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Dickey-Lincoln School Lakes Project: Transmission System Planning Study

United States Department of the Interior

TRANSMISSION SYSTEM PLANNING STUDY

DICKEY/LINCOLN SCHOOL LAKES PROJECT

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DICKEY-LINCOLN SCHOOL LAKES PROJECT
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Introduction

The purpose of this report is to investigate various transmission system alternatives and recommend a plan of service to integrate power from the Dickey-Lincoln School Lakes (D-L) Project into the New England electric power transmission system.

This study is one of three being conducted by the Department of the Interior (DOI) for the Department of the Army Corps of Engineers.

A marketing study has been conducted concurrently with the transmission planning study. An environmental impact analysis of the study area, which encompasses all feasible alternate transmission line corridors, is also being developed. Information from these three efforts will be brought together and used to select a proposed plan of service for the integration of the plant and a proposed corridor for the required transmission facilities.

The Dickey-Lincoln School Lakes Project

The project is authorized to have an installed capacity of 760 MW at Dickey and 70 MW at Lincoln School for a total nameplate capacity of 830 MW. One-fourth of the capacity at Dickey Dam, 190 MW, has been recommended for reversible pump-turbine operation providing pumped-storage capability. The overload ratings would be 874 MW at Dickey and 80 MW at Lincoln School for a total of 954 MW of peaking capability.

The project has an ultimate potential for an additional 380 MW of pumped-storage capacity at Dickey Dam when sufficient low cost pumping energy is available. This ultimate level would increase the nameplate rating at Dickey to 1,140 MW and the project total to 1,210 MW. The overload rating for Dickey would be 1,311 MW for a total project peaking capability of 1,391 MW.

The following table summarizes the plant outputs for the two levels of development:

	Level of Development			
	Authorized		Ultimate	
	Peak (MW)	Energy 1/ (GWH)	Peak (MW)	Energy 1/ (GWH)
Dickey	874	894	1,311	894
Lincoln School	80	262	80	262
Total	954	1,156	1,391	1,156

1/ Natural flow energy only. Downstream benefits would add approximately 175 GWH; pumped-storage operations are estimated to provide an additional 289 GWH at the authorized level and 587 GWH at the ultimate level for a total of 2207 GWH.

It has been assumed that the project would be integrated into and dispatched as a part of the New England Power Pool (NEPOOL) system. The additional

380 MW of pumped-storage capability would be added in the future as determined by projected power demands and availability of economic pumping energy. The need is presently estimated for the 1995-2000 time frame.

It is important to note that the plans of service presented here do not commit the sale of power to specific locations. For example, a review of the three western plans might imply that the total power output would be sold in the States of New Hampshire and Vermont. This is not the case. Rather these plans represent entry points to the backbone New England power grid system which in turn provides access to areas throughout New England. These plans are designed to be part of -- and satisfy the requirements of -- the integrated New England transmission system. Facilities in each plan satisfy a number of transmission requirements including integration requirements, system load carrying capabilities, shifts of generation between plants, steady state and transient stability, and reliability of the New England power system.

This transmission planning study used a 1974 study for a starting point. The previous report was prepared by the D-L Study Working Group of the New England Planning Committee, the planning organization of NEPOOL. The Working Group consisted of members of their permanent staff at New England Power Planning (NEPLAN), and utility members of the Committee. The report examined the feasibility of the Dickey-Lincoln School Project at the authorized level, as well as transmission requirements. It concluded that the project output as then conceived, 830 MW without pumped-storage facilities, could be coordinated with and integrated into the New England system as then anticipated by the middle 1980s if the project was under the control of and dispatched by NEPEX, NEPOOL's control and dispatching center. A copy of the 1974 study and a copy of the NEPOOL Reliability Criteria are included as Appendices C and D.

The cost of "transmission required to connect this project into the grid and to provide sufficient additional capability to deliver the project output to New England load centers" was then estimated to be about $110 million for the conventional 830-MW project based on 1974 costs. The transmission needed could be obtained, the report said, by expanding the existing 345-kV system or by combining direct current (dc) transmission with 345-kV alternating current (ac). The study found that a 765-kV integration transmission plan could not compete economically if the project were to be energized in the mid-1980s.

The present report discusses the five alternative transmission plans now being considered. This is done at the initial level of 874 MW for Dickey as well as for its ultimate potential higher level of 1,311 MW.

Alternate Routes

The five transmission alternates studied are shown in Figures 1 through 5. All extend through Maine into New Hampshire and Vermont. Two of the alternatives follow an eastern route through Maine, and three a western route. All ac plans include a mid-point switching station between

Dickey and either Chester or Comerford, depending upon the alternative. In addition, plans D and E are series-compensated between Dickey and Comerford.

Plans A and B are 345-kV ac systems routed through eastern Maine. These plans are identical for the 874-MW level. The plans differ at the 1,311-MW level; at this level Plan A has more transmission than Plan B. Each of these plans calls for four 345-kV ties -- of which two now exist -- between Maine and New Hampshire at the 874-MW level and five such ties at the 1,311-MW level.

These ties are required since, with the location of several large generating units in Maine, such as Maine Yankee and the Sears Island plant, the load/generation balance for the period under consideration is such that large amounts of power and energy will be exported out of the State. This exported power and energy will be excess to the State's requirements.

Plans, C, D, and E follow the western route. Plan C is a $\pm$ 400-kV dc line from the project to Comerford Substation near Littleton, New Hampshire, near the Vermont border. It includes a 345-kV ac line from Comerford to Granite substation near Barre, Vermont, for both levels and an additional 345-kV ac line from Comerford to Beebe substation near Plymouth, New Hampshire, for the 1,311-MW level. Plans D and E are 345-kV systems that follow the same route as the dc line. Plan D calls for two single-circuit lines supported by wood poles. Plan E is a double-circuit line supported by a single row of steel towers.

Transmission additions for each alternative plan are indicated in Figures 1 through 5. They are superimposed on the base New England 345-kV system assumed for the period under study. The system includes facilities associated with two nuclear plants to be built in southeastern Maine and one in western Vermont.

Conclusions and Recommendations

We recognize that a route cannot be selected until the environmental impact study is completed and all alternatives have been given due consideration. However, insofar as this study is concerned, we recommend that Plan E, the alternative using a 345-kV double-circuit line between Dickey and Comerford, be given first consideration for construction if the Dickey-Lincoln School Project is built.

System studies indicate that each of the five plans is capable of integrating the entire output of Dickey into the New England transmission system.

Plan E appears to be the lowest cost alternative that would meet technical requirements. It has a somewhat lower annual cost than its nearest rival, Plan D. Plans D and E are similar electrically. But the right-of-way requirement for Plan E is substantially less because it calls for a double-circuit line rather than two single-circuit lines. On the other hand, the 345-kV wood pole H-frame lines of Plan D are more representative of standard design in the New England area.

It is generally recognized that two single-circuit lines will provide somewhat greater reliability than a double-circuit line. However, the small degree of added reliability would be difficult to measure. Although an entire double-circuit line can be put out of service due to a tower failure or to lightning, the likelihood of such occurrences is very small.

The western plans require less transmission system additions than either of the eastern plans, thus the right-of-way requirements are less. The western dc plan has the lowest right-of-way requirements, but it also requires the highest investment due to the high cost of the dc terminals. The western ac plans -- in both investment and transmission losses -- are considerably less costly than the eastern plans.

Assumptions

In developing the alternative transmission plans for the Dickey-Lincoln School Project, the following assumptions were made:

1. The 1985-86 1/ winter peak period would be used as in the 1974 NEPLAN study. In addition, to provide continuity, the same load and resource data were used.

2. For the 874-MW level, the transfer capability out of Maine would be 3,000 MW. (Transfer capability refers to the amount of firm power from all energy sources that can be transmitted

reliably from Maine to New Hampshire and Vermont by the interconnecting transmission lines.)

3. For the 1,311-MW level, the transfer capability out of Maine should be 3,450 MW.

4. Transmission system additions, except for those associated with the Dickey-Lincoln School Project would be common to all alternatives.

5. An output of 80 MW from Lincoln School is assumed to serve local loads. If integrated with Dickey generation, the output of Lincoln School would cause no change in the alternative transmission plans. (Computer studies were conducted without the output from Lincoln School integrated into the transmission system required for Dickey.)

6. Two 1,150-MW nuclear units in southeastern Maine and one 1,150-MW nuclear unit in western Vermont together with the associated transmission facilities will be added by 1986. 1/

The 1985-86 period load level was chosen for the Transmission System Planning Study covered by this report for two reasons:

1/ Current load estimates reflect a lower rate of growth so that the load level and resource schedule assumed in 1 and 6 now are estimated to be representative of about 1990-1991.

(1) That period represented the earliest date at which it was considered the Dickey-Lincoln School Project could be put on-line if it is found to be feasible.

(2) NEPLAN had made a study in 1974 using 1985-86 and the then-projected load level for that period which considered the desirability of the project from the standpoint of its "fit," or usability, with other projected resources in meeting estimated load requirements of that date. In addition, the study considered transmission requirements for the project. The availability of their findings and the system data from that study would expedite the completion of the additional studies that were required. This study is supplemental to theirs. As previously stated, a copy of this NEPLAN report dated November 21, 1974, is attached to and made a part of this document.

It is important to note that the 1974 NEPLAN report considered only the 830-MW authorized level for the project. The study on which the current report is based was directed primarily to the ultimate level of development at the project. Should the project prove to be feasible at the authorized level, some additional studies would be required to determine the feasibility of installing the additional generating units. This includes the fit of the added generation into the New England load shape.

Subsequent to the time the load-resource projections were developed for the 1974 NEPLAN study, and particularly of recent date, these load-resource projections have been altered very substantially. The projected load levels then considered accurate for the 1985-86 period are now estimated to be representative of the projected loads for the 1990-91 period. Delays have also been encountered in the schedules for completion of the new nuclear plants in Maine and Vermont.

This illustrates that the scheduling, magnitude, and location of new loads and resources are very subject to change in today's world. The effect is to necessitate a periodic review of basic assumptions used in planning studies and a determination whether those assumptions are:

(1) Sufficiently valid to allow proper conclusions to be developed; or

(2) An updating of the study parameters is indicated.

Review of this study's parameters and assumptions indicate that valid conclusions can be drawn from the study results even though due to the revised load projections the load and resource data are indicative of a load level for a period several years later than the assumed study year of 1986.

However, continuing load and resource changes should be monitored and judgment made as to their possible impact upon the conclusions reached in this study.

This study has assumed that the new nuclear plants and their associated transmission facilities would be on-line prior to energization of the Dickey-Lincoln School project. Should it develop that Dickey-Lincoln

School comes on-line before these plants, some of their transmission requirements would have to be constructed ahead of schedule to satisfy the integration requirements of the Dickey-Lincoln School project. In this event, additional studies will be required to determine the transmission system required and the costs to be borne by the project.

It should be noted that the western plans are less dependent upon nuclear plant transmission facilities than the eastern plans. They would be less impacted in the event that the nuclear plants and their associated transmission facilities were delayed beyond the date at which the Dickey-Lincoln School Project would be energized.

Costs

Transmission facility unit costs were developed by the Central Maine Power Company (CMP) and the Public Service Company of New Hampshire (PSNH) and the Department of the Interior to reflect New England design and construction costs.

Total transmission costs to the ultimate consumer must include an evaluation of transmission costs and losses on the D-L transmission system and wheeling charges and losses on the New England transmission system.

Cost estimates for transmission facilities based on 1976 dollars for the 874-MW level range from \$157 million to \$191 million depending on which alternative is considered. These figures include interest during construction (IDC). Similar costs for the 1,311-MW level are estimated to range from $181 million to $255 million. Based on current costs, Plan E is expected to cost $136 million without IDC and about $157 million with IDC. Additional transmission to accommodate the added units at Dickey would increase the cost to about $181 million with IDC.

The estimated capital and annual costs including IDC of these alternatives are given in the two following tables for both the authorized and ultimate level of development at the project. Energy costs shown in the second table for the ultimate level can be misleading in that the additional generating units that may be added at Dickey are peaking units.

All of the natural-flow energy (kilowatthours) at Dickey can be developed at the authorized level, so the added peaking units provide no additional firm energy. They do, however, provide peaking capability which can be used during peakload hours to help meet system peakload requirements and are valuable from this standpoint. Hence, the cost evaluation based on peaking capability ($/kW-yr.) is more meaningful than one based on energy (mills/kWh) for these two units.

The value of transmission losses as well as wheeling charges must be added to the transmission cost figures in both tables to arrive at the total cost of D-L power and energy delivered to the ultimate consumer. Transmission losses will occur on the facilities associated with the project as well as on the New England transmission system.

Losses on transmission facilities associated with the project will be about 5 to 7 percent of the peak output at the authorized level. These losses will vary for the different alternatives and will be somewhat higher for the ultimate level because of the higher loading of the transmission facilities. Table A-6 shows the losses and gives a dollar value for the losses for the different alternatives. A figure of $55 per kilowatt-year was used to estimate the dollar value of the losses.

Economic evaluations for the alternate plans were made on the basis of three approaches to financing: all Federal, a combination of Federal and non-Federal, or all non-Federal.

The composite IDC percentage used in this study is approximately 16 percent for Federal financing. It is based on construction capital cost and an interest rate of 7 percent.

An IDC percentage of 16 percent was also used for non-Federal financing. We assumed that a higher non-Federal interest rate would be offset by a shorter disbursement period for construction.

Detailed costs are shown in Tables 1, 2, and 3 at the end of the main body of the report and in Tables A-1 through A-8 of Appendix A.

A composite annual cost ratio of 20 percent was assumed throughout for non-Federal facilities except for Plan E in which 18 percent was used for the steel double-circuit line. Each utility was assumed to be

Dickey/Lincoln School Project
Authorized Level of Plant Capacity
Transmission Cost Comparison
(Without loss evaluations and wheeling charges)

	Plan A	Plan B	Plan C	Plan D	Plan E
Total Investment (000)	$177,900	$177,900	$191,100	$157,200	$157,200
All Federal Construction					
Total Annual Cost (000)	19,800	19,800	18,900	17,600	15,000
$/kW-yr (Peak = 954 MW)	20.8	20.8	19.8	18.4	15.7
Mills/kWh (Energy = 1,156 GWH)	17.1	17.1	16.3	15.2	13.0
Combined Federal/non-Federal Construction					
Total Annual Cost (000)	27,800	27,800	20,000	18,800	16,200
$/kW-yr (Peak = 954 MW)	29.1	29.1	21.0	19.7	17.0
Mills/kWh (Energy = 1,156 GWH)	24.0	24.0	17.3	16.3	14.0
All non-Federal Construction					
Total Annual Cost (000)	35,600	35,600	38,200	31,400	29,200
$/kW-yr (Peak = 954 MW)	37.3	37.3	40.0	32.9	30.6
Mills/kWh (Energy = 1,156 GWH)	30.8	30.8	33.0	27.2	25.3

Notes:
1. All costs are in 1976 dollars.
2. Federal cost of money -- 7 percent; non-Federal bond costs calculated at 10 percent.
3. Approximately 27 percent of non-Federal annual costs are in taxes.
4. $/kW-yr and mills/kWh figures are each based on total annual costs: i.e., $\$/\text{kW-yr} = \frac{\text{total annual cost}}{954{,}000 \text{ kW}}$, and $\text{mills/kWh} = \frac{\text{total annual cost}}{1{,}156 \times 10^6 \text{ kWh}}$; the figures are not additive.
5. Total investment includes interest during construction.
6. The value of transmission losses is not reflected in this table.
7. NEPOOL wheeling charges and losses are not included.
8. The energy figures do not reflect added energy from downstream benefits and pumped-storage operation (see footnote 1, page 2).
9. For total costs that include values for estimated losses and wheeling charges, see DOI marketing study.

Dickey/Lincoln School Project
Ultimate Level of Plant Capacity
Transmission Cost Comparison
(Without loss evaluations and wheeling charges)

	Plan A	Plan B	Plan C	Plan D	Plan E
Total Investment (000)	$254,600	$237,800	$253,400	$180,600	$180,600
All Federal Construction					
Total Annual Cost (000)	28,200	26,500	24,900	20,400	17,800
$/kW-yr (Peak = 1,391 MW)	20.3	19.1	17.9	14.7	12.8
Mills/kWh (Energy = 1,156 GWH)	24.4	22.9	21.5	17.6	15.4
Combined Federal/non-Federal Construction					
Total Annual Cost (000)	43,100	39,800	27,100	22,700	20,100
$/kW-yr (Peak = 1,391 MW)	31.0	28.6	19.5	16.3	14.5
Mills/kWh (Energy = 1,156 GWH)	37.3	34.4	23.4	19.6	17.4
All non-Federal Construction					
Total Annual Cost (000)	50,900	47,600	50,700	36,100	33,900
$/kW-yr (Peak = 1,391 MW)	36.6	34.2	36.4	26.0	24.4
Mills/kWh (Energy = 1,156 GWH)	44.0	41.2	43.9	31.2	29.3

Notes:
1. All costs are in 1976 dollars.
2. Federal cost of money -- 7 percent; non-Federal bond costs calculated at 10 percent.
3. Approximately 27 percent of non-Federal annual costs are in taxes.
4. $/kW-yr and mills/kWh figures are each based on total annual costs: i.e., $\$/\text{kW-yr} = \frac{\text{total annual cost}}{1{,}391{,}000 \text{ kW}}$, and $\text{mills/kWh} = \frac{\text{total annual cost}}{1{,}156 \times 10^6 \text{ kWh}}$; the figures are not additive.
5. Total investment includes interest during construction.
6. The value of transmission losses is not reflected in this table.
7. NEPOOL wheeling charges and losses are not included.
8. The energy figures do not reflect added energy from downstream benefits and pumped-storage operation (see footnote 1, page 2).
9. For total costs that include values for estimated losses and wheeling charges, see DOI marketing study.

responsible for the construction of the facilities within its own service area. Costs of transmission facilities were based on preliminary estimates prepared by DOI, the Central Maine Power Company, and the Public Service Company of New Hampshire. Unit costs are shown in Table A-7. The development of Federal annual cost ratios is shown in Table A-8.

The composite annual cost under complete Federal financing is about 10 percent or half the annual cost for complete non-Federal financing for each alternative. For the combined plans, the western alternatives would be substantially less costly than the eastern plans since a higher percentage of the facilities would be Federally-financed. Detailed tabulations of the cost estimates and the unit costs of major transmission facility components are included as part of Appendix A.

A comparison of capital investment costs at the authorized level indicates that the western a-c plans (Plan D and Plan E) are the most economical, followed by the eastern ac plans (Plan A and Plan B). The dc plan (Plan C) was the least economical due to the cost of the converter terminals. For the ultimate level, the western ac plans have the least capital investment costs followed in order by Plans B, C, and A. On an annual cost basis, the western ac plans are the most economical, followed by either the eastern ac plans or the dc plan depending on the type of financing used. Of the two western ac plans, Plan E has a lower annual cost because of the lower maintenance cost and longer service life of its double-circuit, steel line.

Land Requirements

Although the eastern plans involve more transmission, much of it could parallel existing rights-of-way. The western route from Dickey to Comerford will require a new corridor through less developed parts of the region.

Table 4 lists the transmission line additions associated with each alternate plan in terms of miles. Total additions and the types of construction for the authorized and ultimate levels at Dickey are shown. Table A-13 gives typical right-of-way requirements according to the type of construction.

Land requirements are much less for the western plans simply because these plans require fewer transmission line additions than the eastern plans. Of the western plans, Plan D contains two single-circuit lines from Dickey to Comerford, thus its land requirements are substantially greater than for Plans C or E. The possibility of replacing existing lines of lower voltage has not been considered in our evaluation.

A more detailed discussion of land use requirements will be included in the draft environmental impact statement for transmission.

System Studies

Stability tests on the critical faults of each ac alternate have shown that a braking resistor would be effective in maintaining stability in all cases. However, 437 MW (peak) of Dickey generation would have to be tripped and the brake applied for a fault at Buxton on the Deerfield line in the eastern plans or at Dickey on one of the Midpoint lines in the western ac plans. A braking resistor would not be required for the dc plan.

Results of the stability studies indicate that the stability of the New England system can be maintained for all faults which were considered.

No one alternate has an appreciable advantage over the others in terms of the measures required to maintain system stability after a fault.

Each plan was designed to integrate the full output from Dickey-Lincoln School into the New England transmission grid. The transfer capability out of Maine is 3,000 MW for the 874-MW level at Dickey and 3,450 MW for the 1,311-MW level. All of the ac plans would have two 345-kV circuits out of Dickey. With the loss of one of the circuits, the remaining circuit should be able to carry the full output of the Dickey plant. With the dc plan, however, the loss of one pole of the dc line from Dickey to Comerford would reduce the line's capacity by half. However, loads could still be served even while transferring power to New Hampshire and Vermont if generation were increased elsewhere on the system. Since the largest unit planned for this period would be nearly as large as the ultimate level at Dickey (1,150 MW compared with 1,311 MW), generation reserves should be adequate.

Table A-9 shows the Maine-New Hampshire transfer limits. The western plans have a somewhat higher transfer limit than either of the eastern plans. The limiting facilities for all plans are the two existing lines south from Buxton substation.

Of the western plans, Plan C and E have a disadvantage in that a tower failure on the line out of Dickey will cause the loss of the entire output of the plant. Plan D, however, offers about the same degree of reliability as the eastern plans for Dickey transmission.

The system planning studies were a joint effort of NEPLAN and DOI. NEPLAN performed the computer studies. These included power flows and stability studies in addition to load flow analysis studies which were used to determine power transfer limits.

Before the current study was begun, some work had already been done by NEPLAN to determine the minimum transmission required to connect Dickey-Lincoln to the New England grid. All of the previous studies were based on the authorized 874-MW level for Dickey, without consideration of pumped-storage facilities.

Initially a base transmission system was studied which did not include Dickey-Lincoln School, but did include the new Maine and Vermont nuclear units. It called for 345-kV transmission line additions resulting in a transfer capability of 2,200 MW. The system was then expanded to include the integration of Dickey at the 874-MW level. Both ac and dc alternatives were considered for the integration which resulted in a transfer capability of 3,000 MW.

The systems proposed for the 874-MW level were then expanded to accommodate a 1,311-MW level at Dickey and a transfer of 3,450 MW. The studies assumed the same then-anticipated 1986 period loads and incorporated the same transmission system additions associated with the new Maine and Vermont nuclear units.

Three different load levels were used to test the alternative systems at the 1,311-MW generation level at Dickey. These were: heavy load (90 percent of winter peak), intermediate load (60 percent of winter peak), and light load (45 percent of winter peak). The heavy and intermediate load levels were used to test each alternative system with Dickey peaking. In the tests, the system had to withstand a single contingency outage while accommodating scheduled transfer of 3,450 MW out of Maine.

The light load level was used to test the alternate systems with Dickey-Lincoln School in the pumping mode to determine whether some transmission limitation existed. None was found.

Power flow studies were made for each load level. Stability tests were made for the heavy and intermediate load levels but not for the light load level.

Base case power flows for each of the alternatives for the heavy and intermediate load levels are included in Appendix A as Figures A-1 through A-7. Only seven diagrams are used because Plans D and E are electrically identical and Plan C power flows at the 1,311-MW level would be much the same as for Plan D. Switching diagrams for the alternatives are also included in the Appendix as Figures A-8 through A-12.

Based on power flow studies, the transfer capability out of Maine was determined for each alternative plan with Dickey generating 1,311 MW. This was done at both the 90 percent and the 60 percent load levels. Table A-9 shows the transfer limits for each alternative.

Selected stability tests were made for the alternative plans at the 90 percent load levels. All of the tests assumed Dickey to be generating 1,311 MW and the transfer out of Maine to be the scheduled maximum. Tables A-10, A-11, and A-12 summarize the pertinent stability cases. The results show that the use of a braking resistor at Dickey would maintain system stability for all of the 3-phase, 4-cycle normally cleared faults which were considered. A reasonable brake size at Dickey would be 900 MW. After the initial cases were run, it was decided to apply the brake in 6 cycles for local faults and 8 cycles for remote faults to allow for coordination. The time that a brake was applied varied with the fault location. Faults which were closer to Dickey usually required a longer "on time" for the brake. With the use of the brake, all of the cases were made stable at the 90 percent load level. For the 60 percent load level, however, in addition to the use of the brake, one-third (437 MW) of the Dickey generation had to be tripped for a fault at Buxton on the Deerfield line in Plan B and for a fault at Dickey on the Midpoint line in Plan D. It has been assumed that, if the system can be made stable for a fault in Plan B, it can also be made stable for similar faults in Plan A, since Plan A while similar to Plan B has a greater amount of transmission. Plan E is electrically the same as Plan D, and Plan C has inherently a higher level of stability. Therefore, no tests were run on Plans E and C, as such.

Unit dropping at Dickey in lieu of using a brake was considered. While this method would provide for stable operation of the system, we believe that use of a brake would be more advantageous. It would allow the generation to stay on-line and result in less maintenance of switchgear and generating units. However, before the final decision is made on the type of stability control to be used, additional studies, which will include unit dropping as the primary measure, will be made.

Several single-phase line-to-ground fault transient tests were also made assuming delayed clearing. Only Plans B and D at the 60 percent load level were examined since it was assumed that if system stability can be maintained for faults with these plans, it can also be maintained for similar faults with the other plans. The test results showed that for certain faults no braking resistor was needed to maintain system stability. Others required dropping one-third of the generation (437 MW) at Dickey in addition to applying the brake.

Substation and Power System Control Facilities

The development of a transmission system for the Dickey-Lincoln School project would include the addition of substation and power system control facilities.

Each of the alternative plans would require the construction of new substations and in some cases the expansion of certain existing or future substations. Table 5 lists the locations of these substation facilities. Many would be adjacent to existing facilities. The approximate geographical locations of the substations are indicated in Figures 1 to 5.

The DOI is proposing a 12-channel microwave system to control and monitor the transmission facilities associated with the Dickey-Lincoln School project. Four channels would be used for relaying, two for voice communications and one channel each for automatic control of generation, telemetering, control of the braking resistor, mobile radio, generation dropping, and supervisory control.

