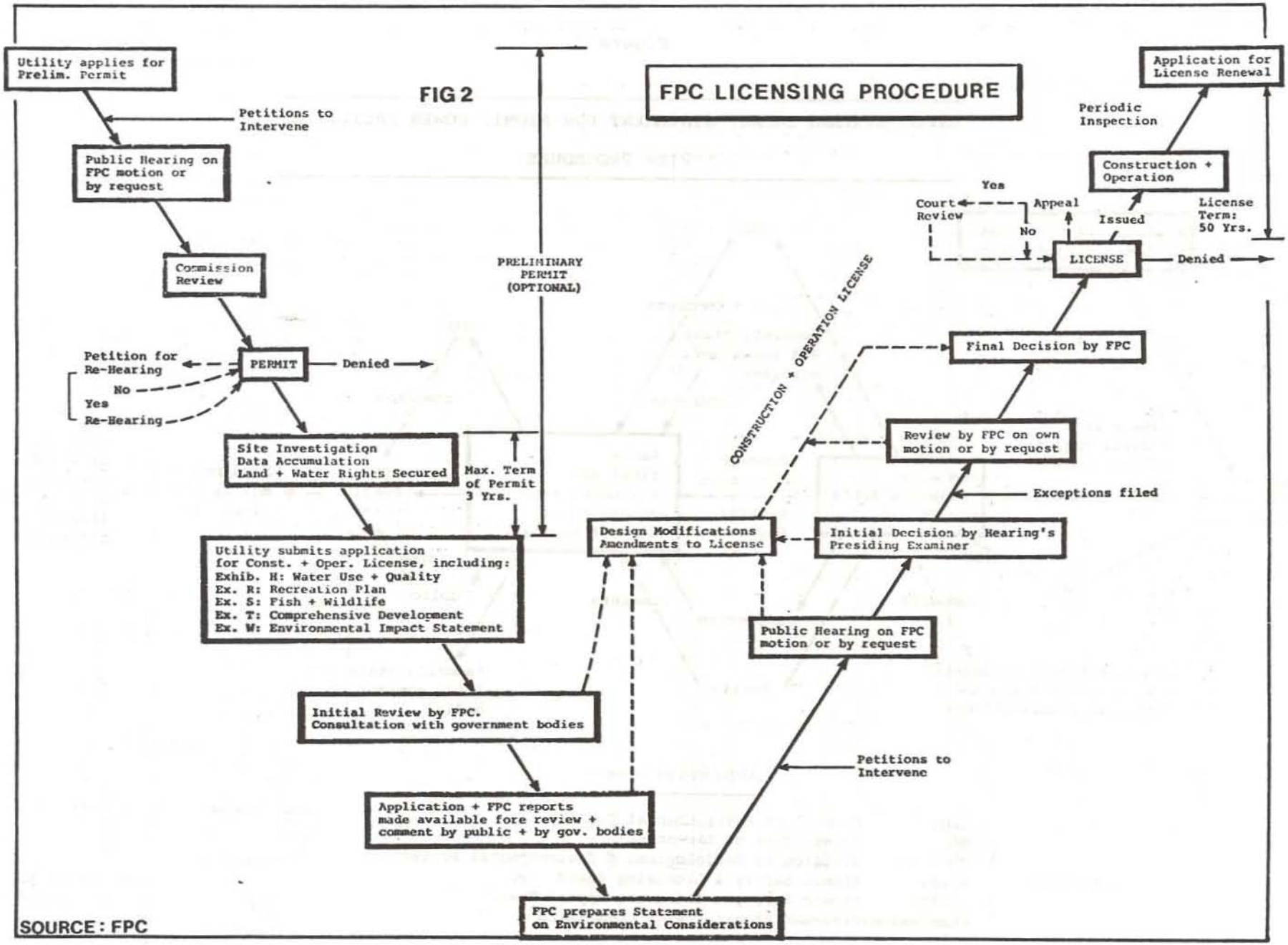