Three preliminary communication system plans have been developed to perform power system control functions for the Dickey-Lincoln School project, one for the eastern alternatives and two for the western alternatives. All plans will be microwave systems interconnecting with the existing New England Shared Microwave System (NESMS). Sufficient microwave sites have been identified so as to provide an indication of the maximum land use impact of the communication systems. These sites are, however, tentative pending further studies involving environmental effects, availability, feasibility, etc.

The existing microwave communication system is shown in Figures 6, 7, and 8, which illustrate the communication system alternatives under consideration.

Figure 6 shows the preliminary microwave plan for the eastern alternatives. It consists of four microwave terminals and seven microwave repeater stations. The stations will be located insofar as is feasible along the transmission line routes.

Two preliminary microwave plans are indicated for the western alternatives. The first plan, shown in Figure 7, assumes that a microwave system can be installed in close proximity to the transmission line right-of-way between Dickey and Comerford. This could be achieved if sites can be picked close to existing roads and to available ac power. This plan would require three microwave terminals and seven microwave repeater stations.

A second microwave plan for the western alternatives assumes that a more economical system could be realized by providing channels to Comerford over the existing system, and to Midpoint (near Jackman, Maine) and Dickey by extending the existing system from the vicinity of Bangor, Maine. This system would require three microwave terminals and six microwave repeater stations as shown in Figure 8. A disadvantage of this plan is that it would not provide complete VHF mobile coverage of the transmission line between Dickey and Comerford.

Future Studies

The integration of the Lincoln School plant is currently being studied. The output can be integrated by connecting the plant to the Dickey transmission system, to the Maine Public Service Company, near Fort Kent, Maine, or both. The plan selected here will not have any appreciable impact on the transmission alternatives developed for Dickey, either from a power flow or stability standpoint. We have included estimated costs in our analysis for a tie from Dickey to Lincoln School to Ft. Kent at 138 kV to connect with the projected Maine Public Service system for the mid-1980s, with transformation at Dickey as required. This tie evolved from discussions with the company and NEPLAN.

Further studies will be undertaken if the project is approved for construction. These studies will define more accurately transmission line lengths, transmission line centerline locations, specific system facility additions, transmission system design parameters, effects on the underlying systems, etc., and will be based on the most current load projections and system developments available.

Cognizance will be taken of any major changes should they occur and affect the basic assumptions of this feasibility study. For example, the New Brunswick Electric Power Commission has incorporated the Dickey-Lincoln School Project into its studies of the Bay of Fundy tidal power development. Transmission alternatives investigated include a combined New England-New Brunswick transmission system for marketing Dickey-Lincoln School power.

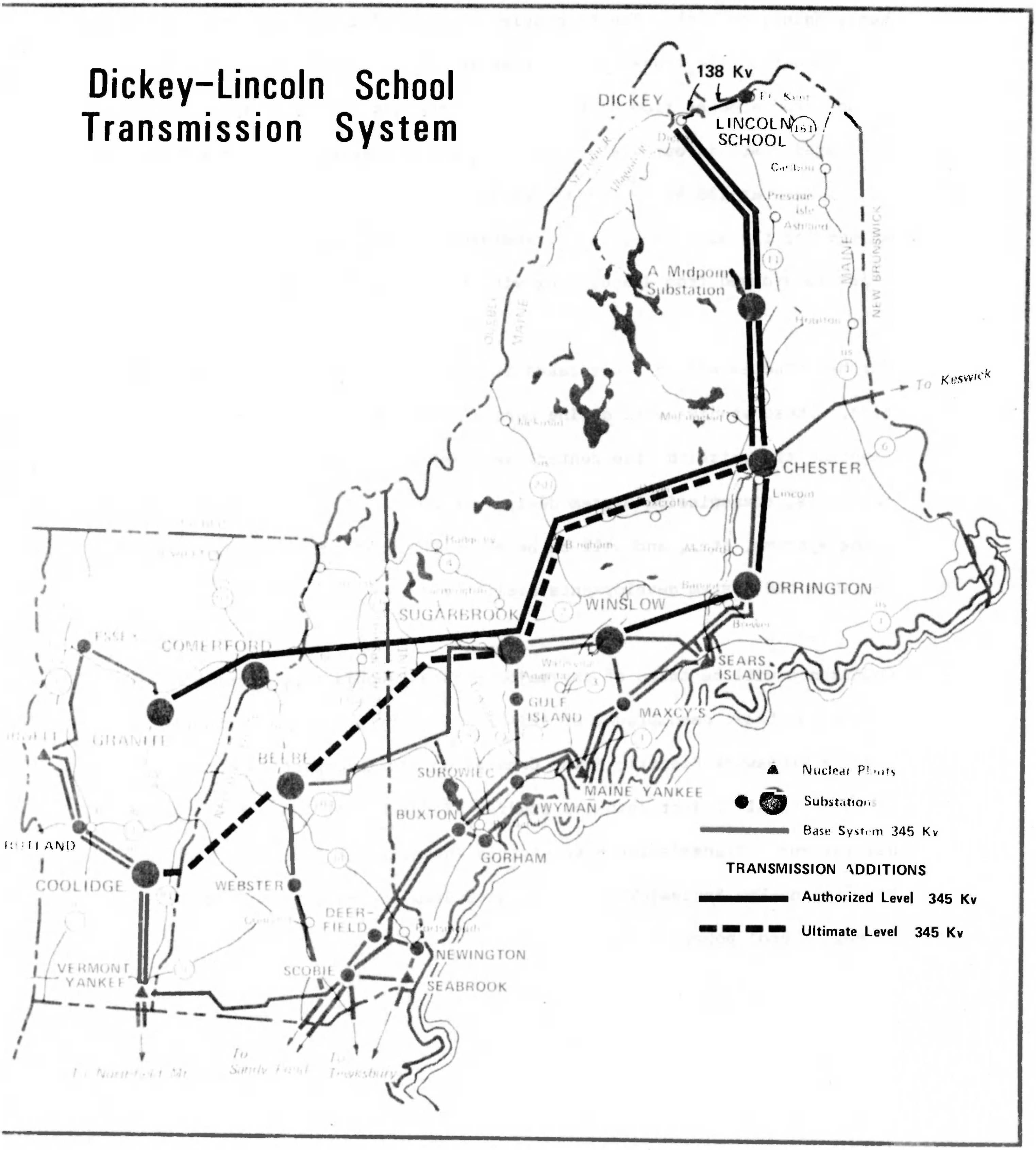


Figure 1 Plan A (Eastern AC plan no. 1)

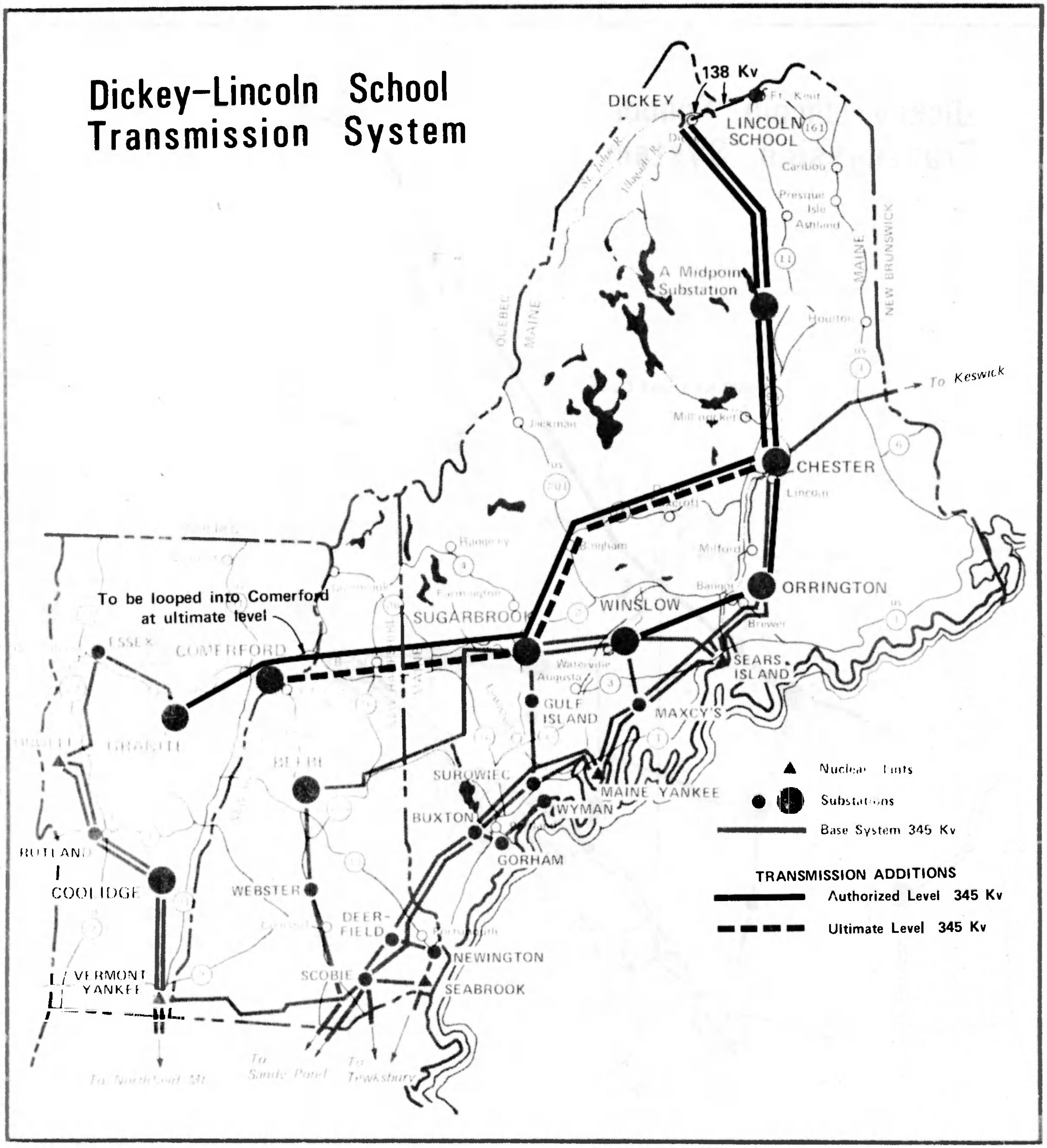


Figure 2 Plan B (Eastern AC plan no. 2)

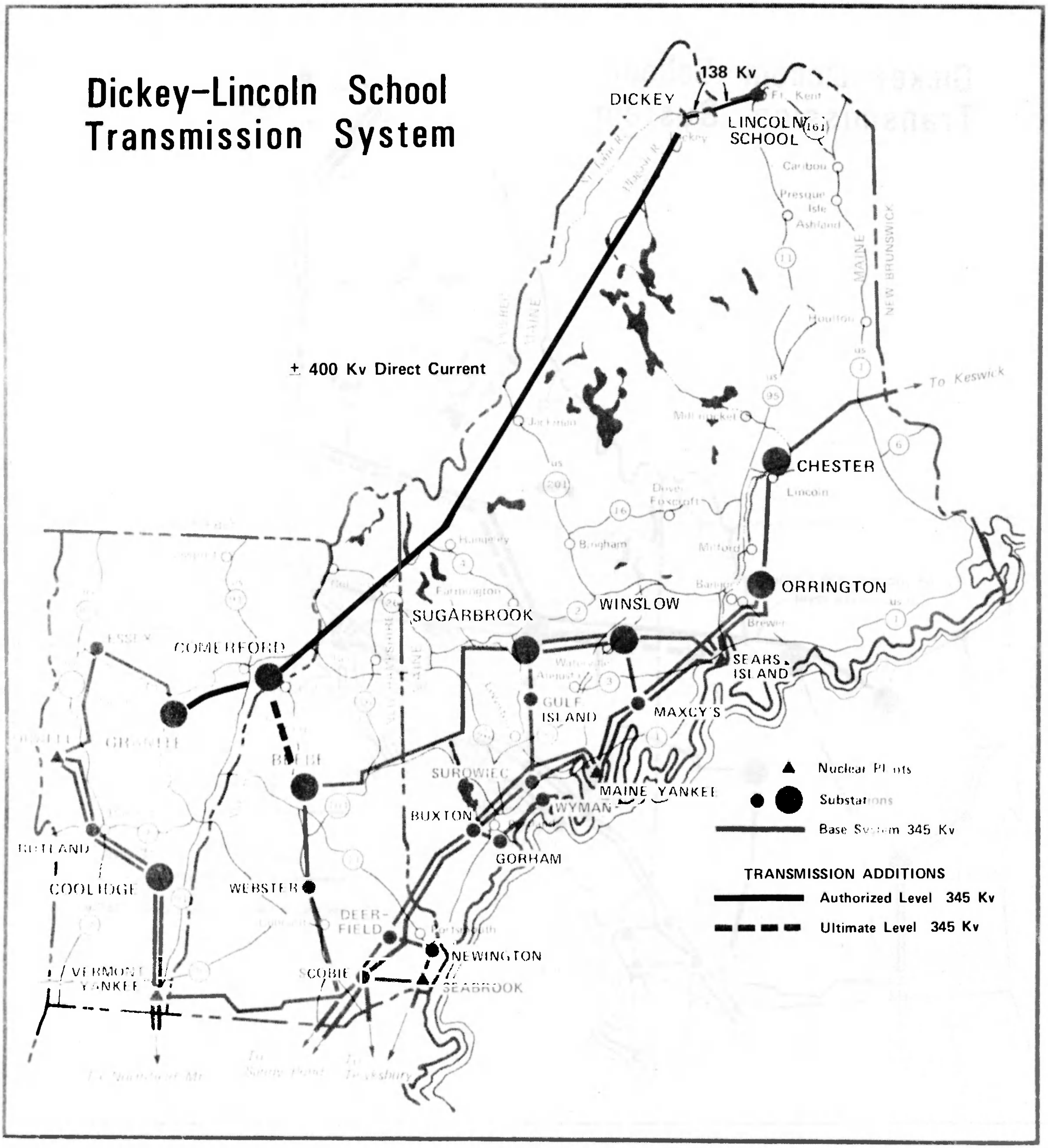


Figure 3 Plan C (Western DC plan)

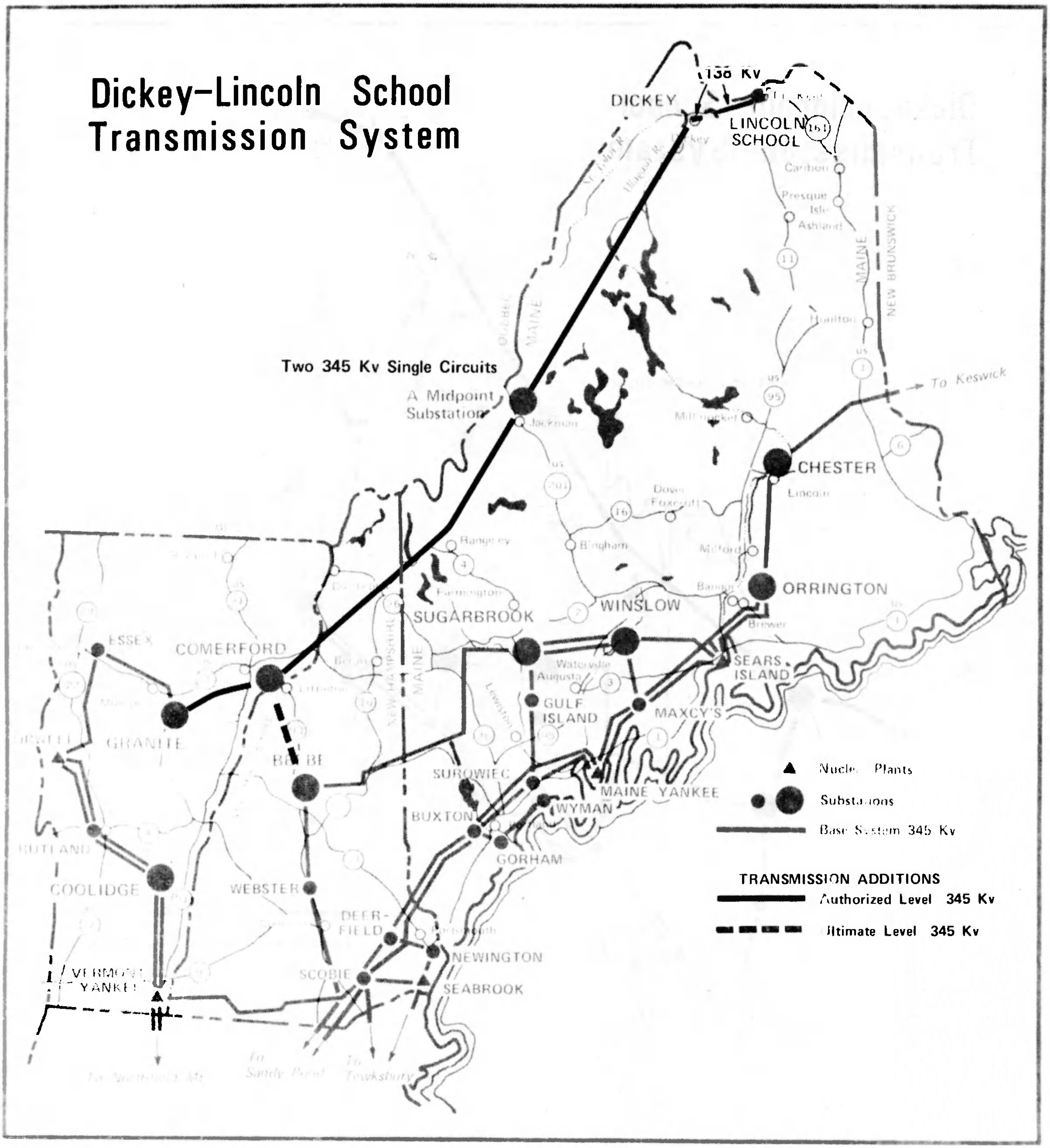


Figure 4 Plan D (Western AC plan no. 1)

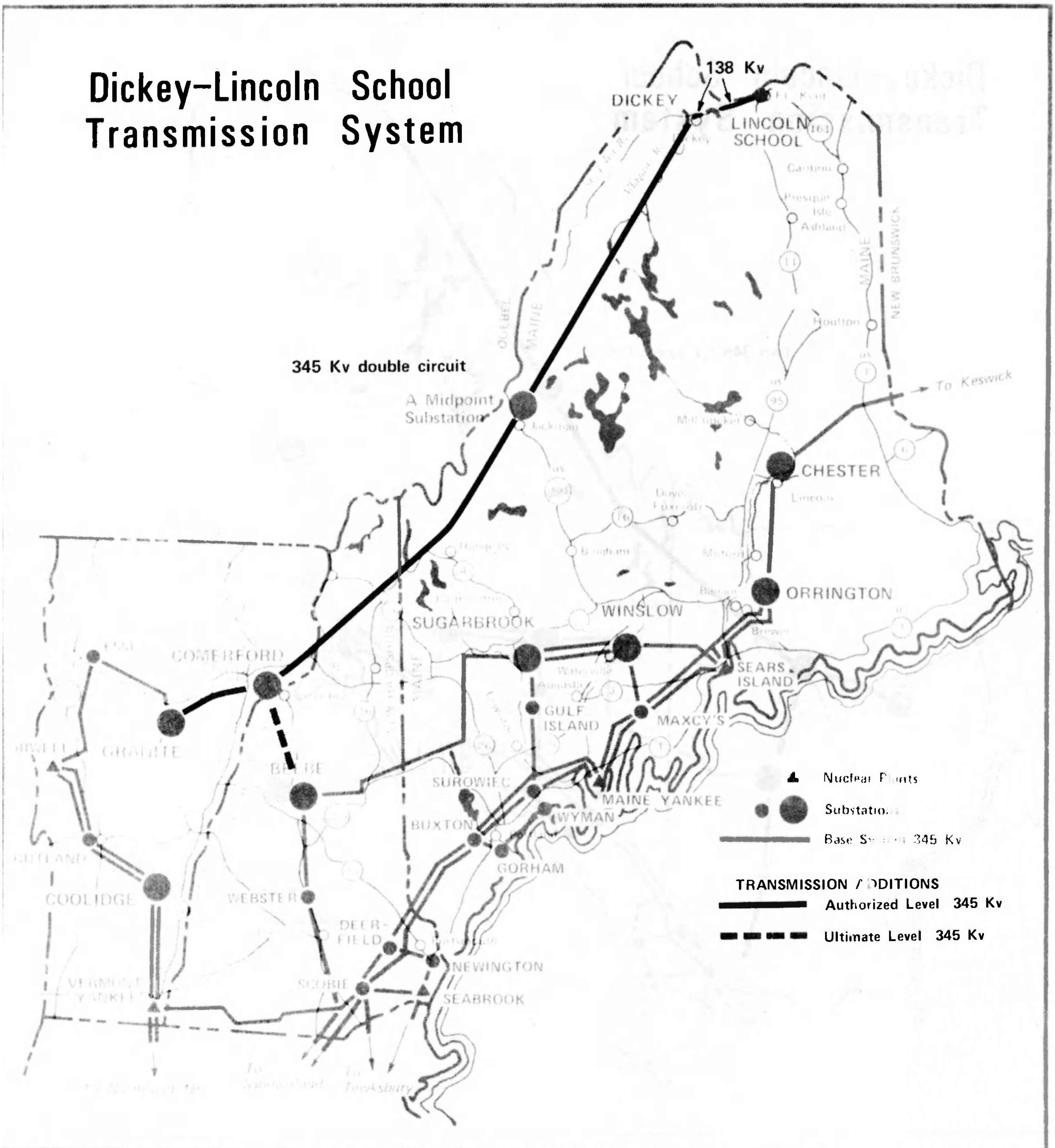


Figure 5 Plan E (Western AC plan no. 2)

Table 1
Dickey Lincoln School Transmission System Planning Study
Cost Estimates
(All Federal Construction)

Authorized Level		Plan A	Plan B	Plan C	Plan D	Plan E
Construction Cost	($000)	153,500	153,500	164,300	135,800	135,800
Interest During Construction	($000)	24,400	24,400	26,800	21,400	21,400
Total Investment	($000)	177,900	177,900	191,100	157,200	157,200
Interest & Amortization	($000)	13,600	13,600	14,700	12,000	11,800
Operation & Maintenance	($000)	6,200	6,200	4,200	5,600	3,200
Total Annual Cost	($000)	19,800	19,800	18,900	17,600	15,000
$/kW (Peak = 954 MW)		186	186	200	165	165
$/kW-yr (Peak = 954 MW)		20.8	20.8	19.8	18.4	15.7
Mills/kWh (Energy = 1156 GWH)		17.1	17.1	16.3	15.2	13.0
Ultimate Level						
Construction Cost	($000)	219,600	205,200	217,900	156,100	156,100
Interest During Construction	($000)	35,000	32,600	35,500	24,500	24,500
Total Investment	($000)	254,600	237,800	253,400	180,600	180,600
Interest & Amortization	($000)	19,400	18,200	19,500	13,900	13,600
Operations & Maintenance	($000)	8,800	8,300	5,400	6,500	4,200
Total Annual Cost	($000)	28,200	26,500	24,900	20,400	17,800

Table 1 (Cont.)
Dickey-Lincoln School Transmission System Planning Study
Cost Estimates
(All Federal Construction)

Ultimate Level	Plan A	Plan B	Plan C	Plan D	Plan E
$/kW (Peak = 1,391 MW)	183	171	182	130	130
$/kW-yr (peak = 1,391 MW)	20.3	19.1	17.9	14.7	12.8
Mills/kWh (Energy = 1,156 GWH)	24.4	22.9	21.5	17.6	15.4

Note:
1. Federal interest rate = 7 percent
2. Interest during construction based on a Federal schedule of expenditures and 7 percent interest rate.
3. Peak and energy figures include output of Lincoln School plant (80 MW peak, 262 GWH average annual energy).

Table 2
Dickey-Lincoln School Transmission System Planning Study
Cost Estimates
(Combined Federal-Non-Federal Construction)

Authorized Level	Plan A	Plan B	Plan C	Plan D	Plan E
Federal Constr. Cost ($000)	76,500	76,500	151,800	123,000	123,000
Federal IDC ($000)	12,100	12,100	24,900	19,500	19,500
Total Fed. Invest. ($000)	88,600	88,600	176,700	142,500	142,500
Non-Fed. Const. Cost ($000)	77,000	77,000	12,500	12,800	12,800
Non-Fed. IDC ($000)	12,300	12,300	1,900	1,900	1,900
Total Non-Fed. Investment ($000)	89,300	89,300	14,400	14,700	14,700
Total Investment ($000)	177,900	177,900	191,100	157,200	157,200
Federal Annual Cost ($000)	9,900	9,900	17,100	15,900	13,300
Non-Fed. Annual Cost ($000)	17,900	17,900	2,900	2,900	2,900
Total Annual Cost ($000)	27,800	27,800	20,000	18,800	16,200
$/kW (Peak = 954 MW)	186	186	200	165	165
$/kW-yr (Peak = 954 MW)	29.1	29.1	21.0	19.7	17.0
Mills/kWh (Energy = 1,156 GWH)	24.0	24.0	17.3	16.3	14.0
Ultimate Level					
Federal Constr. Cost ($000)	76,800	76,800	194,600	132,500	132,500
Federal IDC ($000)	12,100	12,100	32,000	20,900	20,900
Total Fed. Invest. ($000)	88,900	88,900	226,600	153,400	153,400
Non-Fed. Const. Cost ($000)	142,800	128,400	23,300	23,600	23,600
Non-Fed. IDC ($000)	22,900	20,500	3,500	3,600	3,600
Total Non-Fed. Investment ($000)	165,700	148,900	26,800	27,200	27,200
Total Investment ($000)	254,600	237,800	253,400	180,600	180,600
Ultimate Level					
Federal Annual Cost ($000)	10,000	10,000	21,700	17,200	14,600
Non-Fed. Annual Cost ($000)	33,100	29,800	5,400	5,500	5,500
Total Annual Cost ($000)	43,100	39,800	27,100	22,700	20,100

Table 2 (Cont.)

Dickey-Lincoln School Transmission System Planning Study

Cost Estimates

(Combined Federal-Non-Federal Construction)

	Plan A	Plan B	Plan C	Plan D	Plan E
$/kW (Peak = 1,391 MW)	183	171	182	130	130
$/kW-yr (Peak = 1,391 MW)	31.0	28.6	19.5	16.3	14.5
Mills/kWh (Energy = 1,156 GWH)	37.3	34.4	23.4	19.6	17.4

Note: 1. Federal interest rate = 7 percent

2. Non-Federal annual cost ratio = 20 percent

3. IDC assumed to be the same for Federal and non-Federal construction.

4. Peak and energy figures include output of Lincoln School plant (80 MW peak, 262 GWH average annual energy).

Table 3
Dickey-Lincoln School Transmission System Planning Study
Cost Estimates
(All Non-Federal Construction)

Authorized Level		Plan A	Plan B	Plan C	Plan D	Plan E
Construction Cost		153,500	153,500	164,300	135,800	135,800
Interest During Construction	($000)	24,400	24,400	26,800	21,400	21,400
Total Investment	($000)	177,900	177,900	191,100	157,200	157,200
Annual Cost	($000)	35,600	35,600	38,200	31,400	29,200
$/kW (Peak = 954 MW)		186	186	200	165	165
$/kW-yr (Peak = 954 MW)		37.3	37.3	40.0	32.9	30.6
Mills/kWh (Energy = 1,156 GWH)		30.8	30.8	33.0	27.2	25.3
Ultimate Level						
Construction Cost	($000)	219,600	205,200	217,900	156,100	156,100
Interest During Construction	($000)	35,000	32,600	35,500	24,500	24,500
Total Investment	($000)	254,600	237,800	253,400	180,600	180,600
Annual Cost	($000)	50,900	47,600	50,700	36,100	33,900
$/kW (Peak = 1,391 MW)		183	171	182	130	130
$/kW-yr (Peak = 1,391 MW)		36.6	34.2	36.4	26 0	24.4
Mills/kWh (Energy = 1,156 GWH)		44.0	41.2	43.9	31.2	29.3

Note: 1. Assumed same IDC as for all Federal construction.

2. Assumed annual cost ratio of 20 percent except 18 percent for steel double-circuit line in Plan E.

3. Peak and energy figures include output of Lincoln School plant (80 MW Peak, 262 GWH average annual energy).

Table 4
Dickey-Lincoln School Transmission System Planning Study
Transmission Line Additions

Authorized Level (874 MW at Dickey)

Plan	A	B	C	D	E
Circuit Miles	670	670	322	582	582
Corridor Miles	520	520	322	322	322
WHF (Single line) 1/	370	370	62	62	62
WHF (Two lines in parallel)	150	150	--	260	--
WHF dc	--	--	260	--	--
SDC	--	--	--	--	260
Possible Parallel 2/	280	280	95	95	95

Ultimate Level (1,311 MW at Dickey)

Plan	A	B	C	D	E
Circuit Miles	989	895	371	631	631
Corridor Miles	714	520	371	371	371
WHF (Single line) 1/	439	145	111	111	111
WHF (Two lines in parallel)	275	375	--	260	--
WHF dc	--	--	260	--	--
SDC	--	--	--	--	260
Possible Parallel 2/	480	280	145	145	145

1/ Includes 30 miles of 138-kV line.

2/ Corridor miles possibly paralleling existing or future lines.

Notes: 1. WHF - Wood H-Frame
2. dc - direct current
3. SDC - Steel double-circuit

Table 5

Dickey-Lincoln School Transmission System Planning Study

(Substation Additions)

Plan	New 345-kV Substations	New 138-kV Substations	Existing 345-kV Sub. Expanded	Future 345-kV Sub. Expanded
A	Dickey	Dickey	Orrington	Sugarbrook
	Midpoint	Lincoln School		Winslow
	Chester	Ft. Kent		Granite
	Beebe 1/			Coolidge 1/
B	Dickey	Dickey	Orrington	Sugarbrook
	Midpoint	Lincoln School		Winslow
	Chester	Ft. Kent		Granite
	Comerford 1/			
C	Comerford 2/	Dickey 2/		Granite
	Beebe 1/	Lincoln School		
		Ft. Kent		
D,E	Dickey	Dickey		Granite
	Midpoint	Lincoln School		
	Comerford	Ft. Kent		
	Beebe 1/			

1/ Additions for the ultimate level of development at Dickey.

2/ Converter terminals would also be constructed at these sites.

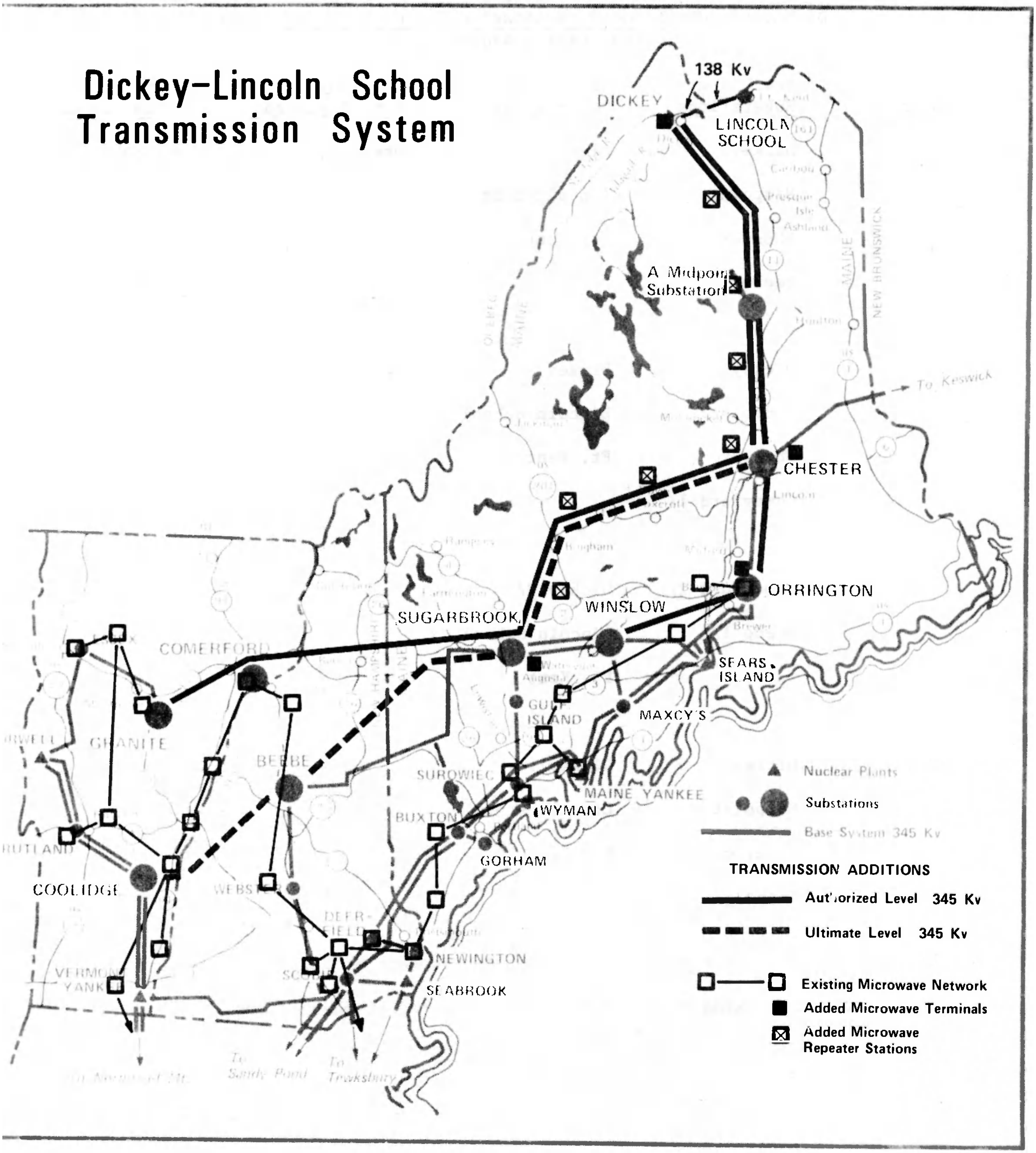


Figure 6 Microwave Communication System (Eastern Plan)

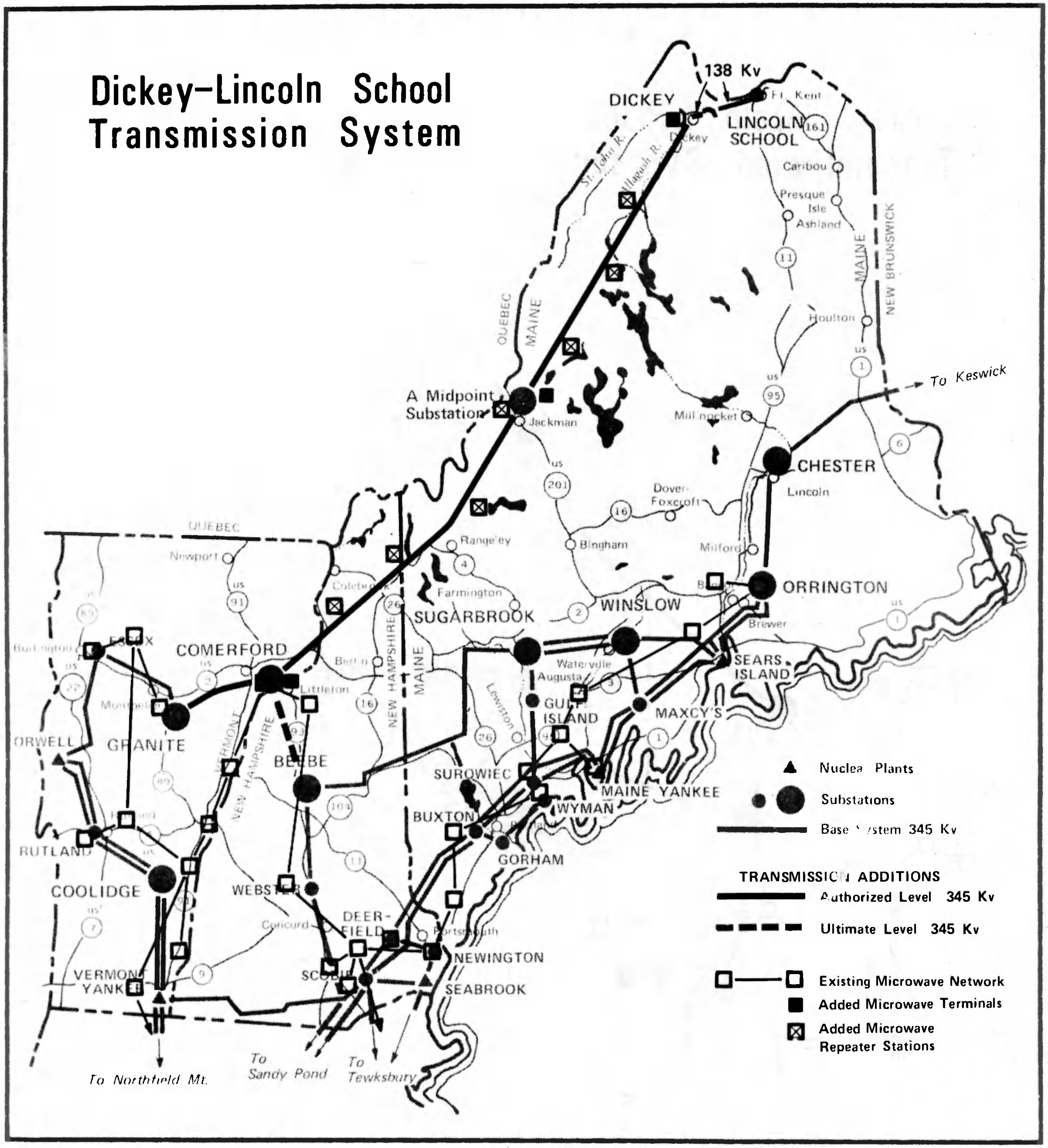


Figure 7 Microwave Communication System (Western Plan No. 1)

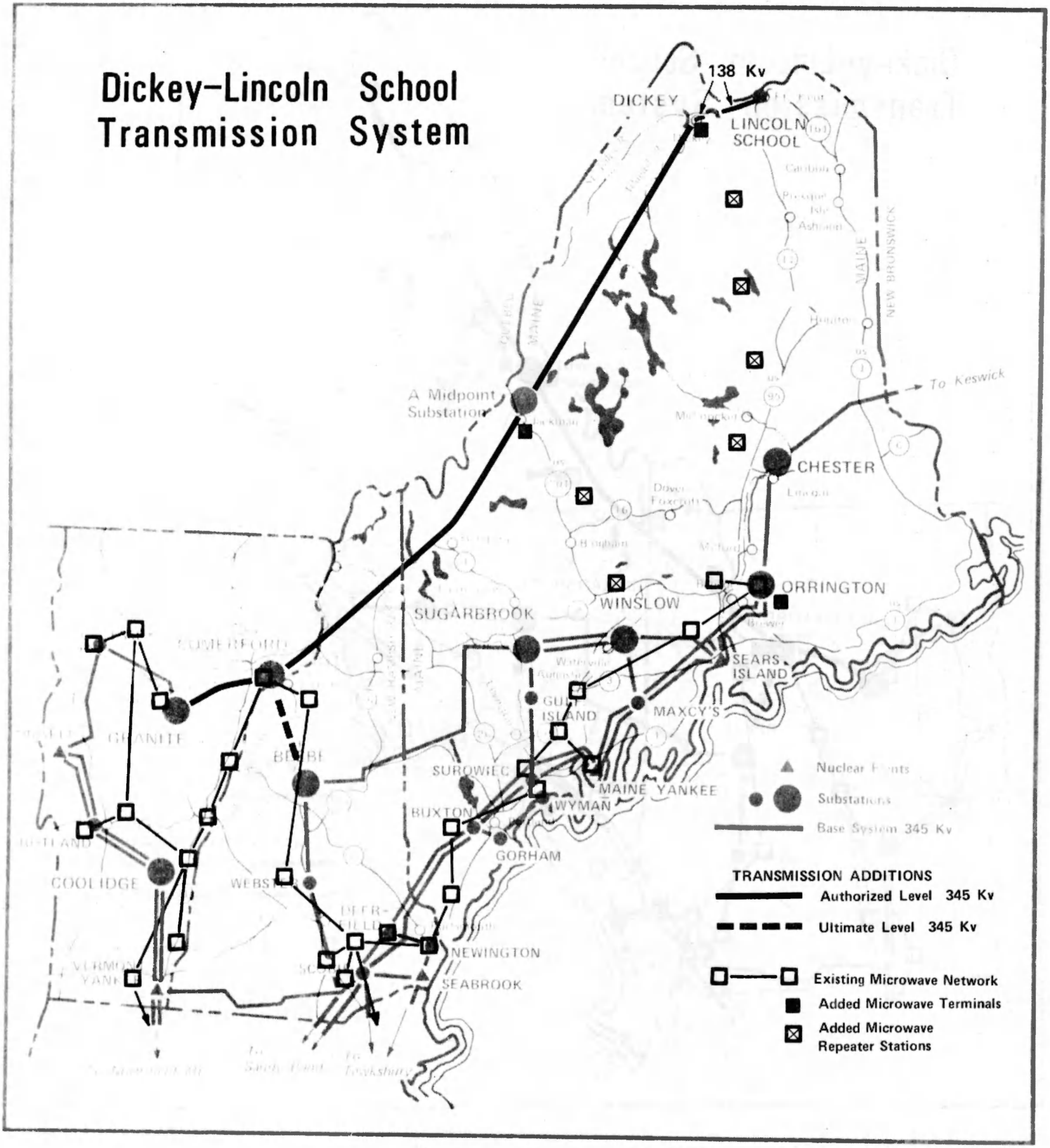


Figure 8 Microwave Communication System (Western Plan No. 2)

Acknowledgement

The computer studies used in the analysis of transmission system alternatives for the Dickey-Lincoln School Lakes Project were conducted by the staff of New England Power Planning (NEPLAN). Their assistance and cooperation in the preparation of this report are greatly appreciated.

APPENDIX A

Table A-1

Dickey-Lincoln School Transmission System Planning Study

Transmission Facilities Additions

($000)

Plan A

Lines	Authorized Level		Additions for Ultimate Level		Ultimate Level	
	Line Mi.	Invest.	Line Mi.	Invest.	Line Mi.	Invest.
Dickey-Chester #1	150	27,750			150	27,750
Dickey-Chester #2	150	27,750			150	27,750
Chester-Orrington	50	9,250			50	9,250
Orrington-Winslow	35	6,475			35	6,475
Chester-Sugarbrook #1	125	23,125			125	23,125
Sugarbrook-Granite	130	24,050			130	24,050
Dickey-Lincoln School-Ft. Kent 138 kV	30	3,450			30	3,450
Chester-Sugarbrook #2			125	23,125	125	23,125
Sugarbrook-Beebe-Coolidge			194	35,890	194	35,890
Subtotal	670	121,850	319	59,015	989	180,865
PCB's	No.	Invest.	No.	Invest.	No.	Invest.
Dickey	6(3000 A)	4,500			6	4,500
Midpoint Switching Station	4(3000 A)	3,000			4	3,000
Chester	9(3000 A)	6,750	2(3000 A)	1,500	11	8,250
Orrington	3(2000 A)	1,680			3	1,680
Winslow	1(2000 A)	560			1	560
Sugarbrook	5(2000 A)	2,800	1(2000 A)	560	6	3,360
Granite	1(2000 A)	560			1	560
Lincoln School 138 kV	2	400			2	400
Ft. Kent 138 kV	1	200			1	200
Beebe			2(2000 A)	1,120	2	1,120
Coolidge			1(2000 A)	560	1	560
Subtotal	32	20,450	6	3,740	38	24,190

Table A-1 (Cont.)

Dickey-Lincoln School Transmission System Planning Study

Transmission Facilities Additions

($000)

Plan A

	Authorized Level		Additions for Ultimate Level		Ultimate Level	
	No.	Invest.	No.	Invest.	No.	Invest.
Transformers						
Dickey 345/138 kV	1	2,500			1	2,500
	MVAR	Invest.	MVAR	Invest.	MVAR	Invest.
Shunt Reactors	570	5,700	280	2,800	850	8,500
Power System Control		2,000		500		2,500
Braking Resistor (900 MW)		1,000				1,000
Subtotals		153,500		66,055		219,555
IDC		24,400		10,600		35,000
Total Investment		177,900		76,655		254,555

Table A-2

Dickey-Lincoln School Transmission System Planning Study

Transmission Facilities Additions

($000)

Plan B

Lines	Authorized Level		Additions for Ultimate Level		Ultimate Level	
	Line Mi.	Invest.	Line Mi.	Invest.	Line Mi.	Invest.
Dickey-Chester #1	150	27,750			150	27,750
Dickey-Chester #2	150	27,750			150	27,750
Chester-Orrington	50	9,250			50	9,250
Orrington-Winslow	35	6,475			35	6,475
Chester-Sugarbrook #1	125	23,125			130	23,125
Sugarbrook-Granite	130	24.050			130	24,050
Dickey-Lincoln School-Ft. Kent 138 kV	30	3,450			30	3,450
Chester-Sugarbrook #2			125	23,125	125	23,125
Sugarbrook-Comerford			100	18,500	100	18,500
Subtotal	670	121,850	225	41,625	895	163,475

PCB's	No.	Invest.	No.	Invest.	No.	Invest.
Dickey	6(3000 A)	4,500			6	4,500
Midpoint Switching Station	4(3000 A)	3,000			4	3,000
Chester	9(3000 A)	6,750	2(3000 A)	1,500	11	8,250
Orrington	3(2000 A)	1,680			3	1,680
Winslow	1(2000 A)	560			1	560
Sugarbrook	5(2000 A)	2,800	1(2000 A)	560	6	3,360
Granite	1(2000 A)	560			1	560
Lincoln School 138 kV	2	400			2	400
Ft. Kent 138 kV	1	200			1	200
Comerford			4(2000 A)	2,240	4	2,240
Comerford 230 kV			1	310	1	310
Subtotal	32	20,450	8	4,610	40	25,060

Table A-2 (Cont.)

Dickey-Lincoln School Transmission System Planning Study

Transmission Facilities Additions

($000)

Plan B

	Authorized Level		Additions for Ultimate Level		Ultimate Level	
	No.	Invest.	No.	Invest.	No.	Invest.
Transformers						
Dickey 345/138 kV	1	2,500			1	2,500
Comerford 345/230 kV			1	3,000	1	3,000
Subtotal	1	2,500	1	3,000	2	5,500
	MVAR	Invest.	MVAR	Invest.	MVAR	Invest.
Shunt Reactors	570	5,700	200	2,000	770	7,700
Power System Control		2,000		500		2,500
Braking Resistor (900 MW)		1,000				1,000
Subtotals		153,500		51,735		205,235
IDC		24,400		8,200		32,600
Total Investment		177,900		59,935		237,835

A-4

Table A-3

Dickey-Lincoln School Transmission System Planning Study

Transmission Facilities Additions

($000)

Plan C

Lines	Authorized Level		Additions for Ultimate Level		Ultimate Level	
	Line Mi.	Invest.	Line Mi.	Invest.	Line Mi.	Invest.
Dickey-Comerford DC	260	40,300			260	40,300
Comerford-Granite	32	5,920			32	5,920
Dickey-Lincoln School-Ft. Kent 138 kV	30	3,450			30	3,450
Comerford-Beebe			49	9,065	49	9,065
Subtotal	322	49,670	49	9,065	371	58,735
PCB's	No.	Invest.	No.	Invest.	No.	Invest.
Comerford	4(3000 A)	3,000	1(3000 A)	750	5	3,750
Comerford 230 kV	1	310			1	310
Granite	1(3000 A)	750			1	750
Lincoln School 138 kV	2	400			2	400
Ft. Kent 128 kV	1	200			1	200
Beebe			1(3000 A)	750	1	750
Subtotal	9	4,660	2	1,500	11	6,160
Transformers						
Comerford	1	3,000			1	3,000
DC Terminals	MW	Invest.	MW	Invest.	MW	Invest.
Dickey & Comerford	954	104,940	437	42,510	1,391	47,450
Power System Control		2,000		500		2,500
Subtotals		164,270		53,575		217,845
IDC		26,800		8,700		35,500
Total Investment		191,070		62,275		253,345

Table A-4
Dickey-Lincoln School Transmission System Planning Study
Transmission Facilities Additions
($000)

Plan D

Lines	Authorized Level		Additions for Ultimate Level		Ultimate Level	
	Line Mi.	Invest.	Line Mi.	Invest.	Line Mi.	Invest.
Dickey-Comerford #1	260	48,100			260	48,100
Dickey-Comerford #2	260	48,100			260	48,100
Comerford-Granite	32	5,920			32	5,920
Dickey-Lincoln School-Ft. Kent 138 kV	30	3,450			30	3,450
Comerford-Beebe			49	9,065	49	9,065
Subtotal	582	105,570	49	9,065	631	114,635
PCB's	No.	Invest.	No.	Invest.	No.	Invest.
Dickey	6(3000 A)	4,500			6	4,500
Midpoint Switching Station	4(3000 A)	3,000			4	3,000
Comerford	4(3000 A)	3,000	1(3000 A)	750	5	3,750
Comerford	1	310			1	310
Granite	1(3000 A)	750			1	750
Lincoln School	2	400			2	400
Ft. Kent	1	200			1	200
Beebe			1(3000 A)	750	1	750
Subtotal	19	12,160	2	1,500	21	13,660
Transformers						
Comerford 345/230 kV	1	3,000			1	3,000
Dickey 345/138 kV	1	2,500			1	2,500
Subtotal	2	5,500			2	5,500

Table A-4 (Cont.)

Dickey-Lincoln School Transmission System Planning Study

Transmission Facilities Additions

($000)

Plan D

	Authorized Level		Additions for Ultimate Level		Ultimate Level	
Series Compensation	MVAR	Invest.	MVAR	Invest.	MVAR	Invest.
Dickey-Comerford #1 & #2	370	4,630	740	9,350	1,110	13,880
Shunt Reactors	490	4,900			490	4,900
Power System Control		2,000		500		2,500
Braking Resistor (900 MW)		1,000				1,000
Subtotals		135,760		20,315		156,075
IDC		21,400		3,100		24,500
Total Investment		157,160		23,415		180,575

Table A-5

Dickey-Lincoln School Transmission System Planning Study

Transmission Facilities Additions

($000)

Plan E

Lines	Authorized Level		Additions for Ultimate Level		Ultimate Level	
	Line Mi.	Invest.	Line Mi.	Invest.	Line Mi.	Invest.
Dickey-Comerford SDC	260	96,200			260	96,200
Comerford-Granite	32	5,920			32	5,920
Dickey-Lincoln School-Ft. Kent 138 kV	30	3,450			30	3,450
Comerford-Beebe			49	9,065	49	9,065
Subtotal	322	105,570	49	9,065	371	114,635

PCB's	No.	Invest.	No.	Invest.	No.	Invest.
Dickey	6(3000 A)	4,500			6	4,500
Midpoint Switching Station	4(3000 A)	3,000	1(3000 A)	750	4	3,000
Comerford	4(3000 A)	3,000			5	3,750
Comerford 230 kV	1	310			1	310
Granite	1(3000 A)	750			1	750
Lincoln School	2	400			2	400
Ft. Kent	1	200			1	200
Beebe			1(3000 A)	750	1	750
Subtotal	19	12,160	2	1,500	21	13,660

Transformers	No.	Invest.	No.	Invest.	No.	Invest.
Comerford 345/230 kV	1	3,000			1	3,000
Dickey 345/138 kV	1	2,500			1	2,500
Subtotal	2	5,500			2	5,500

Table A-5 (Cont.)