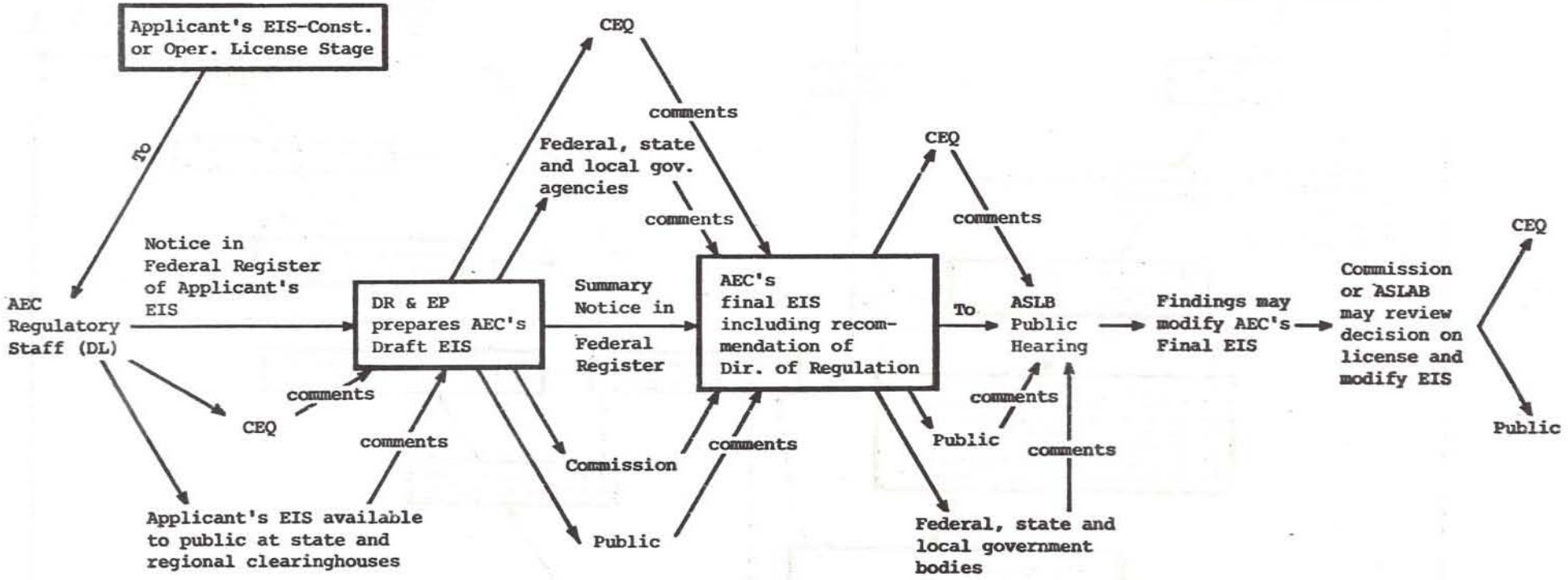