Dickey-Lincoln School Transmission System Planning Study

Transmission Facilities Additions

($000)

Plan E

Series Compensation	Authorized Level MVAR	Authorized Level Invest.	Additions for Ultimate Level MVAR	Additions for Ultimate Level Invest.	Ultimate Level MVAR	Ultimate Level Invest.
Dickey-Comerford SDC	370	4,360	740	9,250	1,110	13,880
Shunt Reactors	490	4,900			490	4,900
Power System Control		2,000		500		2,500
Braking Resistor (900 MW)		1,000				1,000
Subtotals		135,760		20,315		156,075
IDC		21,400		3,100		24,500
Total Investment		157,160		23,415		180,575

Table A-6
Dickey-Lincoln School Transmission System Planning Study
Losses on Project-associated Transmission Facilities

Plan	Description	Authorized (874 MW @ Dickey)			Ultimate (1,311 MW @ Dickey)		
		MW	%	Value of Losses 1/ ($$10^6$)	MW	%	Value of Losses ($$10^6$)
A	Eastern AC Plan #1	60	6.9	3.3	110	8.4	6.1
B	Eastern AC Plan #2	60	6.9	3.3	100	7.6	5.5
C	Western DC Plan	55	6.3	3.0	105	8.0	5.8
D	Western AC Plan #1	40	4.6	2.2	90	6.9	5.0
E	Western AC Plan #2	40	4.6	2.2	90	6.9	5.0

1/ Estimated annual value of losses evaluated at $55/kW-yr.

Table A-7

Dickey-Lincoln School Transmission System Planning Study

Unit Cost Estimates

Transmission Lines 1/	
345 kV ac Woodpole H-Frame	\$185,000/mi.
345 kV ac Steel Double-Circuit	\$370,000/mi.
±400 kV dc Woodpole H-Frame	\$150,000/mi.
138 kV ac Woodpole H-Frame	\$115,000/mi.
Transformers	
345/230 kV 600 MVA	\$3,000,000
345/138 kV 200 MVA	\$2,500,000
Power Circuit Breakers	
345 kV (3,000 Amps)	\$ 750,000
(2,000 Amps)	\$ 560,000
230 kV	\$ 310,000
138 kV	\$ 200,000
Shunt Reactors	
345 kV	\$10/kvar
Series Capacitors	
345 kV	\$12.50/kvar
DC Terminals	
954 MW capacity	\$55/kW per terminal
1,391 MW capacity	\$53/kW per terminal
Power System Control	\$200,000 + \$600,000/100 miles
Braking Resistor (900 MW)	\$1,000,000 including PCB
Value of Transmission Losses	\$55/kW-yr. on peak losses

1/ Conductors for 345 kV ac and ± 400 kV dc lines are 2-954 Kcmil (Catbird)

Table A-8
Dickey-Lincoln School Transmission System Planning Study
Annual Charges for Federal Financing (7 Percent Interest)

Facility	Service Life (yrs.)	I&A (%)	O&M (%)	Total (%)
Lines-WHF	40	7.5	3.1	10.6
SDC	50	7.3	1.0	8.3
AC Substation	30	8.1	5.0	13.1
DC Terminals	35	7.7	1.5	9.2
Power System Control	22	9.0	6.9	15.9

Annual Charges for Non-Federal Financing:

Composite Annual Charge of 20 percent was used, except 18 percent for steel double-circuit line in Plan E.

Table A-9
Dickey-Lincoln School Transmission System Planning Study
Maine-New Hampshire Transfer Limits-MW

Plan	Reinforcement	90 Percent	60 Percent *	60 Percent *
A	Sugarbrook-Beebe-Coolidge 345 kV	3,500 1/ 3/	3,050 3/	3,550 3/
B	Sugarbrook-Comerford No. 2 345 kV	3,450 1/ 3/	3,000 2/	3,325 3/
C	Dickey-Comerford dc Comerford-Beebe 345 kV	3,575 1/	3,475 3/	--
D	Dickey-Comerford 345 kV No. 1 & No. 2 Comerford-Beebe 345 kV	3,575 1/	3,475 3/	--
E	Dickey-Comerford 345 kV Double-Circut Comerford-Beebe 345 kV	3,575 1/	3,475 3/	--

Limiting Element		Rating (MW)	Limiting Outage
1/	Buxton-Scobie	1,260	Buxton-Deerfield
2/	Surowiec-Buxton	1,260	Main Yankee-Buxton
3/	Buxton-Deerfield	1,260	Buxton-Scobie

* Yarmouth No. 4 @ 210 MW, Yarmouth No. 3 @ 120 MW
** Yarmouth No. 4 @ 600 MW, Yarmouth No. 3 @ 0 MW

Notes: 1. Generation scheduled at Dickey: 1,311 MW
2. 90 percent -- Heavy load level; 60 percent -- Intermediate load level

Table A-10

Dickey-Lincoln School Transmission System Planning Study

Stability Summary -- 90 Percent Load

(1,311 MW @ Dickey)

Case No.	Description	Braking Resistor @ Dickey Size	On (cy.)	Off (cy.)	Result
Plan A	(Eastern AC Plan #1)				
90-19-1	3Ø Buxton on Deerfield	None	--	--	Unstable 1/
90-19-2R	3Ø Buxton on Deerfield	900	6	12	Stable
90-19-2R2	3Ø Buxton on Deerfield	900	6	36	Stable
90-19-3	3Ø Chester on Sugarbrook	None	--	--	Unstable 2/
90-19-5	3Ø Dickey on Midpoint	900	6	36	Unstable
90-19-5R	3Ø Dickey on Midpoint	900	6	12	Unstable
90-19-5R5	3Ø Dickey on Midpoint	900	6	25	Stable
90-19-6	3Ø Dickey on Midpoint	600	8	--	Machines Did Not Turn Around
90-19-7	3Ø Dickey on Midpoint	800	8	--	Machines Did Not Turn Around
Plan B	(Eastern AC Plan #2)				
90-21-1	3Ø Buxton on Deerfield	None	--	--	Unstable 3/
90-21-2R	3Ø Dickey on Midpoint	900	6	22	Unstable
90-21-2R2	3Ø Dickey on Midpoint	900	6	25	Stable
90-21-3	3Ø Chester on Sugarbrook	900	8	17	Stable
Plan D	(Western AC Plan #1)				
90-22A-1	3Ø Dickey on Midpoint	900	6	36	Stable
90-22A-2	3Ø Beebe on Webster	900	6	36	Unstable
90-22A-2R	3Ø Beebe on Webster	900	6	12	Stable
90-22A-3R3	3Ø Comerford on Beebe	900	8	18	Stable

1/ For remote faults system response was little different with a 6 or 8-cycle brake application time.

2/ The results of Case 90-21-3 indicate that this case can be made stable.

3/ This fault could be made stable using the same measures as in Plan A.

Table A-11

Dickey-Lincoln School Transmission System Planning Study

Stability Summary -- 60 Percent Load

(1,311 MW @ Dickey)

Case No.	Description	Braking Resistor @ Dickey			Result
		Size	On (cy.)	Off (cy.)	
Plan A	(Eastern AC Plan #1)				
60-7-2	3Ø Chester on Sugarbrook	900	8	20	Stable
Plan B	(Eastern AC Plan #2)				
60-9-1	3Ø Dickey on Midpoint	None	--	--	Unstable
60-9-1B	3Ø Dickey on Midpoint	900	6	26	Stable
60-9-2	3Ø Buxton on Deerfield	None	--	--	Unstable
60-9-2B	3Ø Buxton on Deerfield	900	8	17	Unstable
60-9-2BR	3Ø Buxton on Deerfield	900	8	25	Unstable
60-9-2B2R	3Ø Buxton on Deerfield	900	8	36	Unstable
60-9-5	3Ø Buxton on Deerfield	900	8	14	Stable (Tripped 2 Units at 8 cycles)
60-9-3	3Ø Chester on Sugarbrook	None	--	--	Unstable
60-9-3A	3Ø Chester on Sugarbrook	900	8	16	Stable
Plan D	(Western AC Plan #1)				
60-13B-1	3Ø Dickey on Midpoint	900	6	27	Unstable
60-13B-1R	3Ø Dickey on Midpoint	900	6	27	Stable (Tripped 2 Units at 8 cycles)
60-13B-2	3Ø Comerford Transformer	900	8	19	Stable
60-13B-3	3Ø Beebe on Webster	900	8	15	Stable

Table A-12

Dickey-Lincoln School Transmission System Planning Study

Stability Summary -- 60 Percent Load (Stuck Breaker Tests)

(1,311 MW @ Dickey)

Case No.	Description	Braking Resistor @ Dickey (900 MW) On (cy.)	Off (cy.)	Result
Plan B	(Eastern AC #2)			
60-9-9	1Ø L-G, Buxton on Deerfield Delay Maine Yankee	8	12	Stable (Tripped 2 Units at 8 cycles)
60-9-7	1Ø L-G, Chester on Sugarbrook Delay Midpoint	8	18	Unstable
60-9-6	1Ø L-G, Sugarbrook on Winslow Delay Orrington	--	--	Stable (Brake Not actuated)
Plan D	(Western AC Plan #1)			
60-13B-4	1Ø L-G Comerford on Granite Delay Midpoint	8	20	Unstable 1/
60-13B-5	1Ø L-G, Beebe on Webster Delay Comerford	--	--	Stable (Brake Not actuated)

1/ The response of the Dickey-Lincoln School units in this case is similar to that of Case 60-13B-1 (Table A-10) which was made stable by dropping two units (Case 60-13B-1R). It is assumed that this case can also be made stable by dropping two units.

Note: Plan A cases were not run because previous cases indicated that fault conditions which could be made stable for Plan B would also be stable for Plan A.

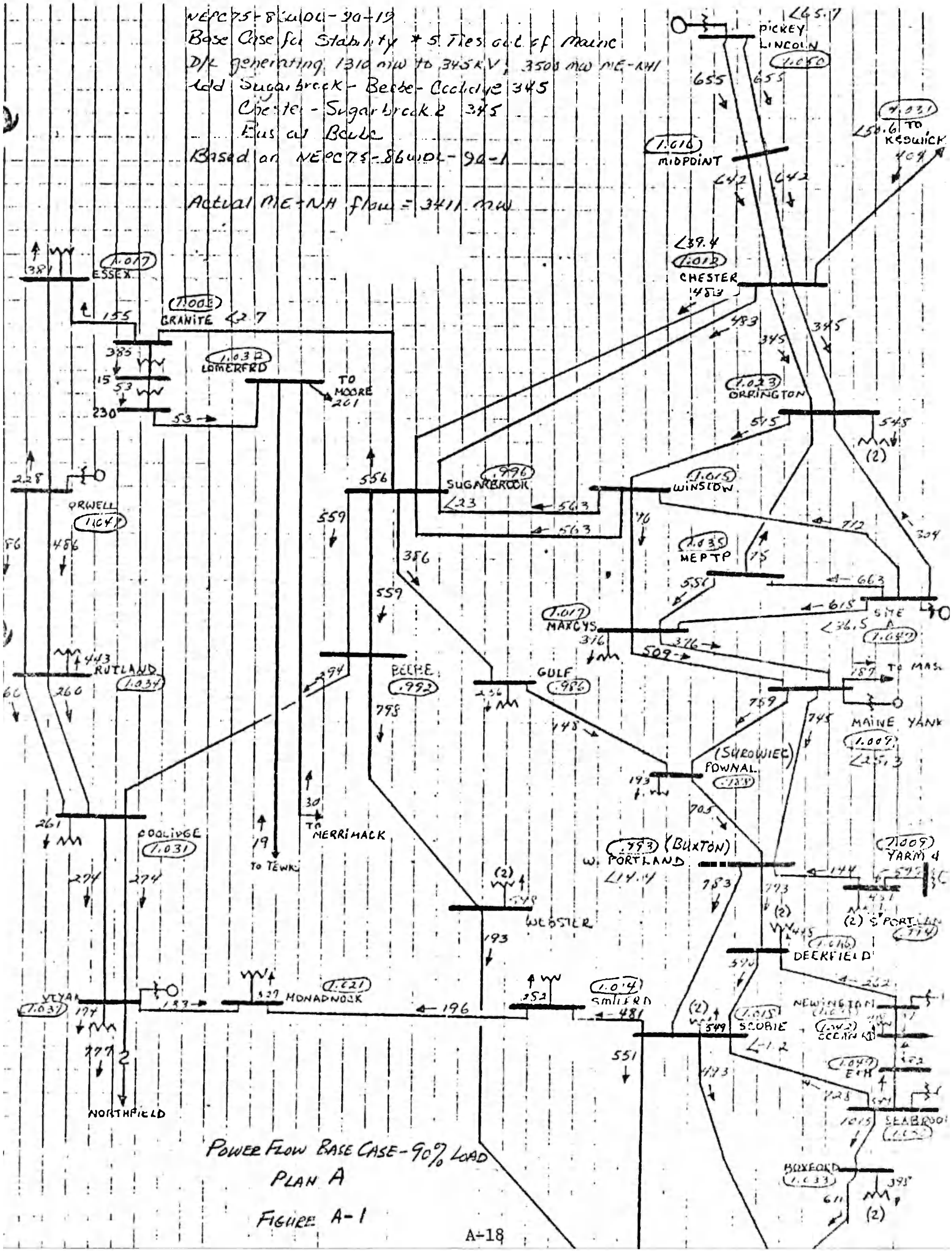
Table A-13

Dickey-Lincoln School Transmission System Planning Study

Transmission Line Right-of-Way Requirements

Construction	R/W Width (feet)	Acres/Mile
Federal		
345 kV ac Woodpole H-Frame	120	14.6
345 kV ac Woodpole H-Frame (2 lines in parallel)	220	26.7
345 kV ac Steel Double-Circuit	135	16.4
±400 kV dc Woodpole H-Frame	100	12.1
138 kV ac Woodpole H-Frame	100	12.1
Non-Federal		
345 kV ac Woodpole H-Frame	170	20.6
345 kV ac Woodpole H-Frame (2 lines in parallel)	300	36.4

Note: Non-Federal R/W widths include adjacent land containing danger trees which must be removed on an individual basis.

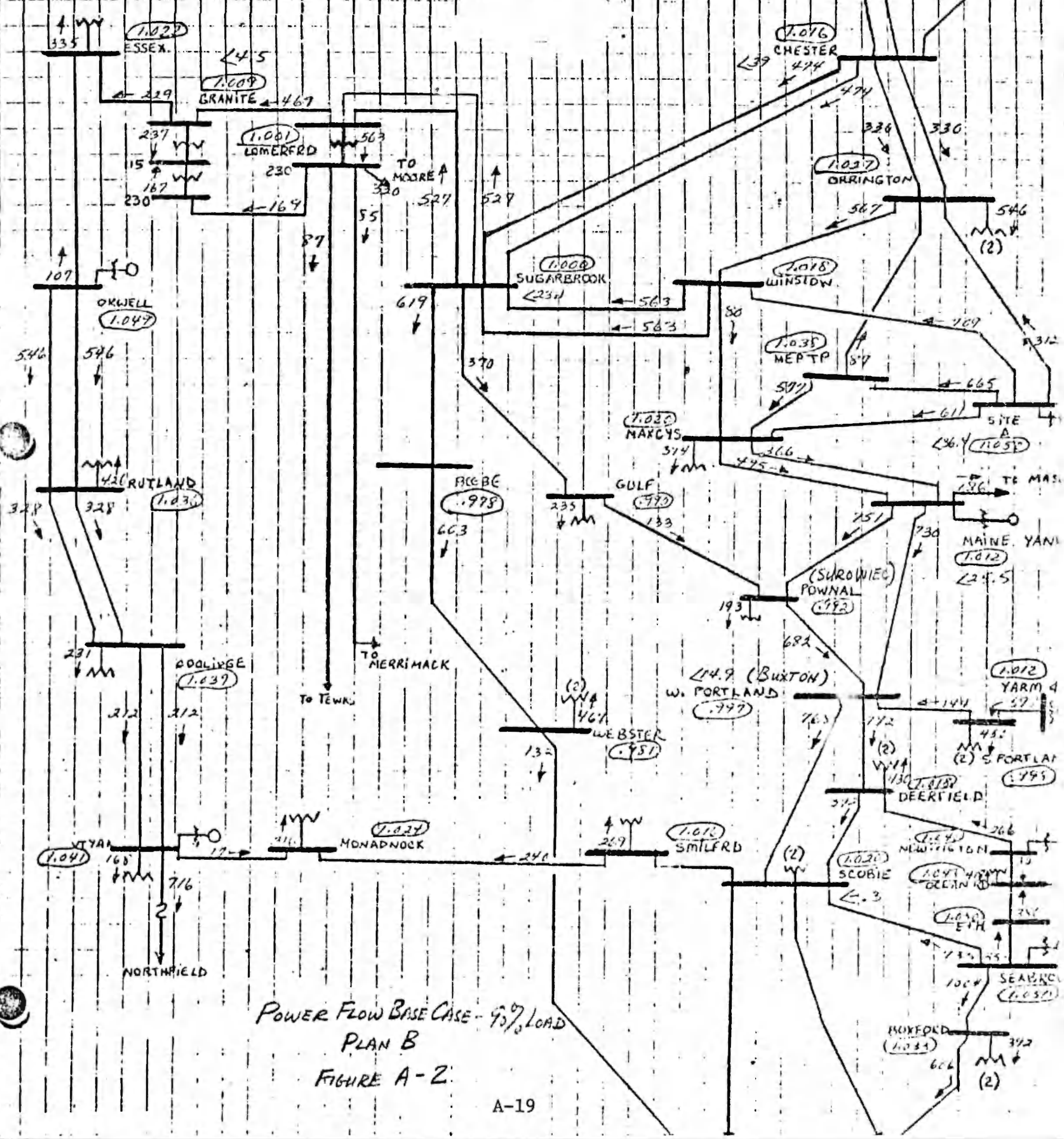


Power Flow Base Case - 90% Load

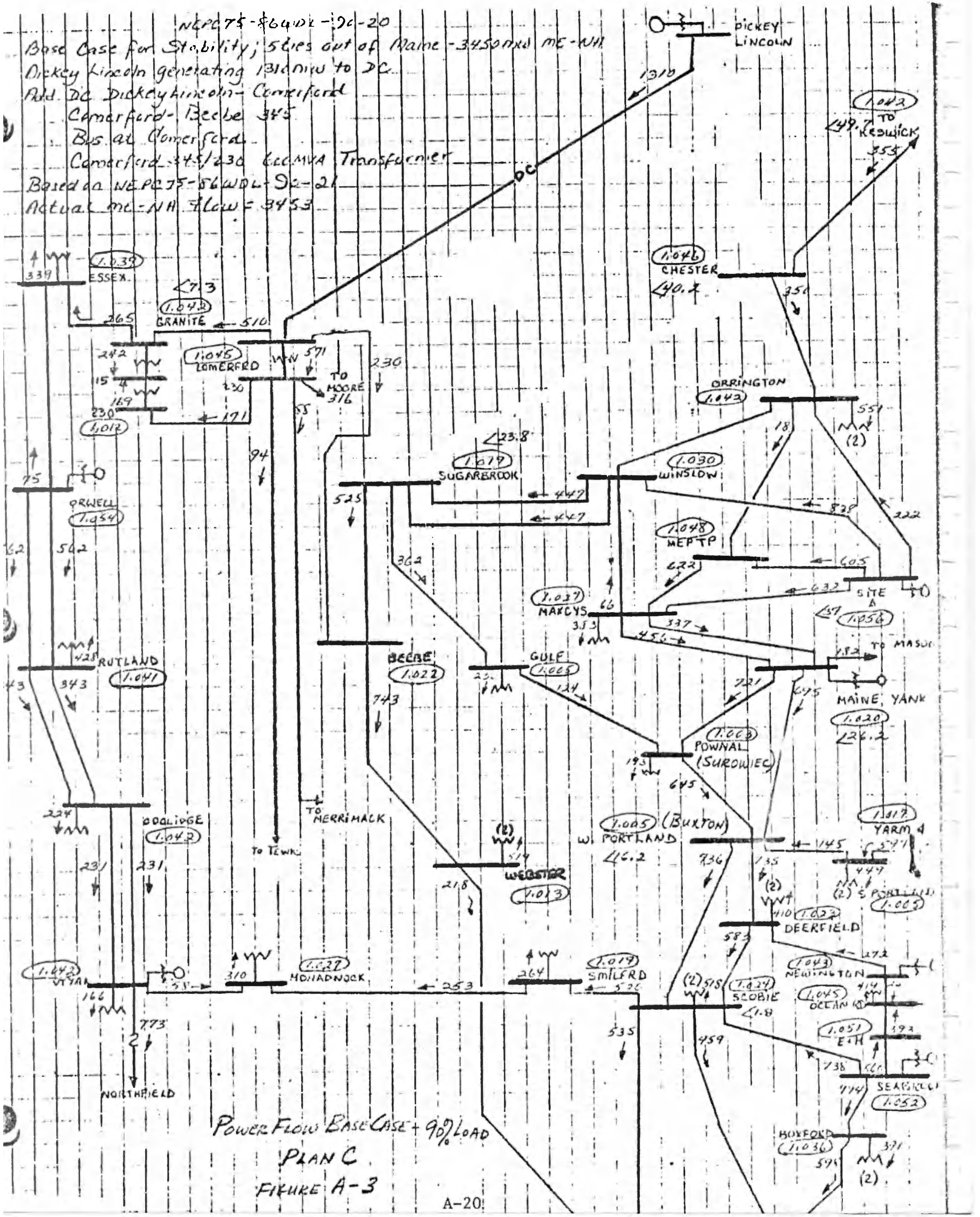
Plan A

Figure A-1

NEPC75-86WDL-DO-2.1
Base Case for Stability + 5 Ties out of Maine + 3455 MW ME-NH
Dickey Lincoln generating 1310 MW to 345 KV
Add: Sugarbrook-Comerford 345 #2
Bus at Beebe + Comerford
Comerford 345/230 Transformer
Full New York, New Brunswick and World Representations
Based on NEPC75-86WDL-DO-1
Actual ME-NH Flow = 3368 MW



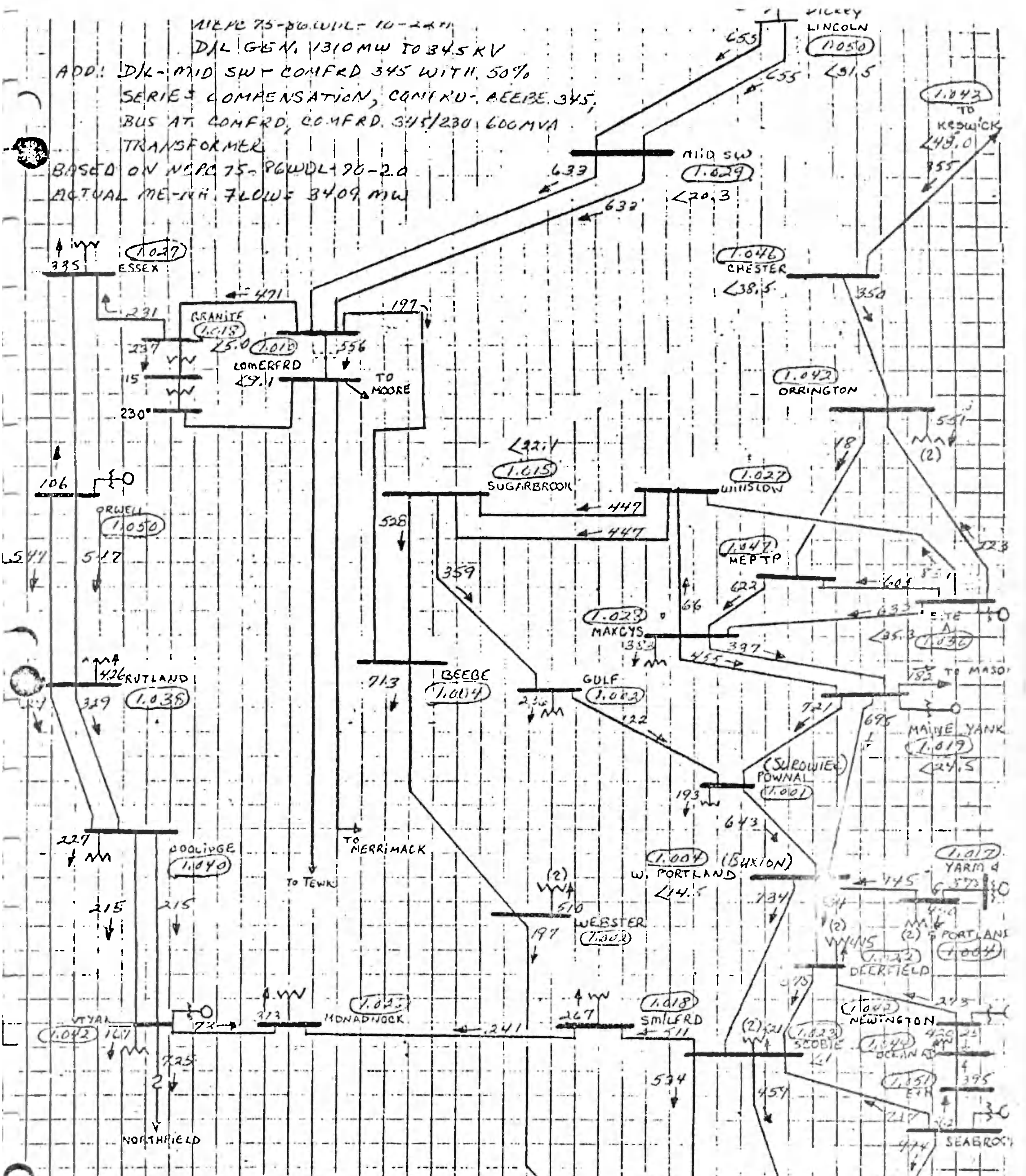
POWER FLOW BASE CASE - 95% LOAD
PLAN B
FIGURE A-2



POWER FLOW BASE CASE + 90% LOAD

PLAN C

FIGURE A-3

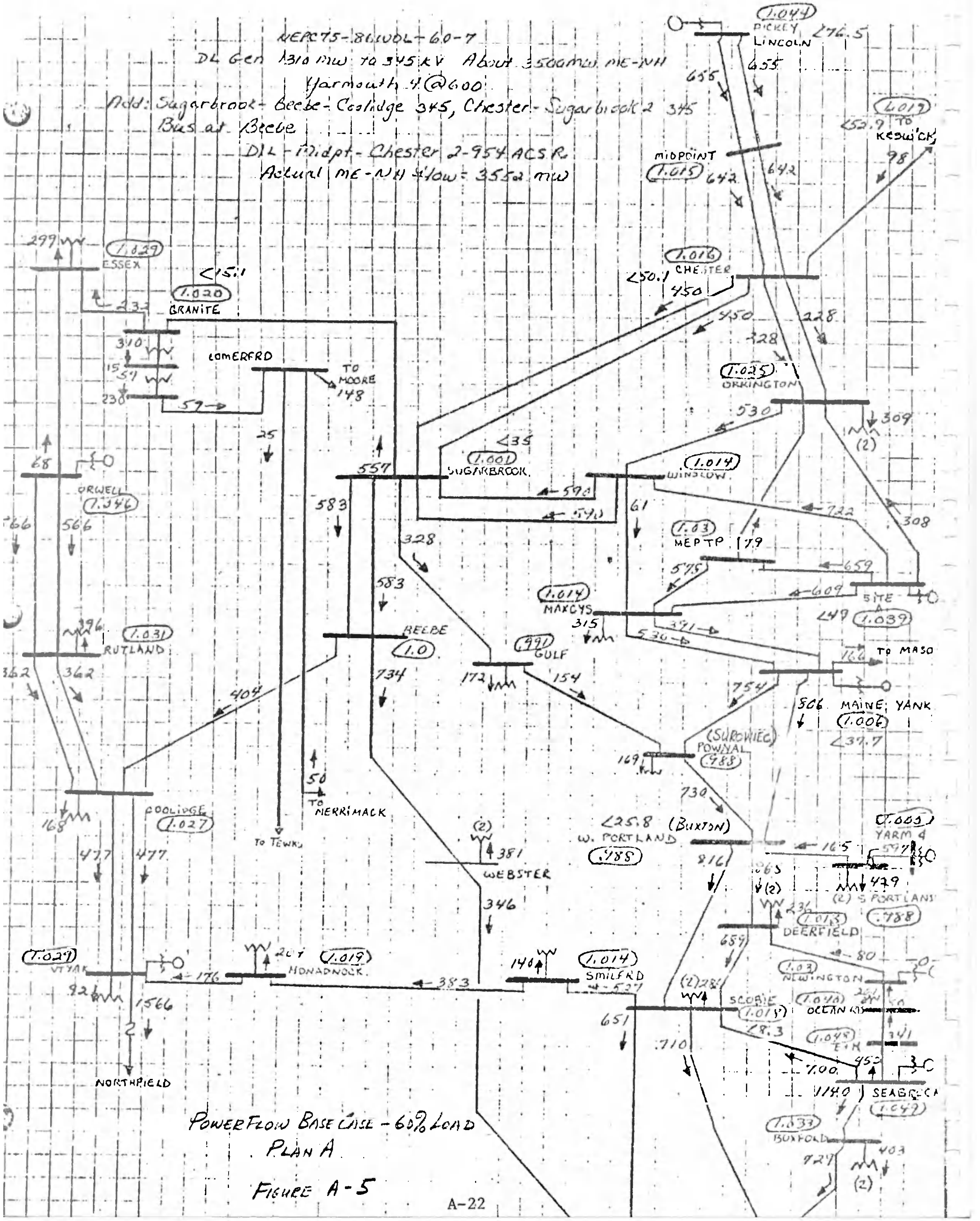


Power Flow Base Case - 90% Load

Plan D

Figure A-4

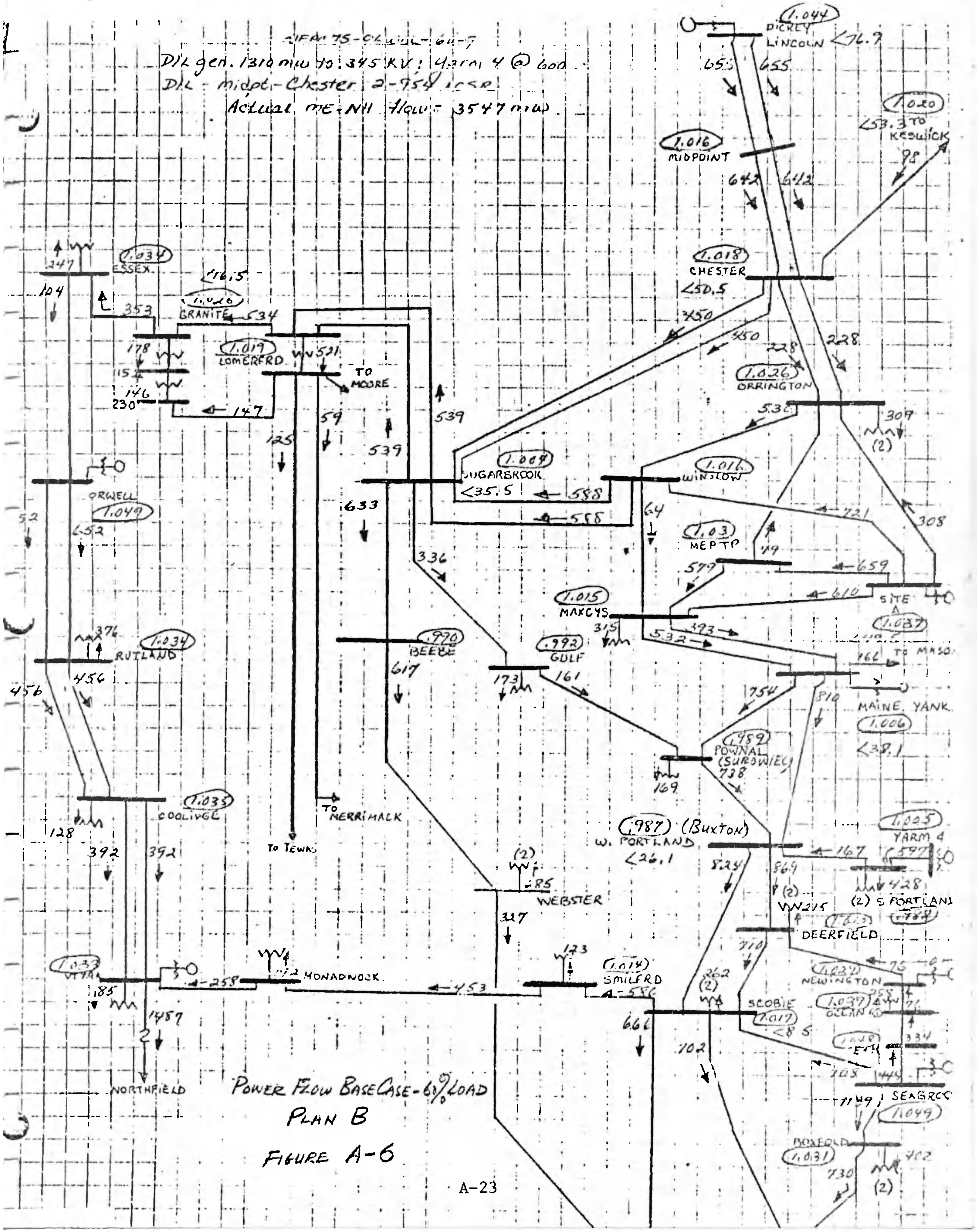
Note: Powerflows Should Be Similar For Plan E



POWERFLOW BASE CASE – 60% LOAD

PLAN A

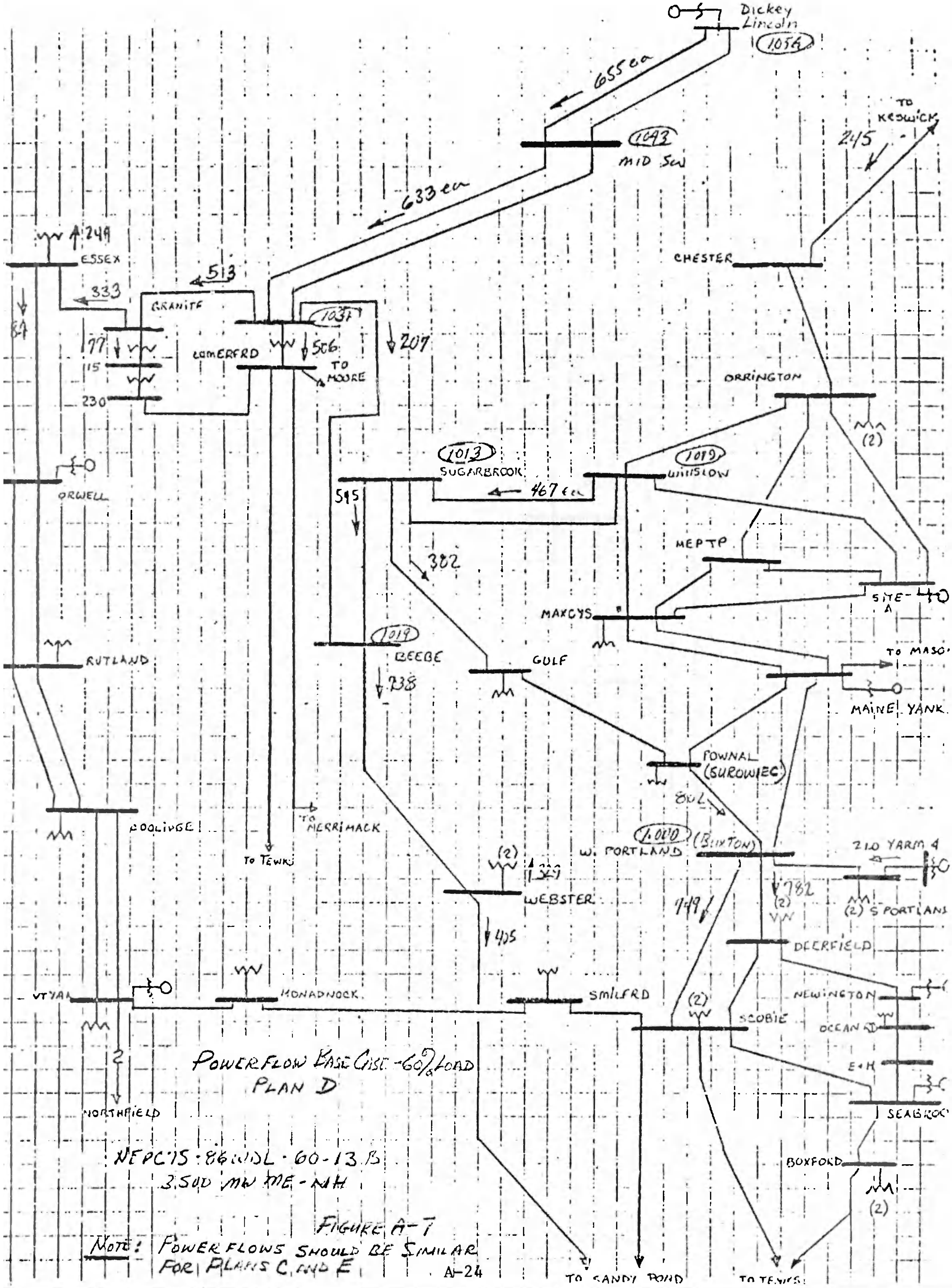
FIGURE A-5



POWER FLOW BASECASE - 60% LOAD

PLAN B

FIGURE A-6



POWERFLOW BASE CASE - 60% LOAD
PLAN D

NEPC75-86WDL-60-13B
3,500 MW ME-NH

FIGURE A-7

NOTE: POWER FLOWS SHOULD BE SIMILAR FOR PLANS C AND E

PRELIMINARY SWITCHING DIAGRAM

1986 DICKEY LINCOLN STUDY

PLAN A

(EASTERN AC PLAN NO. 1)

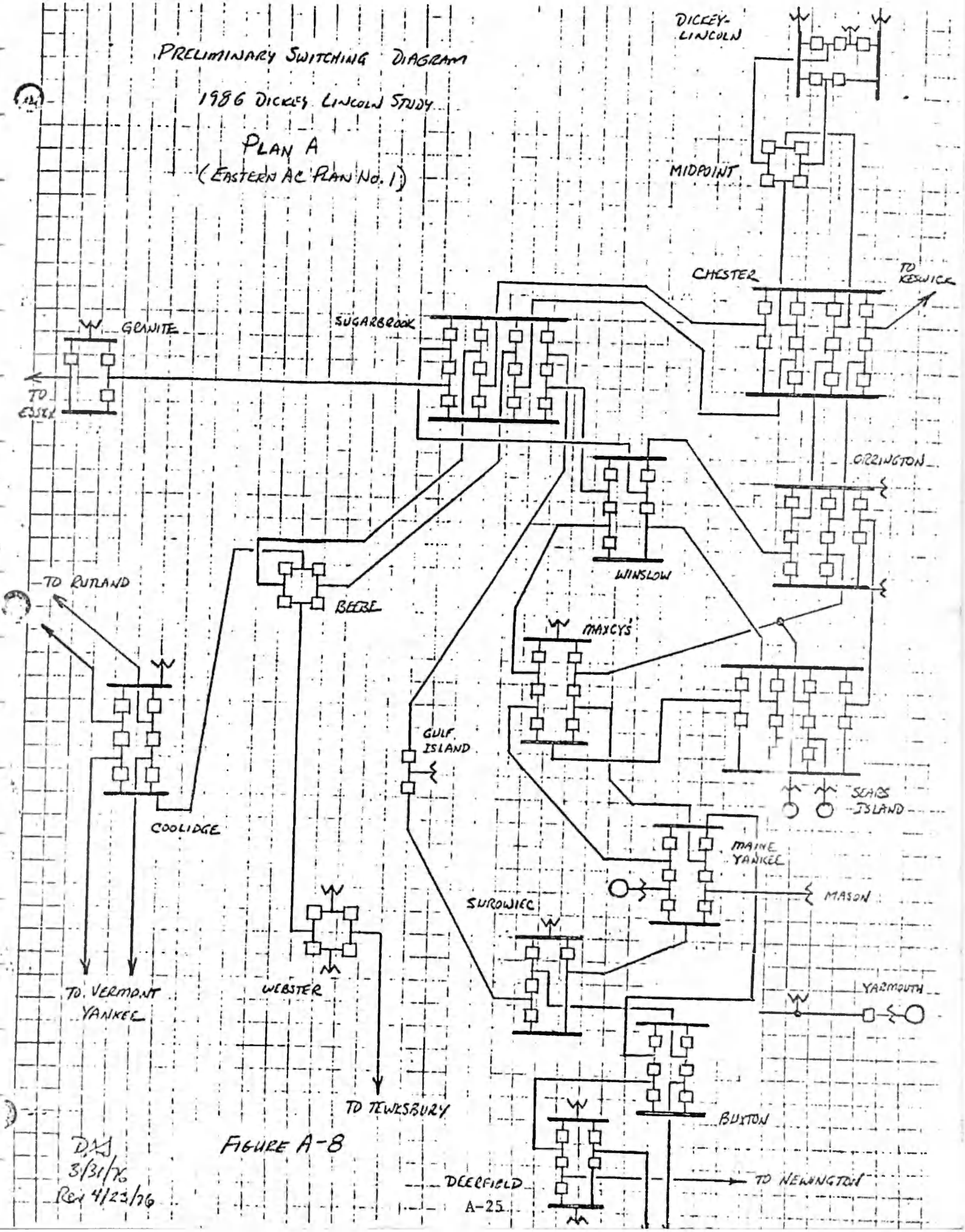


FIGURE A-8

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PRELIMINARY SWITCHING DIAGRAM

1986 DICKEY LINCOLN STUDY

PLAN B

(EASTERN AC PLAN No. 2)

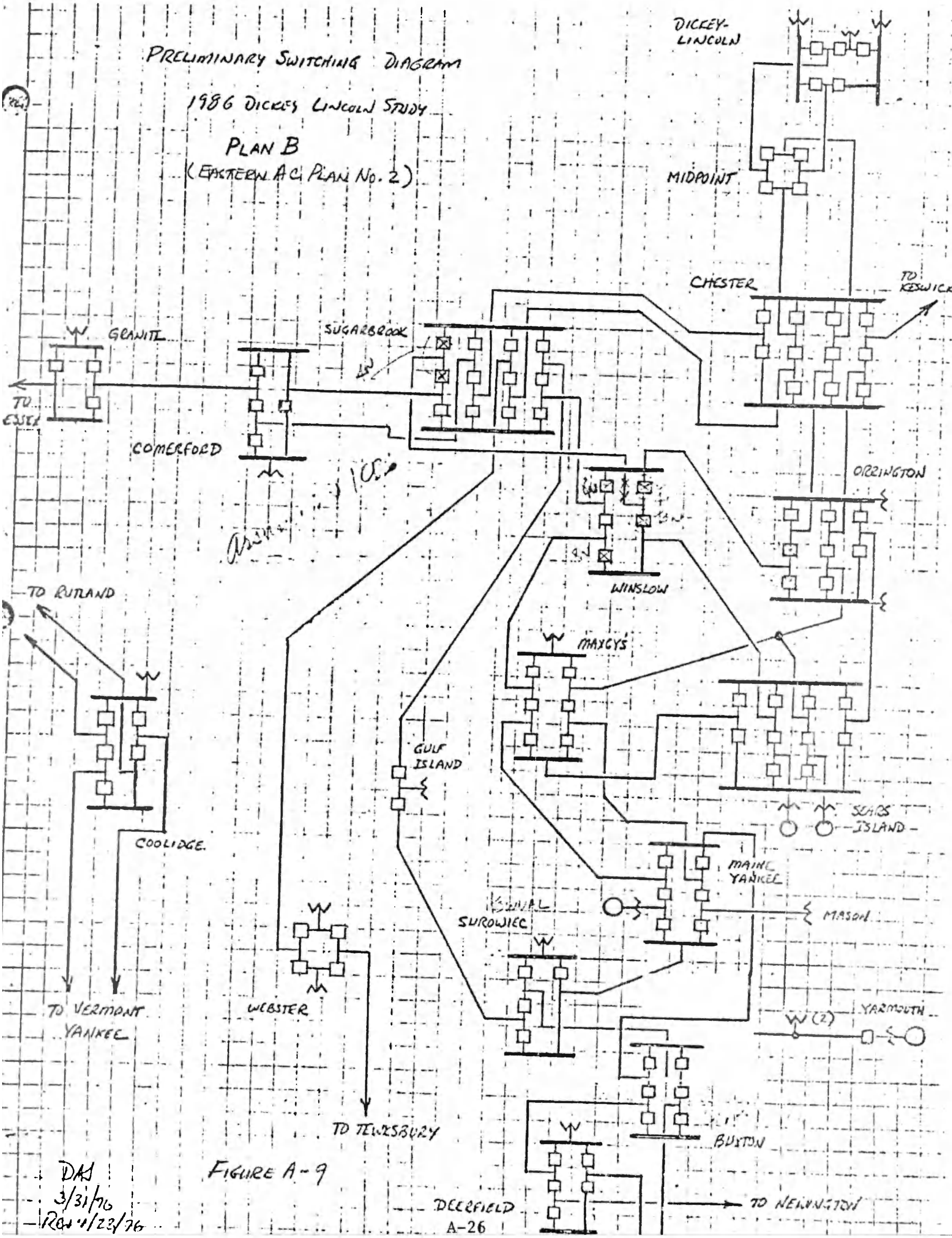

FIGURE A-9

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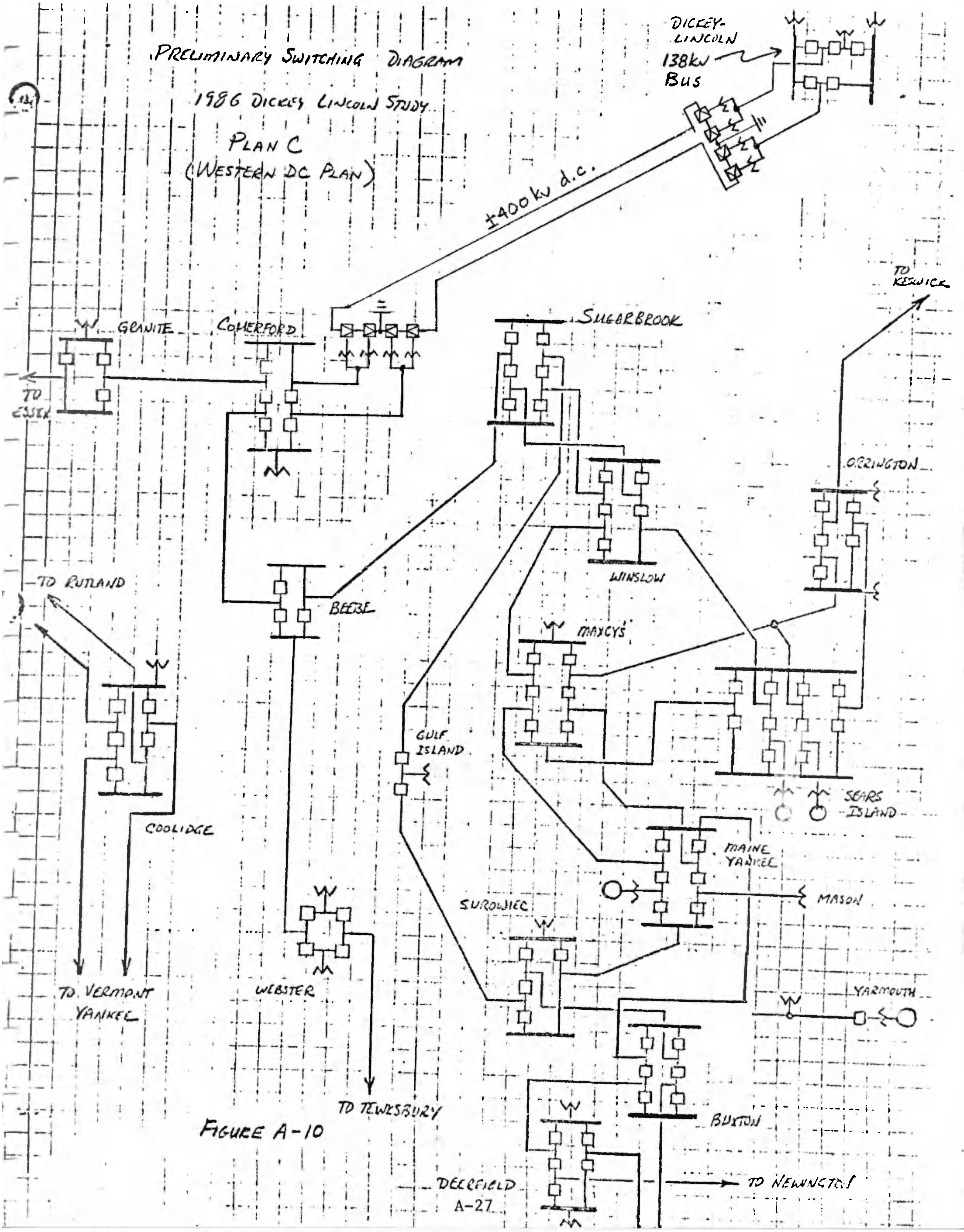
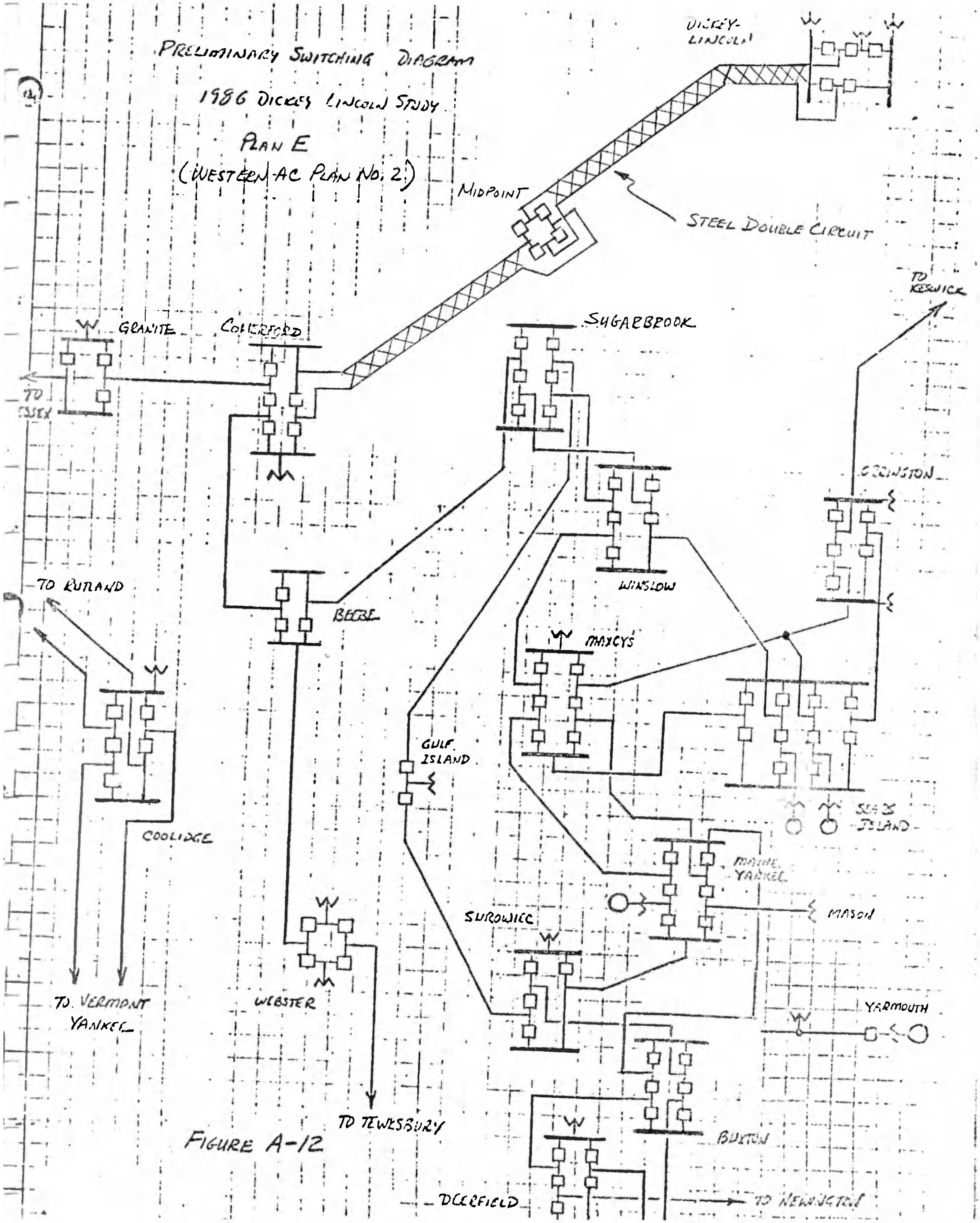
Rev 4/23/76



PRELIMINARY SWITCHING DIAGRAM
1986 DICKEY LINCOLN STUDY
PLAN C
(WESTERN DC PLAN)
DICKEY-LINCOLN
138kV BUS
±400kV d.c.
GRANITE
COMERFORD
SUGARBROOK
TO KESWICK
TO ESSEX
ORRINGTON
WINSLOW
TO RUTLAND
BEEBE
MAXCYS
GULF ISLAND
SEARS ISLAND
COOLIDGE
MAINE YANKEE
MASON
SUROWIEC
YARMOUTH
TO VERMONT YANKEE
WEBSTER
TO TEWKSBURY
BUXTON
DEERFIELD
TO NEWINGTON

FIGURE A-10



PRELIMINARY SWITCHING DIAGRAM
1986 DICKEY LINCOLN STUDY
PLAN E
(WESTERN AC PLAN NO. 2)
DICKEY-LINCOLN
MIDPOINT
STEEL DOUBLE CIRCUIT
TO KESWICK
GRANITE
COMERFORD
SUGARBROOK
TO ESSEX
ORRINGTON
WINSLOW
TO RUTLAND
BEEBE
MAXCYS
GULF ISLAND
SEARS ISLAND
COOLIDGE
MAINE YANKEE
MASON
SUROWIEC
TO VERMONT YANKEE
WEBSTER
YARMOUTH
TO TEWKSBURY
BUXTON
DEERFIELD
TO NEWINGTON

FIGURE A-12

APPENDIX B

GLOSSARY
(DEFINITIONS)

ANNUAL COST RATIO (ACR) - The ratio of annual cost over total investment for a project or a particular part of a project, usually expressed as a percent.