FIG 2
FPC LICENSING PROCEDURE
Utility applies for Prelim. Permit
Petitions to Intervene
Public Hearing on FPC motion or by request
Commission Review
PERMIT
Denied
Petition for Re-Hearing
No
Yes
Re-Hearing
PRELIMINARY PERMIT (OPTIONAL)
Site Investigation Data Accumulation Land + Water Rights Secured
Max. Term of Permit 3 Yrs.
Utility submits application for Const. + Oper. License, including:
Exhib. H: Water Use + Quality
Ex. R: Recreation Plan
Ex. S: Fish + Wildlife
Ex. T: Comprehensive Development
Ex. W: Environmental Impact Statement
Initial Review by FPC. Consultation with government bodies
Application + FPC reports made available fore review + comment by public + by gov. bodies
FPC prepares Statement on Environmental Considerations
CONSTRUCTION + OPERATION LICENSE
Design Modifications Amendments to License
Public Hearing on FPC motion or by request
Petitions to Intervene
Initial Decision by Hearing's Presiding Examiner
Exceptions filed
Review by FPC on own motion or by request
Final Decision by FPC
LICENSE
Denied
Court Review
Yes
No
Appeal
Issued
License Term: 50 Yrs.
Construction + Operation
Periodic Inspection
Application for License Renewal
SOURCE : FPC