ALTERNATING CURRENT (AC) - An electric current that reverses its direction of flow at regular intervals and has alternately positive and negative values.

BRAKING RESISTOR - A massive electrical resistor used to stablize an electric power system by decreasing the amount of acceleration of generators that suddenly change speed due to a fault or a disturbance.

CAPACITY - The maximum load at which a machine, transmission line, station, or system is rated.

CIRCUIT - A system of conductors through which an electric current is intended to flow. Three conductors or three sets of conductors for a 3-phase circuit or two conductors or two sets of conductors for a high-voltage direct-current circuit.

CONDUCTORS - The metallic cables over which the electrical energy is transmitted on high-voltage lines.

CORRIDOR - A broad path identified during early stages of transmission line planning and environmental analysis within which a line could be located as a result of further evaluation.

DC TERMINAL - The assemblage of equipment used to convert alternating current to direct current or vice-versa in a power system.

DIRECT CURRENT (DC) - An unidirectional, practically non-pulsating current.

DISPATCHING - Monitoring and regulating of a power system, including the regulation of the loadings of generators.

DOUBLE-CIRCUIT TOWER - A tower able to support two circuits. All three phases of each circuit are usually located on one side of the tower.

ELECTRICAL LOSSES - Total power loss in an electric system consisting of transmission, transformation, and distribution losses between sources of supply and points of delivery.

ENERGY - The capability of doing work. In electrical power systems energy is expressed in kilowatthours.

FAULT - An unintentional short circuit in a power system due to a breakdown in insulation, causing abnormally large current flows. When the fault current flows into the earth, the fault is called a ground fault.

FIRM TRANSFER - The maximum amount of power that can be transferred from one area to another continuously, for an extended period of time.

GIGAWATT - One million kilowatts.

GIGAWATTHOURS (GWH) - One million kilowatthours.

INTEREST DURING CONSTRUCTION (IDC) - The interest charged to funds borrowed for the construction of new facilities throughout the construction period.

KILOVAR (KVAR) - 1,000 vars (reactive volt-amperes).

KILOVOLT (KV) - 1,000 volts.

KILOWATTHOUR (KWH) - The basic unit of electric energy equal to one kilowatt of power supplied to or taken from an electric circuit steadily for one hour.

LOAD - The amount of electric power delivered or required at any specified point or points on a system. Load originates primarily at the power-consuming equipment of the customers.

LOAD FLOW ANALYSIS STUDIES - High-speed simplified power flow studies designed to point out potential weak spots in the system under study.

LOAD FLOW STUDIES - See Power Flow Studies.

MEGAVAR (MVAR) - 1,000,000 vars; 1,000 kvar.

MEGAWATT (MW) - 1,000,000 watts; 1,000 kW.

MICROWAVE REPEATER STATION - A station in between terminals of a microwave system which receives a signal from a distant station, amplifies and re-transmits the signal to another distant station. Most repeaters do this in both directions simultaneously.

NAMEPLATE RATING - The full-load continuous rating of a generator and its prime mover or other electrical equipment under specified conditions as designated by the manufacturer. Nameplate rating is usually less than the demonstrated capability of the installed machine.

OVERLOAD RATING - The maximum load that a machine, apparatus or device can carry when operating beyond its normal rating, but within the limits of the manufacturer's guarantee.

PEAKING POWER PLANT - A plant which is normally operated to provide power during maximum load periods - daily, weekly or annually.

PEAK LOAD - The maximum electrical load consumed or produced in a stated period of time. It may be the maximum instantaneous load or the maximum average load within a designated interval of time, for example, the maximum average load for a period of 1 hour.

POWER CIRCUIT BREAKER (PCB) - A switching device that can interrupt a circuit in a power system under overload or fault (short circuit) conditions, usually automatically tripped by protective relays.

STABILITY - A description of the dynamic operating conditions of a power system. A power system consists of many generators which are connected together and to load centers by transmission lines. The amount of power that can be transferred from one machine to another following a disturbance such as a line fault is limited. When this limit is exceeded, the machines become unstable and may lose synchronism with each other. When this happens, relays operate to separate the generators not running in synchronization. Otherwise, the disturbance would move out over the system, somewhat like a storm moving outwards from its center, and result in cascading outages. Stability is therefore defined as that attribute of a system which enables it to develop restoring forces equal to or greater than the disturbing forces so as to maintain a state of equilibrium.

SUBSTATION - An electrical power station without generation which serves as a control and transfer point on an electrical transmission system.

TRANSFER CAPABILITY - The ability of an electrical system to move bulk power from one location to another.

TRANSFORMER - A device usually used to transform electrical energy from one voltage level to another.

TRANSMISSION - In power system usage, the bulk transport of electricity from large generation centers over significant distances, at relatively high voltages.

UNIT DROPPING (TRIPPING) - A scheme by which selected generating units are disconnected from a power system following a disturbance in order to improve system stability. The units may be resynchronized to the system and put back into service as the system stabilizes.

VAR (VOLT-AMPERE REACTIVE) - A unit of measurement for reactive power in a circuit.

VOLT - The unit of electromotive force or electric pressure (analogous to water pressure in pounds per square inch in a water system).

WATT - The electrical unit of power or rate of doing work. It is analogous to horsepower or footpounds per minute of mechanical power.

746 watts = one horsepower = 33,000 footpounds per minute

WHEELING - The transmission of large blocks of power over the transmission system of another utility. Wheeling permits better use of existing transmission facilities and avoids expensive duplication of transmission lines.

GLOSSARY
(ABBREVIATIONS)

A	ampere
ac	alternating current
ACR	annual cost ratio
CMP	Central Maine Power Company
D-L	Dickey-Lincoln School Lakes
dc	direct current
DOI	Department of the Interior
GWh	gigawatt-hour = 1 billion watt-hours
IDC	interest during construction
kcmil	1,000 circular mils
kV	kilovolt = 1,000 volts
kvar	kilovar = 1,000 vars
kW	kilowatt = 1,000 watts
kWh	kilowatt-hour = 1,000 watt-hours
MVAR	megavar = 1 million vars
MW	megawatt = 1 million watts
NEPEX	New England Power Exchange
NEPLAN	New England Power Planning
NEPOOL	New England Power Pool
PCB	power circuit breaker
PSNH	Public Service Company of New Hampshire
R/W	right-of-way
VHF	very high frequency
1Ø L-G	single-phase line-to-ground fault
3Ø	three-phase fault

APPENDIX C

REPORT

ON THE

PROPOSED

DICKEY-LINCOLN PROJECT

PART 1, GENERATION FEASIBILITY

PART 2, TRANSMISSION REQUIREMENTS

Submitted To

THE NEW ENGLAND PLANNING COMMITTEE

November 21, 1974

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PART I

DICKEY-LINCOLN GENERATION FEASIBILITY STUDY

PURPOSE:

The purpose of this part of the study is to assess the ability of the Dickey-Lincoln project to function effectively as additional peaking capacity to existing hydro and pump storage with respect to the New England load requirements forecasted for the mid-1980's.

SCOPE:

The study's scope includes an analysis of those weekly load shapes which vary significantly in order to ascertain that the project is checked against every load configuration that is known to exist. The Corps of Engineers' values for installed generating capacity, annual energy output, and reservoir storage capacity were adopted without further investigation as a basis for the study.

The analysis is directed to the peaking capacity of the project. The Lincoln component's output is a mixture of base load and peaking, but its operating hours are so much more than Dickey would run that the study has focused on the latter installation as the primary block functioning under the peak of the curve.

This investigation does not include any economic consideration of the project, nor does it recognize any impact accruing from energy benefits that may be forthcoming from downstream plants in Canada.

SUMMARY:

An analysis of historical loads for the period 1967-1972 resulted in the determination that there are four weekly load shapes that are representative of all load shapes that normally occur in the New England interconnected system. The model weekly shapes occur in December, April, August and October, so that an examination of the Dickey project's ability to function under each of these curves does, in fact, cover all the expected applications.

The philosophy adopted to the loading of generation under the curve is to dispatch all existing peaking hydro first. The pump storages are dispatched immediately under the hydro, and Dickey is assigned the load immediately below the pumpers. This approach tests Dickey's capability to benefit the existing system after deployment of the peaking capacity now available.

Under system peak loads such as represented by the model December week, the Dickey project is fully effective up to a minimum of 760 MW. In April its primary function may be spinning reserve with units on line at loads commensurate with minimum stream flow requirements. In August, Dickey would be dispatched to develop as much energy as possible without violating operating rules. It would be available to deliver full capability should sudden system loads materialize. The October load shape places Dickey in a capacity assignment of a similar nature to that occurring in April. Nevertheless, it is constantly available to deliver its installed capability at any time the dispatcher needs it.

CONCLUSIONS:

There is no question that the Dickey project capacity would be fully effective capacity to the interconnected New England system if it were dispatched in a peaking assignment during the 1985-86 power year.

The enormous storage reservoir makes it possible to use Dickey with maximum flexibility. It can run at full capacity whenever it is needed, and can sustain that power level for the duration of any peak that the system experiences. It makes an ideal source of reserve with quick response, a fact that is most valuable to have as an option open to those responsible for load dispatching.

Although the project does have constraints with respect to flow discharge, the Lincoln re-regulating facility would normally be able to absorb Dickey's full discharge (40,000 cfs) during peaks up to 8 hours in duration without spilling any water. This, of course, presupposes that the two facilities are on a coordinated operating pattern.

It is imperative that the Dickey-Lincoln operation be under the control of NEPEX dispatching, and it is only on that condition that the project can be assured benefit to NEPOOL participants and other electric utility entities within New England.

DESCRIPTION OF DICKEY-LINCOLN PROJECT:

The proposed project, located near the confluence of the St. John and the Allagash Rivers, consists of two separate generating and storage facilities. Dickey, the larger of the two, would be located on the St. John River just upstream from its juncture with the Allagash, while Lincoln Dam would be situated a few miles downstream of the junction. A general map of the project is included as Exhibit 10.

The capacity, annual output and storage capacity of each, as determined by the U. S. Corps of Engineers, is summarized as follows:

	Capacity[1] MW			Annual Energy GWH	Storage Acre-Ft.
	Max.	Avg.	Min.		
Dickey	875	817	760	871	2,800,000
Lincoln	80	75	70	383	24,000
Total	955	892	830	1154	

The storage capacity of Dickey is equivalent to 323 days at the average annual useable flow rate of 4370 cfs, as determined by the Corps of Engineers. Due to its large amount of storage, Dickey can be operated on virtually any annual release pattern which will satisfy river flow constraints. Accordingly, it has been determined that the operating philosophy of Dickey will be to maximize its releases during the high load periods of the year when its capacity and energy will be most beneficial, and to minimize its releases during low load periods when its spinning reserve potential will be most beneficial to the New England Pool.

Lincoln's principal function is to re-regulate the river by smoothing out the daily peaking releases from Dickey. The storage capacity of Lincoln is relatively small; in fact if both Dickey and Lincoln were operated wide open, the reservoir at Lincoln would fill from a maximum drawdown position in ten hours. With Lincoln shut down, the fill would take seven hours. If Dickey were shut down, the Lincoln reservoir would sustain full load for 22 hours. However, since it does have some storage capacity, it could be used for limited peaking.

1. The maximum, average and minimum capacities correspond to the varying head conditions due to reservoir fluctuation.

Certain restrictions on the releases from Dickey and upon the flow in the St. John have been specified by the Corps of Engineers. With respect to Dickey releases, the Corps has recommended the following operating rules:

1. Average monthly discharge is not to exceed 2500 cfs during storage refill season of April and May, except when the reservoir is full.

2. Average monthly discharge will not be less than 2500 cfs at all times other than April and May.

Both of these constraints have been incorporated into this study, together with the requirement that the flow in the St. John River downstream from Lincoln never go below 2600 cfs to recognize the minimum flow contribution of the Allagash.

It has been assumed that a 10 to 11 year lead time is necessary to fulfill all regulatory and environmental requirements and construct the project. In accordance with that assumption the analysis is made on the basis of testing the project in the 1985-86 power year. So long as the load shape remains substantially the same, it is evident that Dickey-Lincoln will be of increasing benefit to the system in subsequent years.

<u>METHODOLOGY AND APPROACH:</u>

The approach used herein estimates the expected hourly operation of Dickey-Lincoln. For the purposes of the operational analysis it was determined that the typical weekly load shapes of the four months December, April, August and October are representative of all possible load shapes during the power year 1985-86. The corresponding curves were constructed from 1968 per unitized daily load data. As shown in

Exhibit 1 the annual load duration curves for 1967 and 1969-72 were compared to the 1968 load duration curve to test for consistency. The four model months were compared to the remaining eight months as shown in Exhibits 2 through 5 in order to be sure that the shapes of one or more of the four model months are of a similar configuration to each of the remaining eight months.

Since Dickey-Lincoln is essentially a peaking facility, only the peak portion of the load curve and the existing peaking hydro units were included in the operational analysis. In general, the available energy for the hydro units was allocated equally among the weekdays and dispatched hourly by the Firm Hydro Program. If it was necessary to use the extra water to meet extraordinary load conditions, the energy deficit caused by this was assumed to be made up as soon as possible.

In loading the curve, the existing conventional hydro units were dispatched first. The data describing their weekly capacity and energy availabilities was taken from NEPLAN GTF production cost data. The data for the individual units was combined to form three equivalent units operating up to 40 hrs., 40 to 80 hrs. and 80 to 120 hrs. respectively. Any unit with over 120 hours of weekly operation was assumed to be base loaded and therefore not included in the analysis.

Next, the existing pumped storage units, Bear Swamp and Northfield Mountain, were loaded onto the four curves. It is recognized that under economic dispatch Dickey would be loaded above the two pumpers on the load curve. However, it was decided that since economics were not in the scope of the study, the existing pumped storage units would be loaded in their current positions. This approach shows what Dickey will add to the existing system. Bear Swamp was loaded first since its pond is the smallest. It was included at 600 MW with 3000 MWH of generation per day. Northfield Mountain was included next at 1000 MW and 6500 MWH per day. It was assumed that the pumpers' head ponds were full at 8:00 AM Monday morning.

It was deemed prudent to make certain that the analysis should reflect, insofar as possible, those factors which are of concern in the operation and dispatch of the New England Pool. Accordingly, the problem was reviewed with NEPEX's director, Harry Mochon, to insure that recognition was taken of the Pool's needs during the different seasons of the year. This interface provided an insight of the periodic requirements for spinning reserve, of reduced as well as maximum output requirements, and of seasonal differences often dictated by the maintenance program. The outgrowth of coordinating the operating and planning points of view resulted in a set of assumed ground rules which are as follows:

1. Operate Dickey to maintain an average monthly discharge corresponding to the minimum flow of 2500 cfs during the months of April and May. New England's heavy maintenance during this period and the fact that most of the hydro units are operating wide open under high spring runoff conditions, makes the reserve capacity of Dickey most attractive. At the same time, the system energy requirement is down so allocation of the Dickey energy into heavier load periods is advantageous. This is consistent with the present operation of existing hydro units which have sufficient storage such as Harris, Moore and Comerford Stations.

2. Operate Dickey to maintain an average monthly release of 3500 cfs during the month of October. This again reflects another period of high maintenance in New England when the ability to carry reserve at Dickey is most valuable. However, the system's energy requirement is greater than in April and May; hence the cutback to 3500 cfs instead of its minimum release rate helps to support that need.

3. The remaining annual energy will be spread equally among the remaining nine months of the year.

4. The dispatch of Dickey will be based on spreading the energy available for the period being considered equally among each of the five weekdays. However, Dickey's energy will be used beyond the daily average allocation to meet load during exceptional peak periods. The extra energy used during those periods will be made up by correction of subsequent dispatches later in the week or during the next week.

Based on the above assumptions, Dickey was first dispatched using the Firm Hydro Program to determine how it would operate assuming perfect foresight. Next, the load shape was reviewed in order to determine any exceptional peaks. At any point when such a peak occurred, Dickey's full spinning reserve capability was dispatched to help meet the unexpected load. For example, referring to Exhibit 8 , in August's Wednesday peak Dickey is peaking to its full capacity at the time of the two spikes and backing off as the load drops. The remaining portion of the week's energy allocation is split between Thursday and Friday. However, extra energy was again used on Friday to meet another abnormal peak. Compensation for use of extra water will be made in the following week.

Before dispatching Lincoln, the amount of energy available was determined by combining the daily releases from Dickey with the inflow from the Allagash. Due to the 2600 cfs minimum flow constraint, 13.3 MW of its capacity is base loaded. The remainder of its available energy was considered peaking energy and divided equally among the weekdays and dispatched hourly by the Firm Hydro Program.

RESULTS:

The hourly operation of Dickey for the four model weeks is shown in Exhibits 6 through 9 and summarized in Table 1. Due to its small capacity and long hours, Lincoln was not included in the four load curves. However, its hourly operation is summarized in Table 2.

During December, Dickey operated a total of 50 hours a week. Its full capacity was utilized two to three hours each weekday. Dickey's output was significantly reduced during April in order to make available its spinning reserve. In fact, Dickey was used beyond its scheduled output for two hours Monday morning to meet the peak. However, it did not reach its maximum capability at any other time during the week. In August, its full capacity was used for two hours on Wednesday and two hours on Friday to help meet the unexpected peaks. The remainder of its available energy was spread over 44 hours for an average output of 424 MW. In October, Dickey's energy output was again decreased so that on the average it operated 65 hours at 206 MW. However, again its spinning reserve capability was taken advantage of. On Friday it was operated three hours at a capacity above that which was anticipated, and during one of those hours it was operated at full capacity.

These examples demonstrate the ability of the project to be dispatched with great flexibility. The enormous storage makes almost any variation in load assignment possible with the sole constraint being the discharge out of Lincoln.

Under emergency conditions Dickey could carry a full load up to nine hours per day for five consecutive days without overfilling Lincoln reservoir, provided it was at point of maximum drawdown at the start of the week and the releases were properly coordinated. Under extreme conditions, Dickey could be operated for longer periods; however, some water would have to be sluiced.

TABLE 1

DICKEY
WEEKLY OPERATION SUMMARY

Month	Max.Peak Output MW	Hours Operating @ 817 MW	Total Operating Hours	Hourly[1] Average MW
December	817	11	50	373
April	817	2	52	184
August	817	4	44	424
October	817	1	65	206

TABLE 2

LINCOLN
WEEKLY OPERATION SUMMARY

	Max. Output MW	Min. Output MW	Hours/Wk.[2] Operating > 13.3 MW	Hours/Wk. Operating @ 75 MW
December	75	13.3	50	11
April	75	13.3	63	9
August	75	13.3	50	45
October	42	13.3	65	0

1. Total weekly energy divided by the number of operating hours.

2. 13.3 MW is considered the amount of base load capacity derived at Lincoln.

EXHIBIT 1

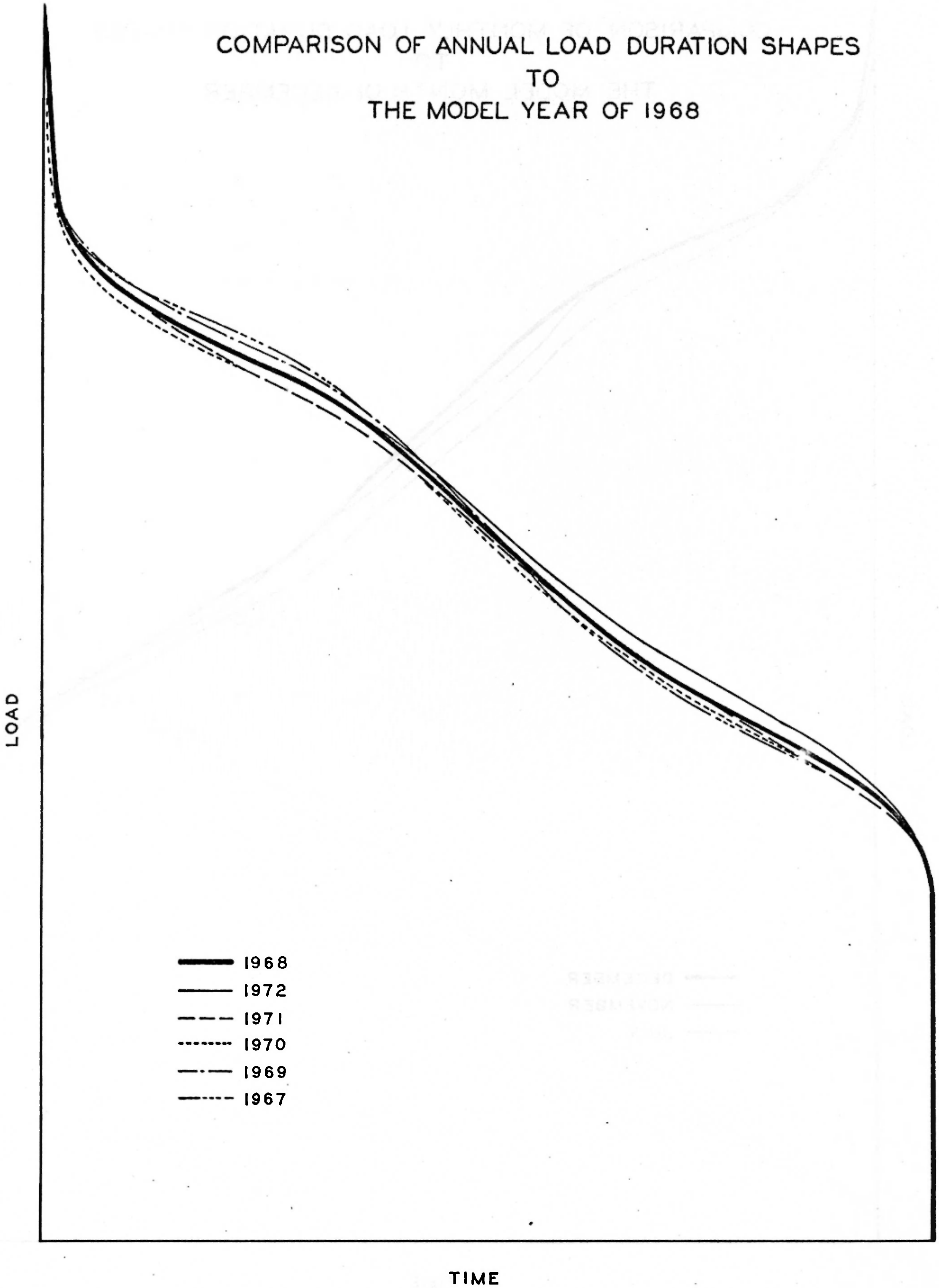
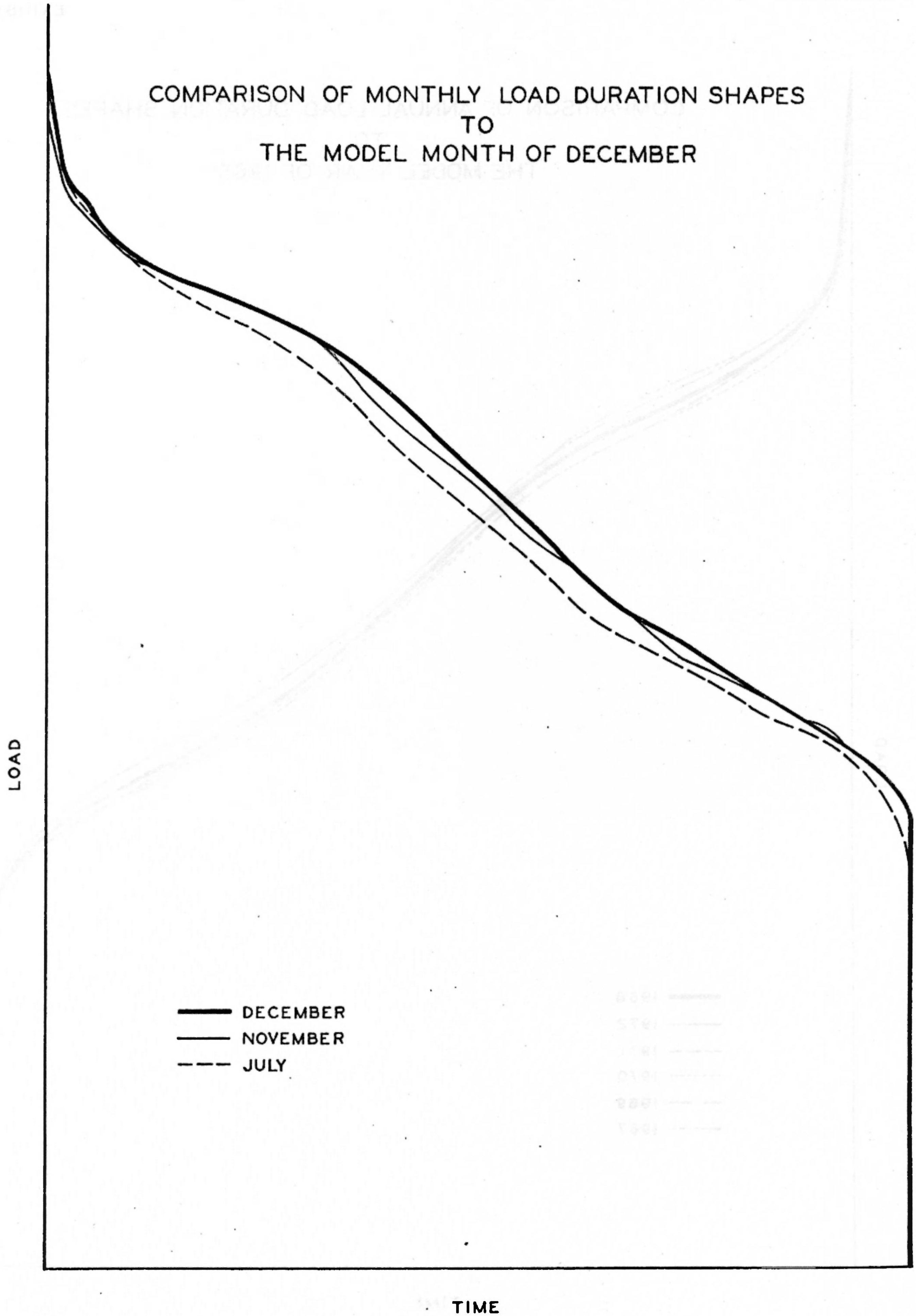

COMPARISON OF ANNUAL LOAD DURATION SHAPES
TO
THE MODEL YEAR OF 1968
LOAD
TIME
1968
1972
1971
1970
1969
1967

EXHIBIT 2


COMPARISON OF MONTHLY LOAD DURATION SHAPES
TO
THE MODEL MONTH OF DECEMBER
LOAD
TIME
DECEMBER
NOVEMBER
JULY

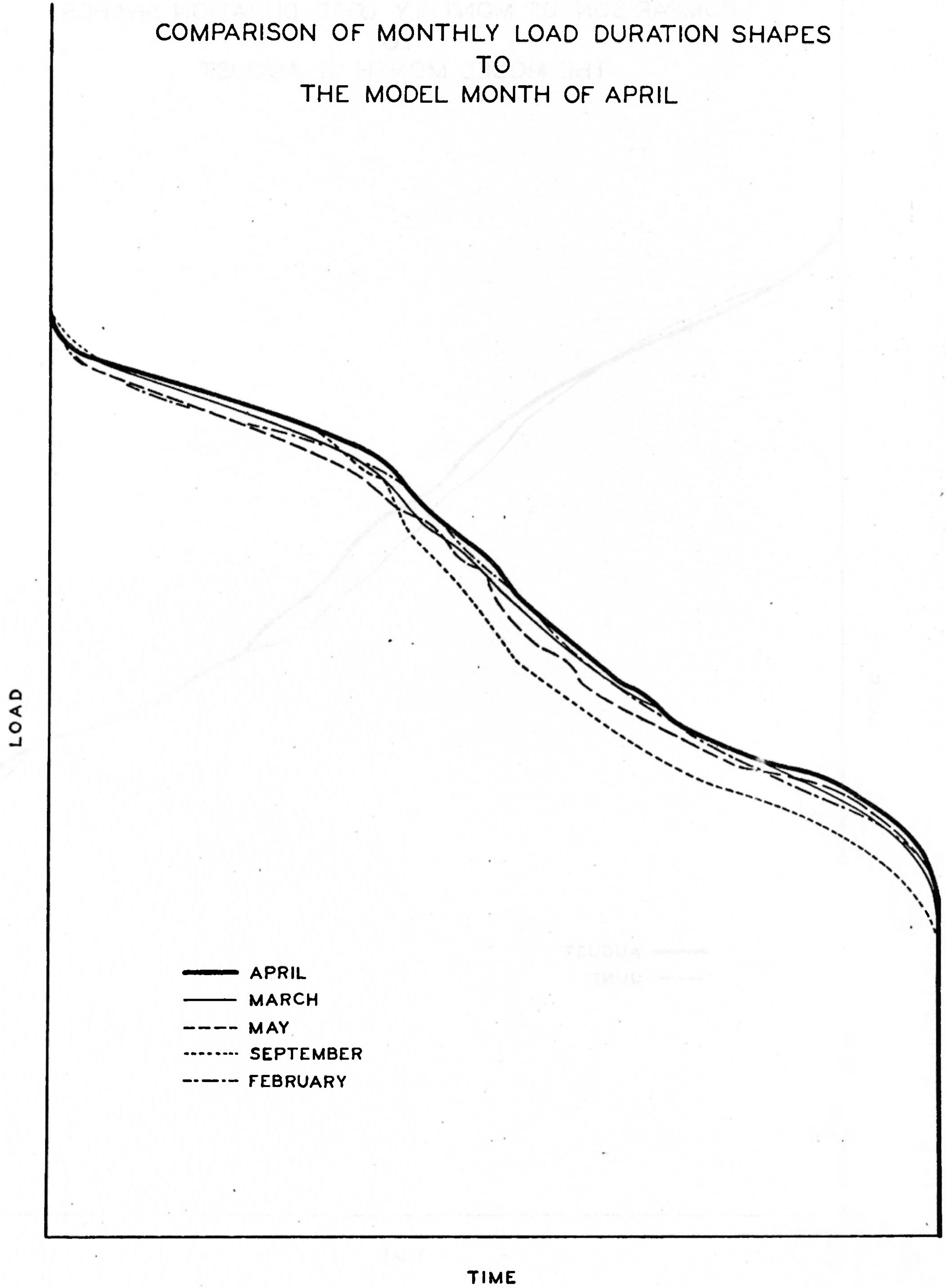
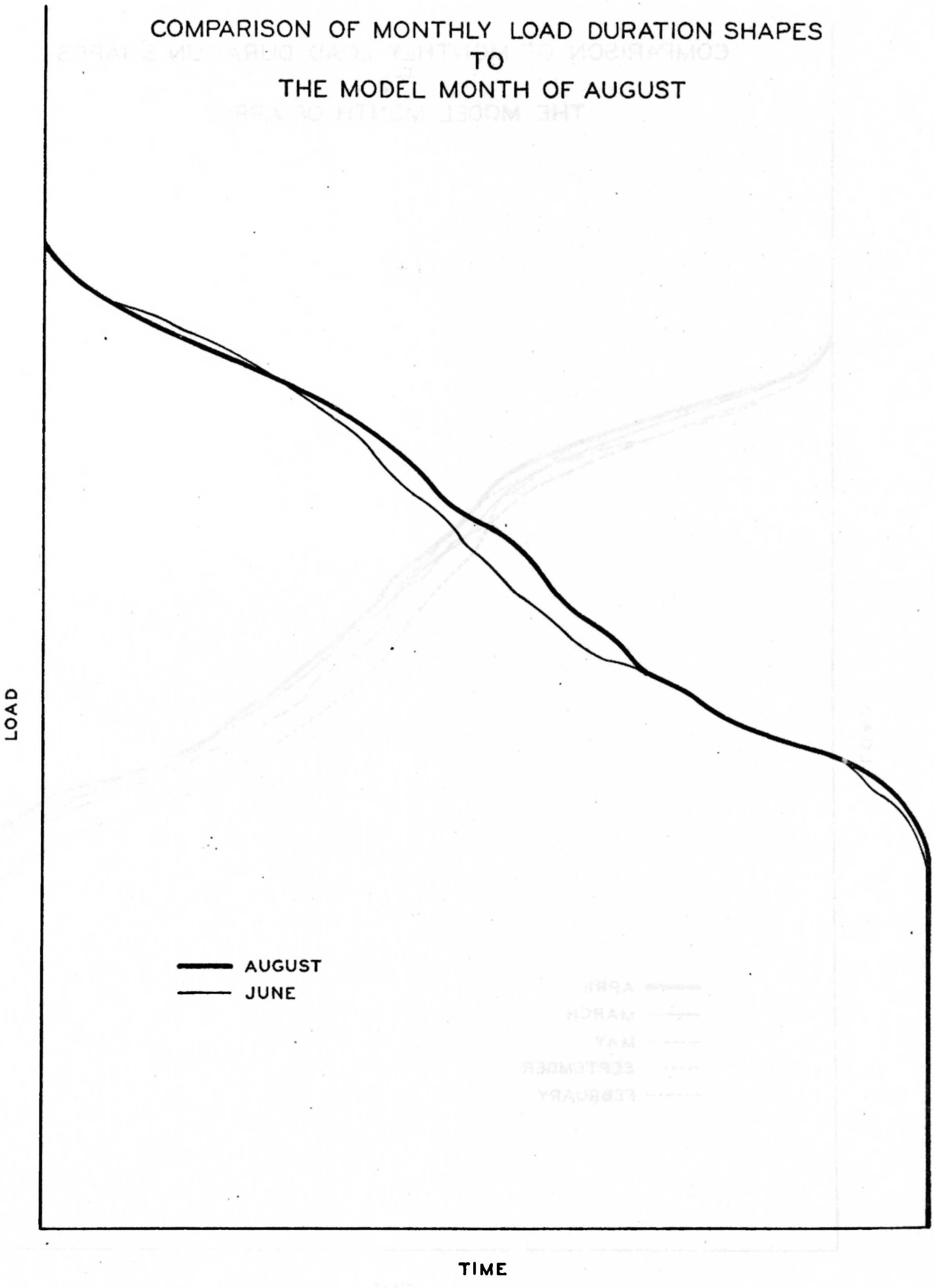
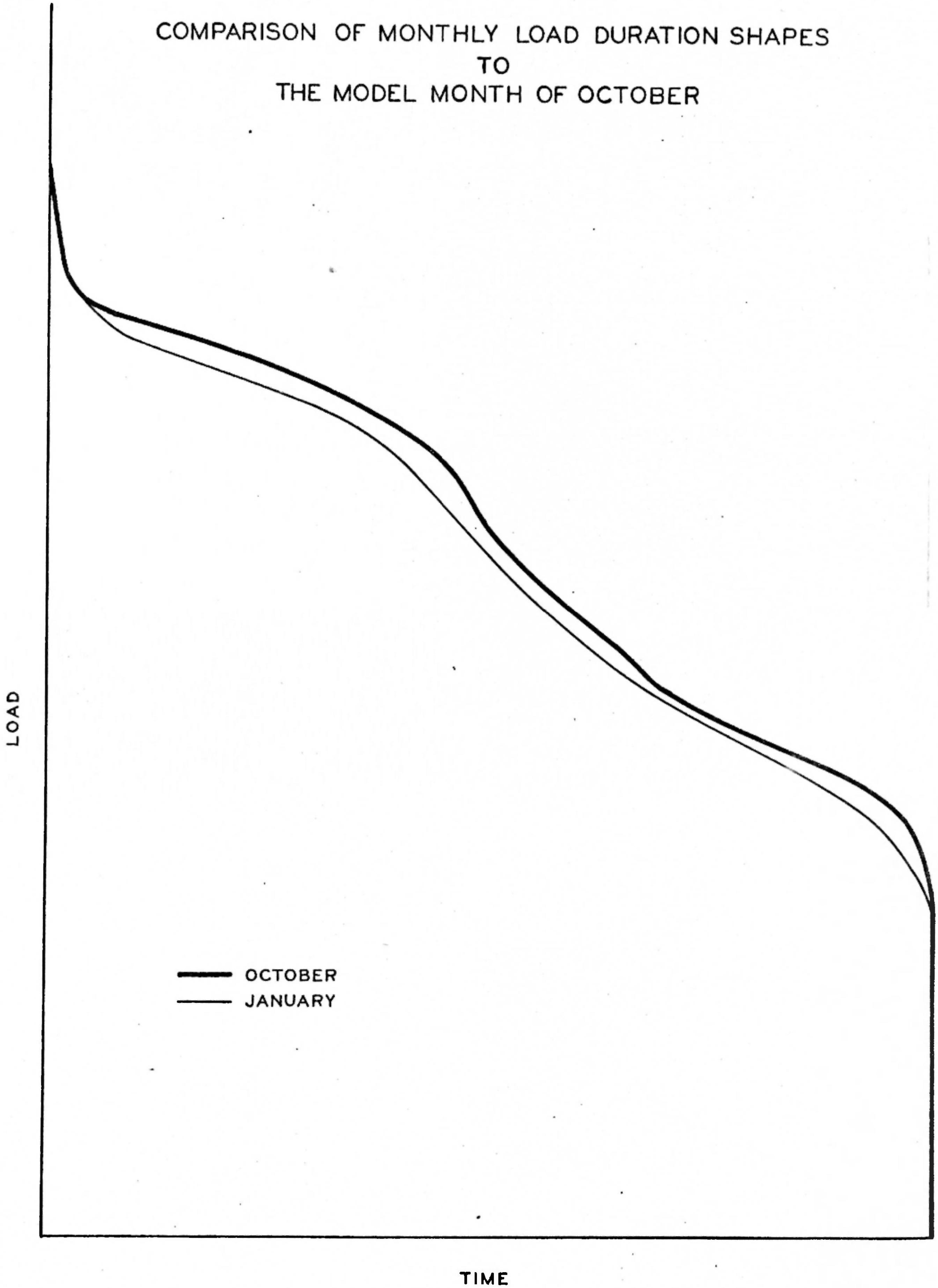

COMPARISON OF MONTHLY LOAD DURATION SHAPES
TO
THE MODEL MONTH OF APRIL
LOAD
TIME
APRIL
MARCH
MAY
SEPTEMBER
FEBRUARY

EXHIBIT 4


COMPARISON OF MONTHLY LOAD DURATION SHAPES
TO
THE MODEL MONTH OF AUGUST
LOAD
AUGUST
JUNE
TIME

COMPARISON OF MONTHLY LOAD DURATION SHAPES
TO
THE MODEL MONTH OF OCTOBER



PART 2

DICKEY-LINCOLN STUDY - TRANSMISSION REQUIREMENTS

PURPOSE:

The purpose of this part of the study is to determine the minimum transmission required to connect the Dickey-Lincoln hydro project to the New England grid.

SCOPE:

The study assumes the addition of 2-1150 MW nuclear units in southeastern Maine by 1986. Since the Dickey-Lincoln project is proposed for the same time period, its transmission requirements have been integrated with the tentative transmission facilities associated with the two nuclear units.

For the purposes of this study it was assumed that the power from the Lincoln School part of the project would be delivered to the local transmission system in the Fort Kent area, and since this is common to all transmission systems studied the cost is not included.

SUMMARY:

The transmission system that can effectively integrate the Dickey-Lincoln project into the New England grid as proposed for 1986 can be either an extension of the 345 KV grid as shown in Exhibit A or D.C. system as shown in Exhibit I.

The cost of either system will be about $110,000,000. This cost could be reduced to about $90,000,000 by using the 345 KV system as shown in Exhibit A but with a single compensated line between Dickey and Chester.

Future system developments may require a more expansive transmission system than either of the alternatives proposed: however it is felt that either the expanded 345 KV system or the D.C. system could be used to transmit Dickey-Lincoln power to the New England grid.

DISCUSSION:

Three different transmission systems for the proposed Maine Nuclear Units and the Dickey-Lincoln project were considered. These are:

(1) Expansion of the existing 345 KV transmission system.

(2) A combination of 765 KV and 345 KV transmission systems.

(3) A combination of D.C. and 345 KV transmission systems.

345 KV EXPANSION:

A 345 KV system was initially developed to include the Maine Nuclear units only. This proposed system, as shown in Exhibit B, was capable of supporting firm transfers of 2000 to 2200 MW out of Maine.

The economic generation dispatch for this system and the magnitude of the power exported from Maine under various load levels is shown in Exhibit D. Exhibit D also shows that some uneconomic generation (assuming 100% availability of Maine capacity) might be locked in, in Maine, at lighter load levels if firm transfer limits are adhered to.

Once a 345 KV expansion required for the 1986 period was determined, the additional transmission needed for the Dickey-Lincoln project was designed. This is shown in Exhibit A.

Exhibit C shows the total 345 KV expansion necessary for both Dickey-Lincoln and the proposed 1986 system. This system is capable of supporting a firm export of approximately 3000 MW from Maine.

Exhibit E shows an economic generation dispatch with Dickey-Lincoln added. This exhibit shows that economic dispatch can be handled by the proposed transmission system, but there might be some uneconomic generation looked in at lighter load levels.

The proposed 345 KV transmission additions for Dickey-Lincoln add 800 to 1000 MW to the firm transfer capability of the Maine transmission system and this approximates the size of the Dickey-Lincoln project. The 345 KV transmission additions proposed for Dickey-Lincoln are therefore justifiably charged to the project.

Exhibit F contains cost estimates for the 345 KV expansion shown in Exhibit A, B and C. The transmission additions associated with the northern New England area (Exhibit B) will cost about $87,000,000. The transmission additions associated with the Dickey-Lincoln project will cost about $115,000,000. (All figures are in 1974 dollars.)

765 KV AND 345 KV EXPANSION:

A combination of 765 KV and 345 KV expansion was considered and is shown in Exhibit G. This configuration would be capable of heavy exports from Maine assuming a 765 KV system existed in southern New England, and had a northeastern hub at Scobie Pond Substation in New Hampshire. The proposal uses a 765 KV loop from Scobie Pond Substation to the Maine Nuclears. A 345 KV expansion is used from the Maine Nuclears to Dickey-Lincoln and to parts of Central Maine.

Exhibit H shows the estimated cost of this system to be $282,000,000. Aside from the added cost of this system there are two drawbacks. Although under study, there is no 765 KV system plan for New England during the the 1980-85 period, and a 765/345 KV expansion does not provide an economically attractive system to meet the projected bulk power transmission requirements in Maine. The 765 KV system would, however, provide greater export capability from Maine than the 345 KV alternate.

D.C. AND 345 KV SYSTEM:

A proposal to move Dickey power directly from the site to Northern New Hampshire and Vermont was considered. This configuration includes the proposed 345 KV transmission system for the Maine Nuclears (Exhibit B) and a D.C. line from Dickey to Comerford, New Hampshire. A 345 KV line from Comerford to the Granite Substation in Barre, Vermont and 345/230 KV transformer at Comerford complete the system. Exhibit I shows the proposed route for the D.C. alternate. Exhibit J shows the cost of the D.C. alternate to be estimated at $105,000,000.

CONCLUSIONS:

Of the three systems considered for Dickey-Lincoln, the 345 KV system or the D.C. system appears to be about equal in cost provided the remainder of the system expansion is on schedule. Future developments, such as the building of 765 KV system in Southern New England and the construction of additional generating plants in Northern New Hampshire and Maine, may make the 765 KV system more attractive. Since there are not firm proposals for these developments, at the present time, the 765 KV concept was not considered further.

It should be emphasized, however, that when considering the 345 KV expansion, the transmission facilities ultimately attributed to the Dickey-Lincoln project will be greatly influenced by the expansion of the Maine systems. A significant delay in facilities such as one or both of the Maine nuclear units (assumed in this study) or the development of a more southerly or inland site could alter the conclusions of this study. Furthermore, the cost of both the 345 KV and the D.C. alternatives will be governed by the expansion of the Vermont 345 KV system.

To make a full comparison of the 345 KV, 765/345 KV and the D.C. systems, additional studies would be required and operating decisions would have to be made. It is felt that no additional studies should be made at the present time. The cost of the Dickey-Lincoln transmission will be approximately $110,000,000 in either case and the decision as to which expansion is preferred need not be made at the present time.