Figure 3

ENVIRONMENTAL IMPACT STATEMENT FOR ATOMIC POWER FACILITIES

REVIEW PROCEDURE



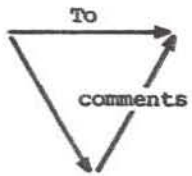
B-10-14

Abbreviations

AEC Staff:

- CEQ: Council on Environmental Quality
- DL: Directorate of Licensing
- DR & EP: Division of Radiological & Environmental Protection
- ASLB: Atomic Safety & Licensing Board
- ASLAB: Atomic Safety & Licensing Appeal Board
- Commission: Five-man Atomic Energy Commission

Symbols



Transmitted to

Transmitted to for review and comment

SOURCE: AEC

FIGURE 4

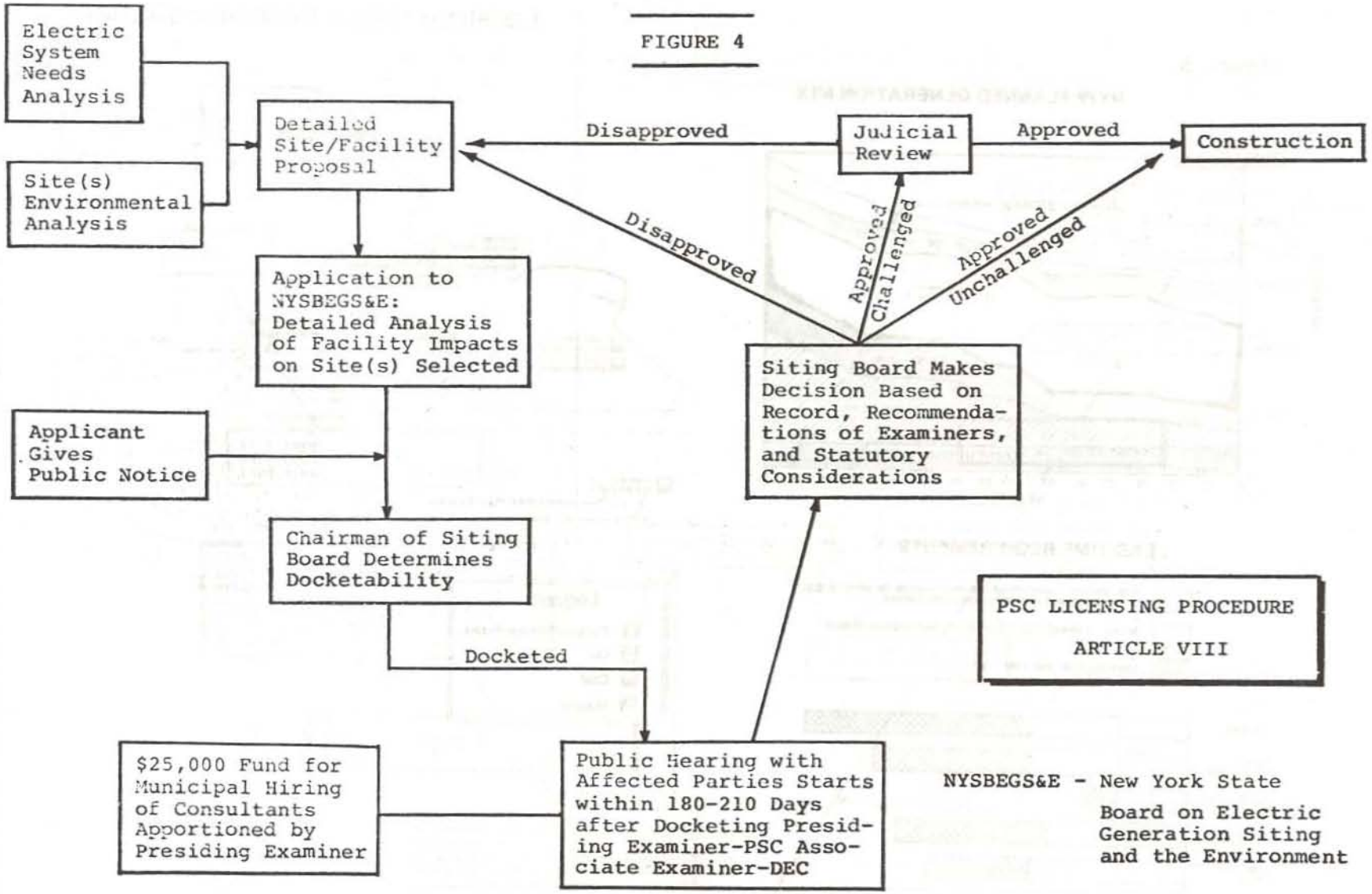
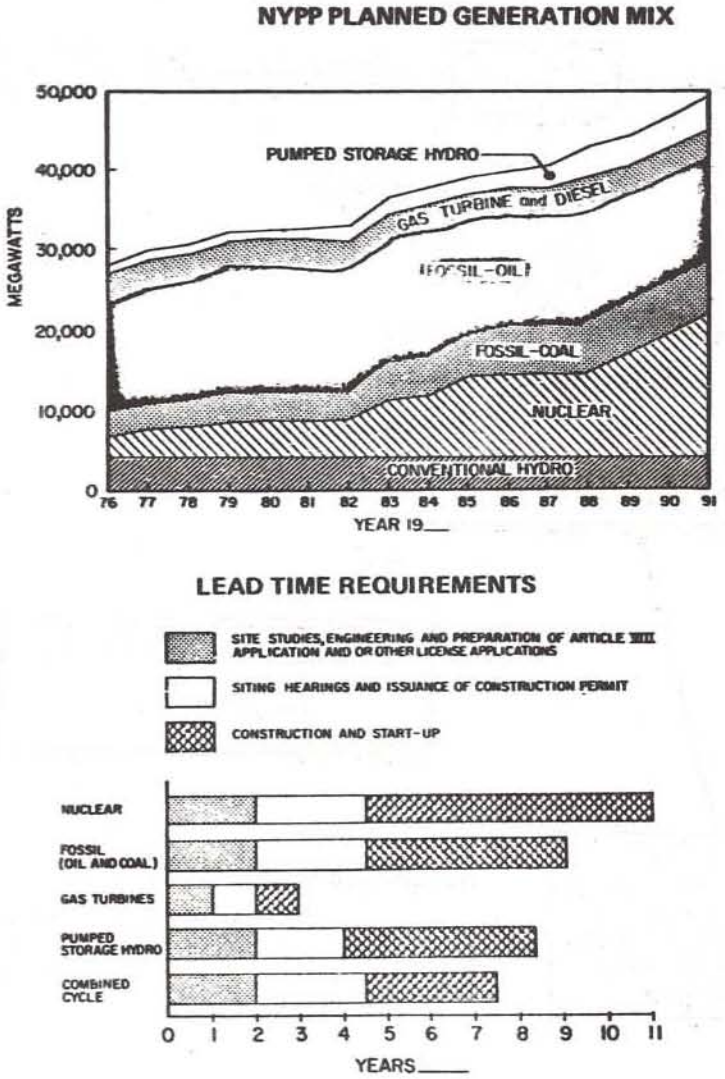

Electric System Needs Analysis
Site(s) Environmental Analysis
Detailed Site/Facility Proposal
Disapproved
Judicial Review
Approved
Construction
Disapproved
Approved Challenged
Approved Unchallenged
Application to NYSBEGS&E: Detailed Analysis of Facility Impacts on Site(s) Selected
Siting Board Makes Decision Based on Record, Recommendations of Examiners, and Statutory Considerations
Applicant Gives Public Notice
Chairman of Siting Board Determines Docketability
Docketed
PSC LICENSING PROCEDURE
ARTICLE VIII
$25,000 Fund for Municipal Hiring of Consultants Apportioned by Presiding Examiner
Public Hearing with Affected Parties Starts within 180-210 Days after Docketing Presiding Examiner-PSC Associate Examiner-DEC
NYSBEGS&E - New York State Board on Electric Generation Siting and the Environment

Figure 5



Location of Major Generating Additions

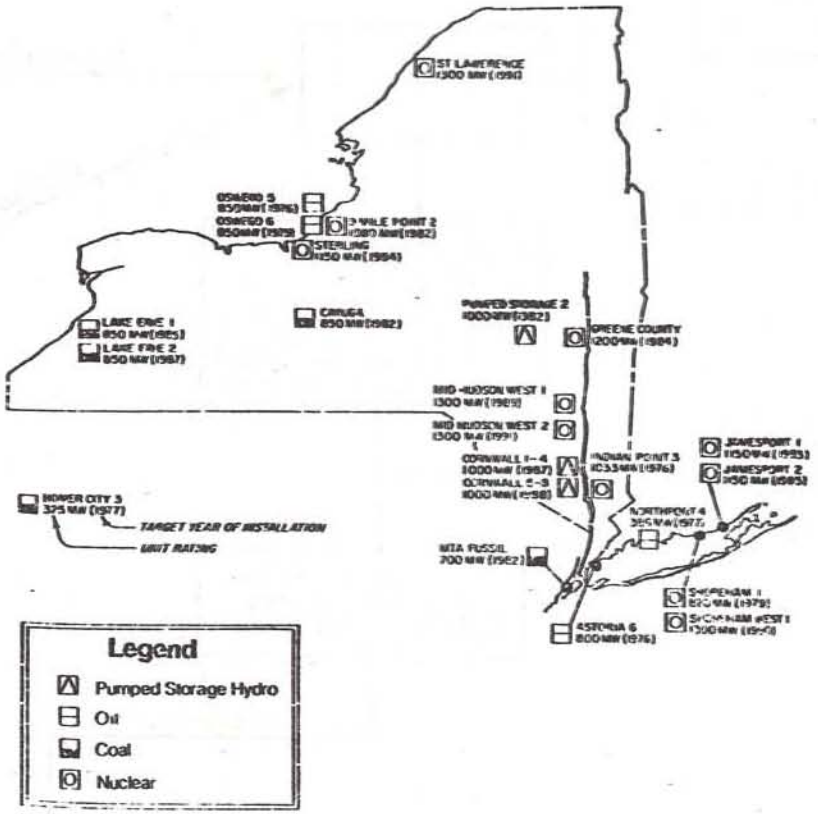


Figure 6

COMPARATIVE ENVIRONMENTAL PROFILE OF BASE-LOAD ALTERNATIVES*

(Note: All quantities shown are approximations and relate to a multi-unit power station of 2300-2400 MW installed capacity.)

	OIL-FIRED	COAL-FIRED	NUCLEAR
A. Fuel Supply			
1. Production	Production and refining of sufficient crude oil to yield 80,000 barrels of fuel oil per day. This roughly corresponds to the fuel-oil output of two large oil refineries.	Mining of 16,000 tons of coal per day.	Mining and milling of 400 tons of uranium ore per day. Processing and fabrication of one ton of uranium metal per day.
2. Transport	One supertanker delivery of crude oil every 2 weeks, or, in the case of the larger tankers now serving U.S. ports, 1 delivery every 2nd day.	Two collier deliveries every 3 days.	12 truckload deliveries per year.
3 Storage	Storage of a 45 day fuel-oil supply would require 4 large oil storage tanks (1 million barrels each) occupying 55 acres.	75-acre coal pile, assuming 45 days reserve.	Nominal
B. Power Plant			
1. Installation	150-acre plant site, assuming cooling towers used (Site size might have to be increased to meet allowable offsite noise levels).	400-acre plant site (assuming cooling towers used).	500-acre plant site, mostly undeveloped.
2. Operation	Discharge of 240 billion BTU of waste heat per day; emission of 25 tons/day of sulfur or SO_2 (assuming low-sulfur fuel oil being burned), 60 tons/day of nitrogen oxides and other gaseous effluents, and 1 ton/day of particulates.	Discharge of 240 billion BTU of waste heat per day; limestone scrubbers are used to remove sulfur from coal to avoid SO_2 emissions. This process creates limestone sludge as a by-product. 120 tons/day of nitrogen oxides and other gaseous effluents and 18 tons/day of particulates (assuming use of highly efficient precipitators and scrubbers).	Discharge of 320 billion BTU of waste heat per day; emission of trace amounts (a few hundred thousandths of a gram per day) of radioactive substance containing 4 curies of comparatively long-lived radioactivity. Shipment of 120 casks of spent fuel per year (120 truckloads or 20 railroad flat car-loads).
C. Waste Disposal	Minor problems.	Disposal of 800 tons/day of fly ash and 430 tons/day of sulfur based on 3% sulfur coal and assuming 90% stack gas desulfurization efficiency.	"Perpetual" storage of solidified high-level radioactive waste concentrates from spent fuel reprocessing, which, in calcined form and with inert diluents, accumulate at a rate of 200 cubic feet per year. Also, land burial of 400 cubic feet per year of miscellaneous low-level radioactive waste materials.

*This exhibit lists the principal ways in which the fueling and operation of base-load power generating facilities interact with the natural environment. Some details, such as the release of modest quantities of chemicals used to prevent fouling of tube surfaces in the steam condenser portion of the turbine-generator system, are not shown. Also, the transmission and distribution of the power produced are not covered.

Fuel Costs

Type of Generation	1985 Fuel Cost–¢/10^6 BTU
Nuclear	60*
Coal	
Eastern high sulfur	240
Western sub-Bituminous	240
Western low sulfur	300
Oil	
.3% Sulfur	360
.75% Sulfur	330
2.8% Sulfur	300
Intermediate Range & Gas Turbine	
#2	410
Kerosene	435

*Components of Nuclear Fuel Cost 1985

Ore $34/lb.
Enrichment $100/SWU
Fabrication $120/KG
Recovery & Disposal $200/KG
Plutonium Credit $14/gm

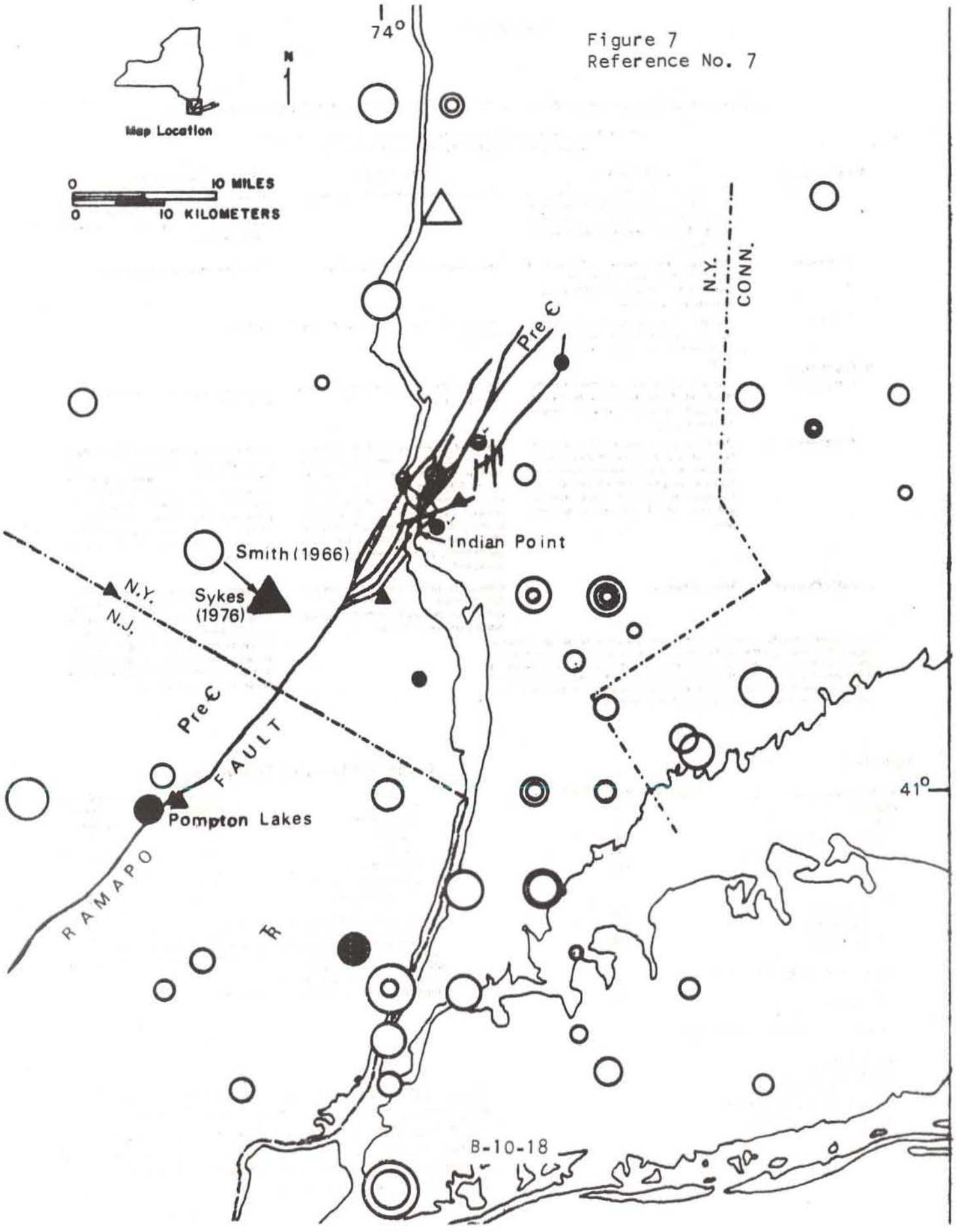
Capital Cost Excluding Transmission

Type of Generation	Nominal Size MW	1985 Cost $/KW
Nuclear***	1100	1060*
Coal***	800	820**
Oil***	800	630****
Gas Turbines	–	305
Intermediate Range	500	530
Pumped Storage Hydro	250	400

*Includes cost of $85/KW for cooling tower
**Includes cost of $55/KW for cooling tower. Excludes cost of sulfur removal equipment ($180/KW) since it was assumed higher cost low sulfur western coal would be used as fuel in expansion coal plants for the purposes of this study.
***Cost based on two units at a site.
****Includes cost of $55/KW for cooling tower.

From the: Report of Member Electric Systems of the New York Power Pool and the Empire State Electric Energy Research Corp., Pursuant to Article VIII, Section 149-b of the Public Service Law, Volume 2, April 1, 1976.

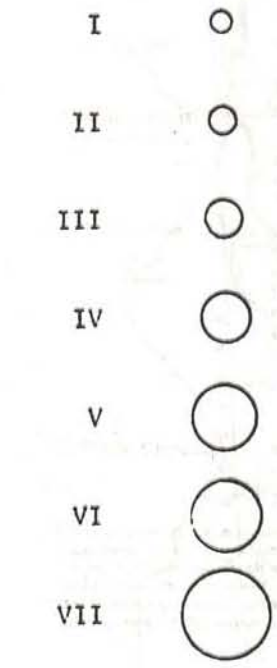
Figure 7
Reference No. 7



Explanation of Figure 7

Historical Earthquakes

Modified Mercalli Intensity Scale



Epicenters are located at the centers of symbols. The numbers correspond to an accompanying event list. A question (?) after the number indicates an uncertainty in the epicenter location.

Instrumentally Located Event*

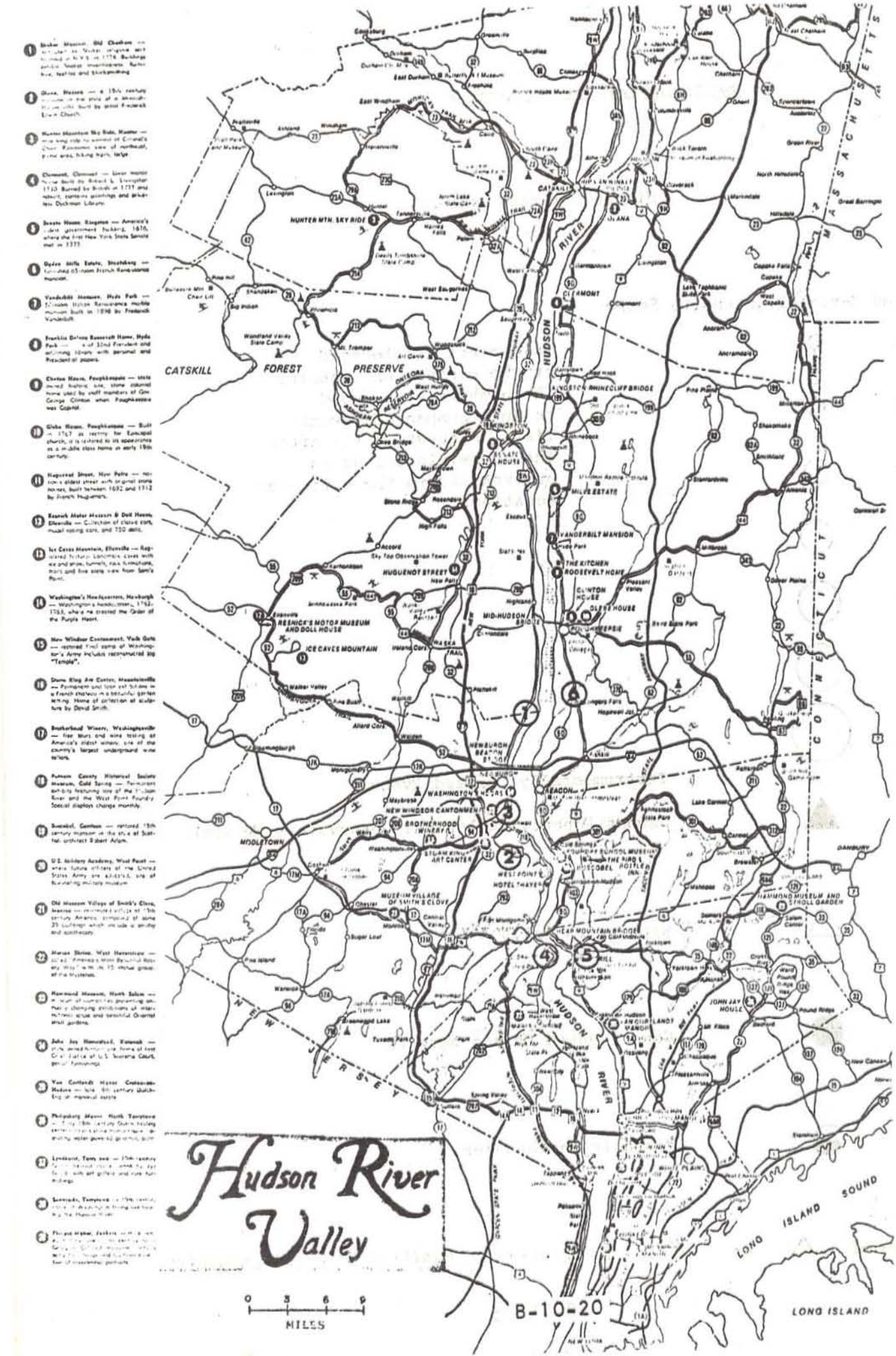
Lamont-Doherty Geological Observatory Network.

Wappingers Falls events.

Consolidated Edison Network

Probable earthquakes

* Size of △ or ○ is relative to Modified Mercalli intensity.


Hudson River Valley
CATSKILL FOREST PRESERVE
HUDSON RIVER
CONNECTICUT
MASSACHUSETTS
NEW JERSEY
LONG ISLAND SOUND
LONG ISLAND
HUNTER MTN. SKY RIDE
CATSKILL
OLANA
CLERMONT
NORTH RHINECLIFF BRIDGE
KINGSTON
ESOPUS
STATE HOUSE
MILLS ESTATE
VANDERBILT MANSION
THE KITCHEN
ROOSEVELT HOME
CLINTON HOUSE
OLDE HOUSE
HUGUENOT STREET
MID-HUDSON BRIDGE
POUGHKEEPSIE
RESNICK'S MOTOR MUSEUM AND DOLL HOUSE
ICE CAVES MOUNTAIN
WALKILL TRAIL
NEWBURGH BEACON BRIDGE
NEWBURGH
BEACON
WASHINGTON HEADQUARTERS
NEW WINDSOR CANTONMENT
BROTHERHOOD WINERY
STORM KING ART CENTER
MIDDLETOWN
WEST POINT
HOTEL THAYER
THE NIBLO HOSTELRY INN
MUSEUM VILLAGE OF SMITH'S CLOVE
BEAR MOUNTAIN BRIDGE
HAMMOND MUSEUM AND STROLL GARDEN
DANBURY
JOHN JAY HOUSE
0 3 6 9
MILES
B-10-20