EXHIBIT A

345 KV Transmission Additons Required for the Dickey-Lincoln Project

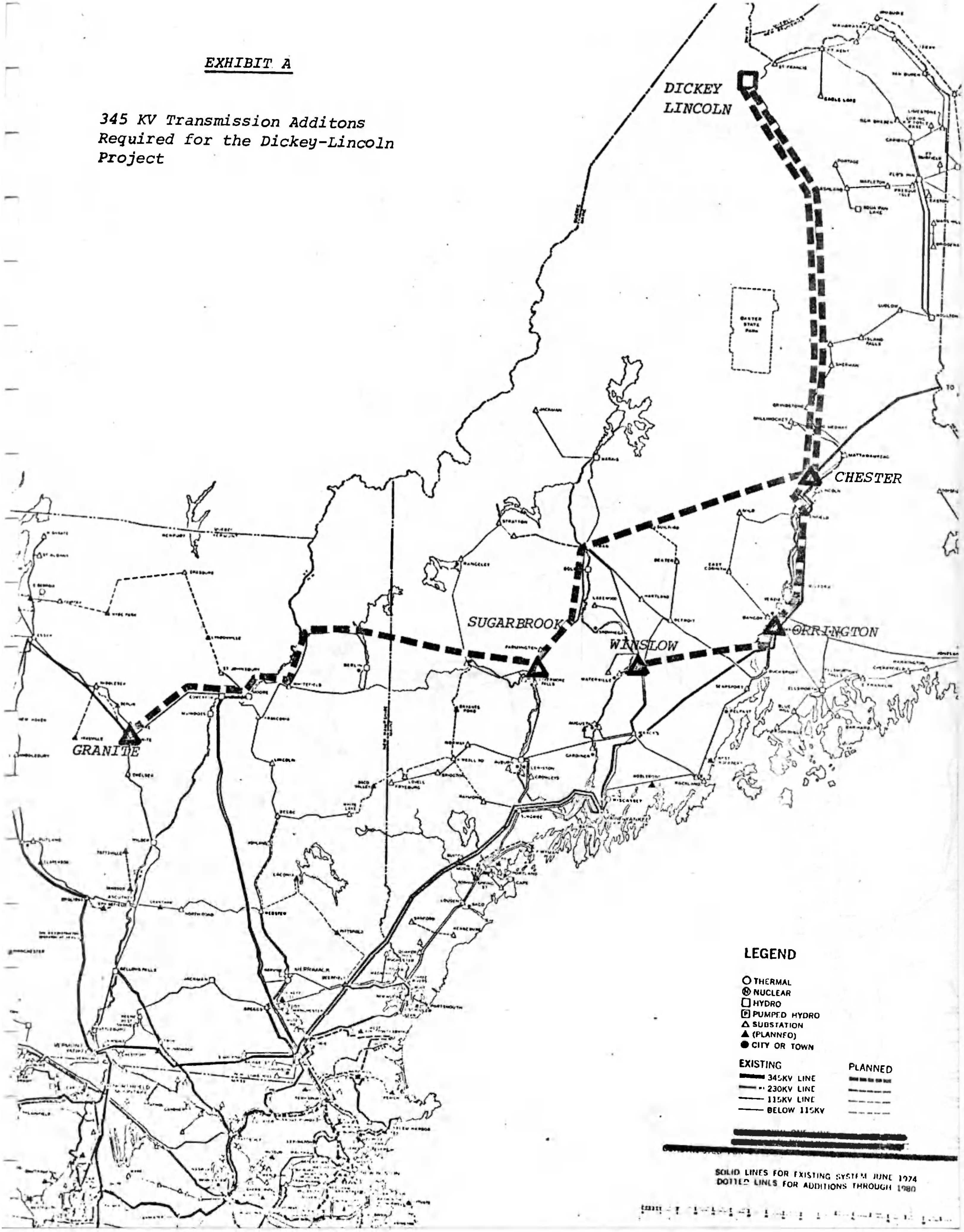


EXHIBIT B

345 KV Transmission Additions Required for Northern New England in the 1986 Time Period.

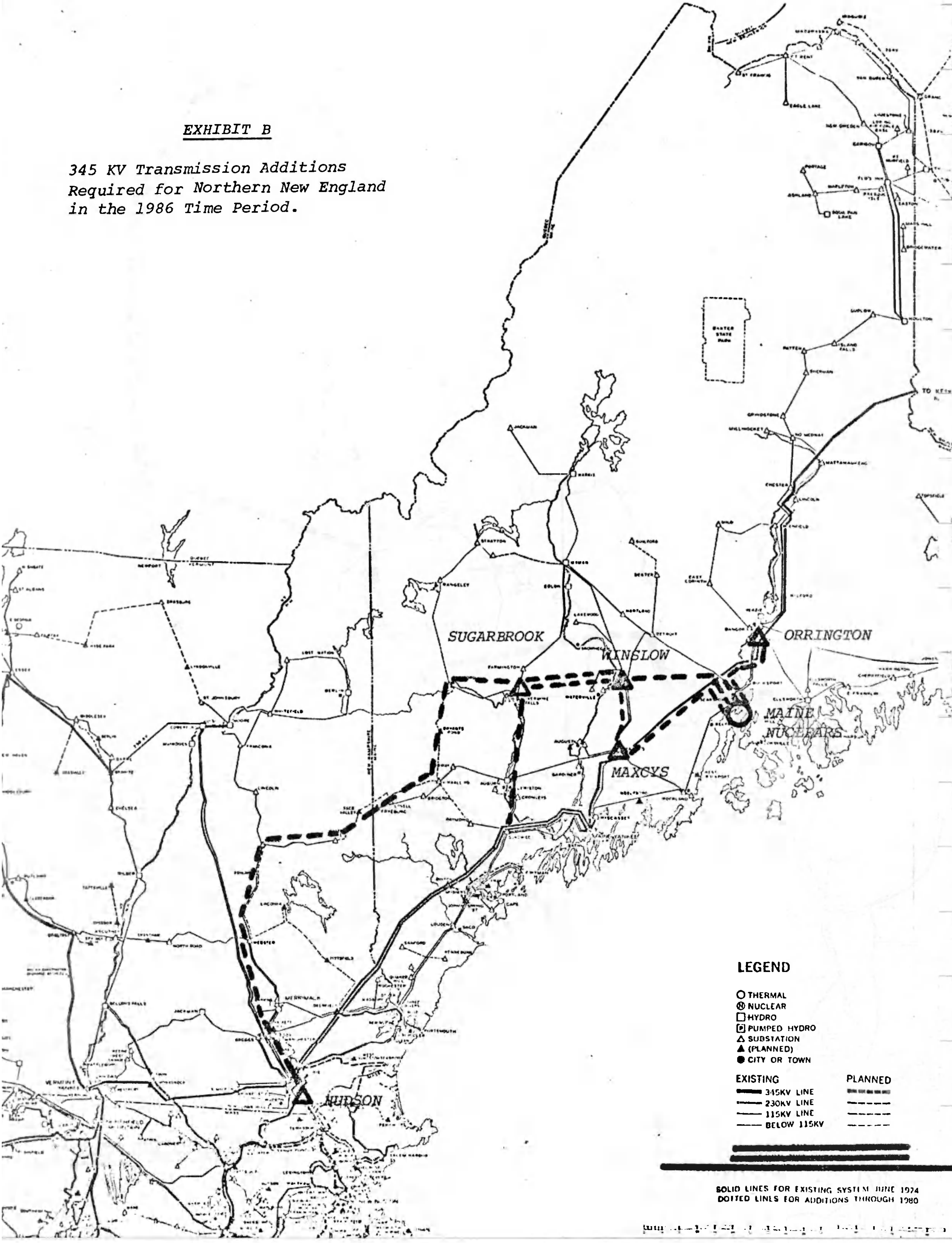


EXHIBIT C

345 KV Transmission Additions Required for Northern New England and the Dickey-Lincoln Project.

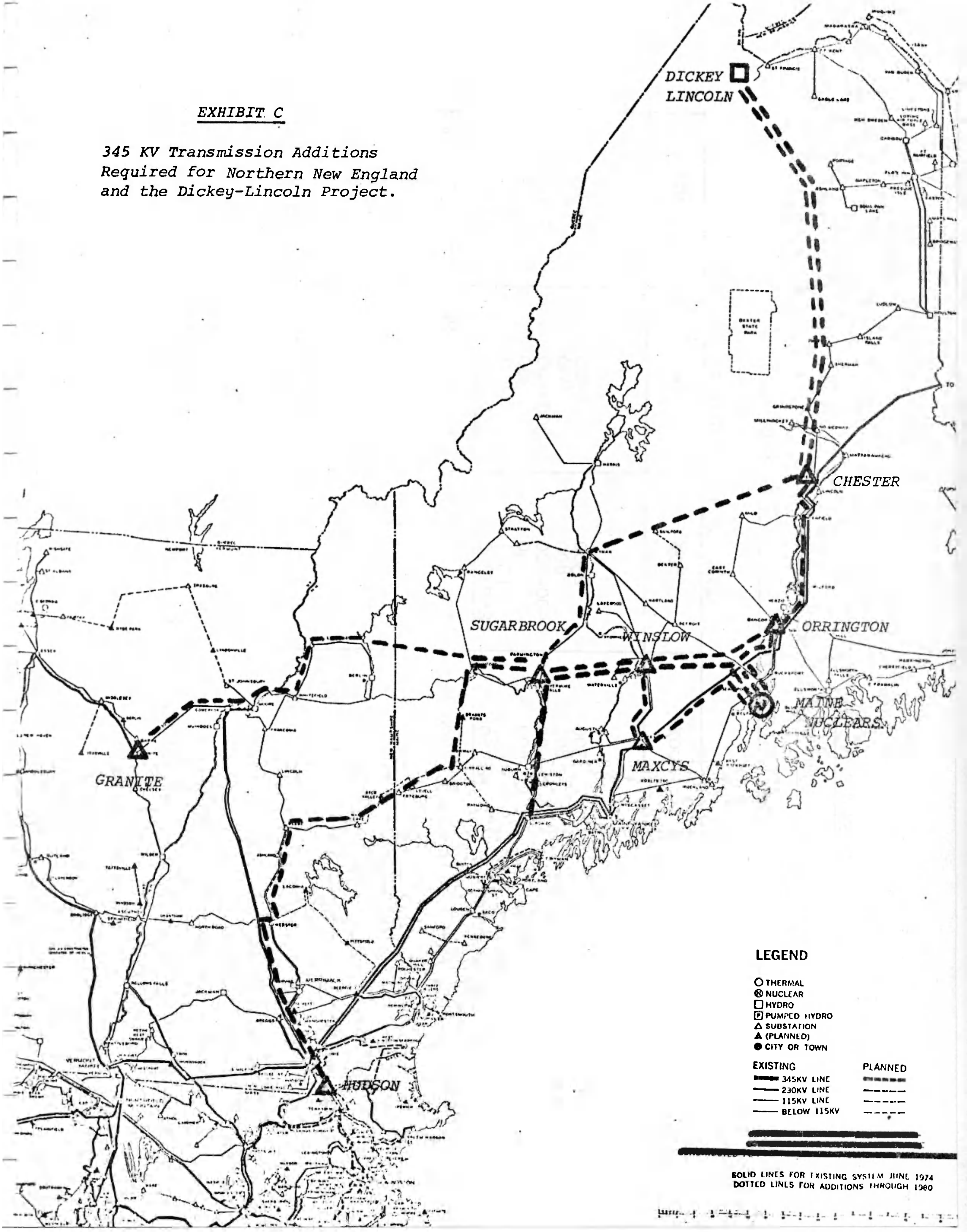


EXHIBIT D

MAINE TO NEW HAMPSHIRE EXPORT

1986 SYSTEM CONDITIONS

"ECONOMIC" GENERATION DISPATCH - NO DICKEY-LINCOLN

	LOAD LEVEL - PERCENT 100%	80%	60%	35%
A. Maine Generation				
1. Site A Nuclear	2300	2300	2300	2300
2. Maine Yankee	800	800	800	800
3. W. F. Wyman #4	500-600	400-500	300-400	0-100
4. N. B. Purchase	400	400	300	100
5. MPSCO (Me. Yankee, etc.)	(50)	(50)	(50)	(50)
6. CMP & BHE Misc. Gen.	350-450	250-350	150-250	0-100
Total Generation	4300-4500 MW	4100-4300 MW	3700-3900 MW	2850-3050 MW
B. CMP & BHE Load	3000 MW	2400 MW	1800 MW	1050 MW
C. Net Maine to N.H. Transfer	1300-1500 MW	1700-1900 MW	1900-2100 MW	1800-2000 MW
D. Total Maine Generation	(4800 MW)			
E. Total Possible Transfer (Assuming 100% Available Maine Capacity)	1800 MW	2400 MW	3000 MW	3750 MW

Note: Economic generation dispatch assumes one 1150 MW nuclear unit out in southern New England.

EXHIBIT F

COST ESTIMATES - 345 KV SYSTEM

Dickey-Lincoln 345 KV System

Transmission Lines:

Dickey to Chester #1	150 Mi.	@	$ 155,000/Mi.	$23,250,000
Dickey to Chester #2	150 Mi.	@	$ 155,000/Mi.	$23,250,000
Chester to Orrington	50 Mi.	@	$ 155,000/Mi.	$ 7,750,000
Chester to Sugarbrook	125 Mi.	@	$ 155,000/Mi.	$19,375,000
Orrington to Winslow	35 Mi.	@	$ 155,000/Mi.	$ 5,425,000
Sugarbrook to Granite	150 Mi.	@	$ 155,000/Mi.	$23,250,000

Substations:

Dickey	5 Breakers	@	$ 600,000	$ 3,000,000
Chester	9 Breakers	@	$ 600,000	$ 5,400,000
Orrington	3 Breakers	@	$ 450,000	$ 1,350,000
Sugarbrook	5 Breakers	@	$ 450,000	$ 2,250,000
Winslow	1 Breaker	@	$ 450,000	$ 450,000
Granite	1 Breaker	@	$ 450,000	$ 450,000
			Total	$115,200,000

Note: (1) It may be possible to eliminate one of the Dickey-Chester lines by the use of series capacitors. This would reduce the cost of the project to $86,840,000 plus approximately $2,000,000 for series capacitors.

(2) A switching station may be required at the midpoint of the Dickey-Chester lines. If required, this would cost an additional $2,400,000.

COST ESTIMATES - 345 KV SYSTEM

Maine Nuclear 345 KV System

Transmission Lines:

Maine Nuclear to 345 KV Line	10 Mi.	$ 1,550,000
Maine Nuclear to Winslow	40 Mi.	$ 6,200,000
Maine Nuclear to Maxcys	50 Mi.	$ 6,550,000
Maxcys to Winslow	25 Mi.	$ 3,875,000
Winslow to Sugarbrook	40 Mi.	$ 6,200,000
Sugarbrook - Pownal	50 Mi.	$ 7,750,000
Maine Nuclear to Orrington	25 Mi.	$ 3,550,000
Winslow - Sugarbrook	40 Mi.	$ 5,000,000
Sugarbrook - Maine/N.H. Line	50 Mi.	$ 7,750,000
Maine/N.H. Line - Webster	70 Mi.	$10,850,000
Webster - Hudson	55 Mi.	$11,000,000

Substations:

Pownal	2 Breakers	@	$ 900,000
Maine Nuclear	10 Breakers	@	$ 6,000,000
Orrington	3 Breakers	@	$ 1,350,000
Winslow	4 Breakers	@	$ 2,400,000
Maxcys	2 Breakers	@	$ 900,000
Sugarbrook	4 Breakers	@	$ 2,400,000
Webster	1 Breaker	@	$ 450,000
Hudson	4 Breakers	@	$ 2,400,000

Total $87,075,000

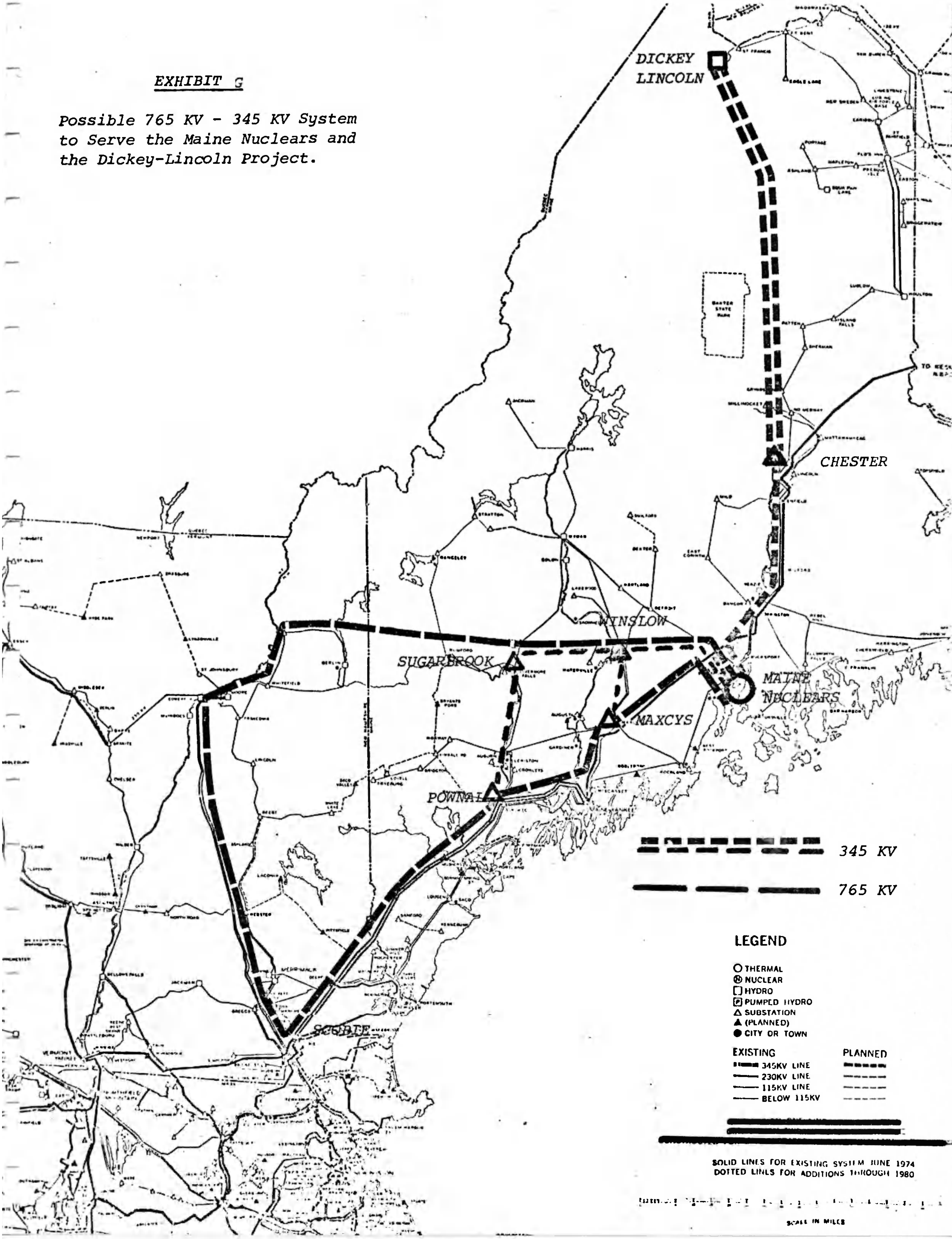
COST ESTIMATES - 345 KV SYSTEM

Total 345 KV System

Maine Nuclear Transmission	$ 87,075,000
Dickey-Lincoln Transmission	$ 115,200,000
Total	$ 202,275,000

EXHIBIT G

Possible 765 KV - 345 KV System to Serve the Maine Nuclears and the Dickey-Lincoln Project.



COST ESTIMATES - 765 KV PLUS 345 KV SYSTEM

765 KV System

Transmission Lines:

Maine Nuclear to Scobie via Comerford
290 Mi. @ $300,000/Mi. = $ 87,000,000
Maine Nuclear to Scobie via Pownal
195 Mi. @ $300,000/Mi. = $ 58,500,000

Transformers:

1 - 765/345 KV, 1500 MVA Transformer at Maine Nuclear $ 7,000,000
1 - 765/345 KV, 1000 MVA Transformer at Buxton $ 5,000,000
1 - 765/345 KV, 1000 MVA Transformer at Winslow $ 5,000,000
765 KV Shunt Compensation $11,000,000

Substations:

Maine Nuclear	4 Breakers	@ $ 1,667,000	=	$ 6,668,000
Scobie	3 Breakers	@ $ 1,667,000	=	$ 5,000,000

Total $185,168,000

EXHIBIT H

COST ESTIMATES - 765 KV PLUS 345 KV SYSTEM

345 KV System

Transmission Lines:

Dickey to Chester #1	150 Mi.	@ $155,000 =	$ 23,250,000
Dickey to Chester #2	150 Mi.	@ $155,000 =	$ 23,250,000
Chester to Orrington	50 Mi.	@ $155,000 =	$ 7,750,000
Orrington to Maine Nuclear	25 Mi.	@ $155,000 =	$ 3,875,000
345 KV Line to Maine Nuclear	10 Mi.	@ $155,000 =	$ 1,500,000
Maine Nuclear to Winslow	40 Mi.	@ $155,000 =	$ 6,200,000
Winslow to Maxcys	25 Mi.	@ $155,000 =	$ 3,875,000
Winslow to Sugarbrook	40 Mi.	@ $155,000 =	$ 6,200,000
Sugarbrook to Pownal	50 Mi.	@ $155,000 =	$ 7,750,000

Substations:

Chester	5 Breakers @	$ 3,000,000
Maine Nuclear	4 Breakers @	$ 2,400,000
Winslow	4 Breakers @	$ 2,400,000
Sugarbrook	2 Breakers @	$ 1,200,000
Pownal	2 Breakers @	$ 900,000
Dickey	5 Breakers @	$ 3,000,000

Total $ 96,600,000

Note: (1) It may be possible to eliminate one of the Dickey-Chester Lines by the use of series capacitors. This would reduce the cost of the 345 KV part of this scheme to $72,150,000 plus approximately $2,000,000 for the series capacitors.

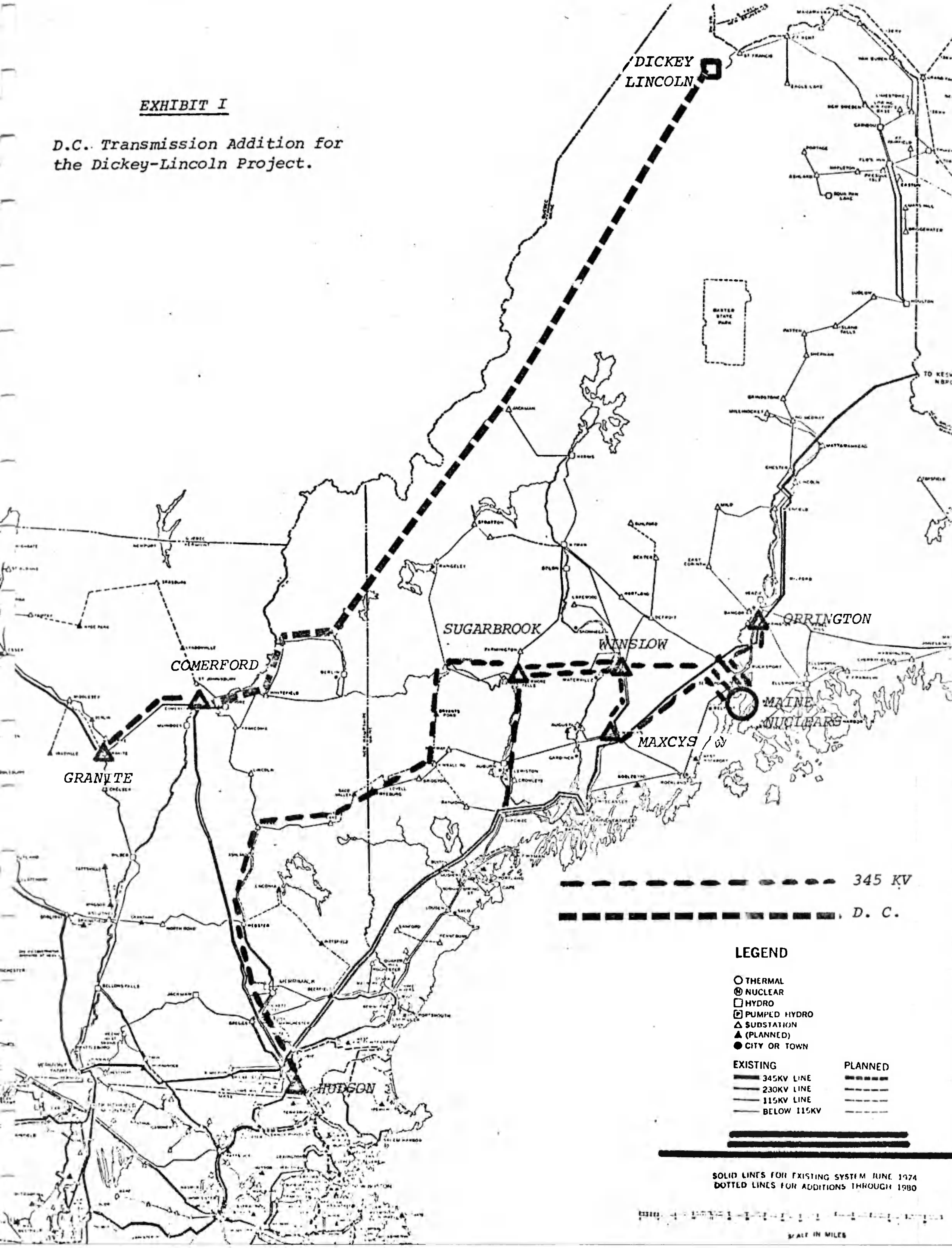
(2) A switching station may be required at the midpoint of the Dickey-Chester Lines. If required, this would cost an additional $2,400,000

Total Cost of Project:

765 KV -	$ 185,168,000
345 KV -	$ 96,600,000
	$ 281,768,000

EXHIBIT I

D.C. Transmission Addition for the Dickey-Lincoln Project.



COST ESTIMATES - D.C. PLUS 345 KV

D. C.

Transmission:

Dickey to Comerford 260 Mi. @ $100,000 = $ 26,000,000

Terminals:

875 MW @ 80/KW $ 68,560,000

345 KV

Transmission:

Comerford-Granite 32 Mi. @ $155,000 $ 4,960,000

Substations:

Comerford	3 Breakers	@ $ 600,000	$ 1,800,000	
Comerford	1 Breaker	@ $ 250,000	$ 250,000	(230 KV)
Granite	3 Breakers	@ $ 600,000	$ 1,800,000	

Transformers:

1 - 345/230, 400 MVA Transformer @ $ 2,000,000 = $ 2,000,000

Total $105,370,000

345 KV

Same as Exhibit F, Page 2 $ 87,075,000

Total Cost $192,445,000

Note: D.C. transmission line costs are based on a ± 400 KV D.C. line with earth return using 2 - 954 MCM ACSR conductors per pole.

APPENDIX D

RELIABILITY STANDARDS

FOR THE

NEW ENGLAND POWER POOL

Adopted by the NEPEX
Executive Committee on
December 16, 1970

Amended by the NEPOOL
Executive Committee on
August 2, 1974

CONTENTS

RELIABILITY STANDARDS

FOR THE

NEW ENGLAND POWER POOL

1. INTRODUCTION

The purpose of these New England Power Pool standards is to maintain the reliability and efficiency of the interconnected power system of its members through improved coordination in system design.

It is recognized that more rigid objectives may be applied in some segments of the pool because of local considerations. It is also recognized that the basic design criteria are not necessarily applicable to those elements of the individual member's systems that are not a major part of the interconnected bulk power system.

An interconnected bulk power system should be designed at a level of reliability such that the loss of a major portion of the system would not result from reasonably foreseeable contingencies. In determining this reliability, it is desirable to give consideration to all combinations of contingencies occurring more frequently than once in some stipulated number of years. However, data and techniques are not available at the present time to define all the contingencies that could occur or to assess and rank their probability of occurrence. Therefore, the interconnected bulk power system must be designed to meet representative severe contingencies.

Loss of a small portion of a system (such as a radial section) may occur provided it does not jeopardize the integrity of the overall interconnected bulk power system.

The standards outlined hereinafter are not tailored to fit any one system or combination of systems as they exist today, but rather outline a set of guides to the system designer which will maintain a high level of efficiency and reliability in the interconnected bulk power system.

2. GENERATING CAPACITY

Generating capacity should be installed in such a manner that, after due allowance for the factors enumerated below, the expected frequency of insufficient generation (including contract purchases) to cover the load, as determined on an annual (power year) basis, should not exceed one occurrence in ten years:

a) The possibility that load forecasts may be exceeded as a result of weather variations.

b) Immature and mature forced outage rates appropriate for generating units of various sizes and types, recognizing partial and full outages.

c) Seasonal adjustment of generation capability.

d) Proper maintenance requirements.

e) The reliability benefits of interconnections with systems that are not NEPOOL participants.

f) Such other factors as may from time-to-time be appropriate.

The use of the load management techniques outlined in steps 1 through 12 of NEPEX Operating Procedure #4 shall not be construed as a failure to cover load for the purposes of this criterion.

3. TRANSMISSION REQUIREMENTS

The pool bulk power system should be designed with sufficient transmission capacity to serve pool loads under the conditions noted below. The power system should also be operated in such a manner that the design objectives are fulfilled.

Two categories of inter-pool power transfer are to be considered:

a. Normal (contractual plus economy)

b. Emergency

Design studies will assume applicable contractual transfers and the most severe expected load and generation conditions. Operating transfer capability studies will be based on the particular load and generation pattern expected to exist for the period under study. All reclosing facilities will be assumed in service unless it is known that such facilities have been rendered inoperative.

3.1 Stability Conditions

Stability of the pool bulk power system shall be maintained during and after the most severe of the conditions stated in a, b, c and d below. Also, the system must be adequate for testing of the faulted element by manual reclosing after the outage and before adjusting any generation. These requirements will also apply after any critical generator unit, circuit or transformer has already been lost, assuming that the area generation and power flows are adjusted between outages by use of Five-Minute Reserve.

a. A permanent three phase fault on any element with due regard to reclosing facilities.

b. A permanent phase to ground fault on any of the phases of two adjacent circuits on a multiple circuit tower with due regard to reclosing facilities.

c. A permanent phase to ground fault on any generator, circuit, transformer, or bus section with delayed clearing and with due regard to reclosing facilities. This delayed clearing could be due to breaker, relay system or signal channel malfunction.

d. Loss of any element.

3.2 Steady State Conditions

a. Voltages, line loading and equipment loading shall be within normal limits for pre-disturbance conditions.

b. Voltages, line loading and equipment loading shall be within applicable emergency limits for the system load and generation conditions that exist following a disturbance specified in 3.1.

4. INTER-POOL TRANSFER CAPABILITIES

Transfers of power from one pool to another, as well as within the pool should be considered in the design of inter-pool and intra-pool transmission facilities.

Operating capabilities shall be adhered to for normal transfers and transfers during emergencies. These capabilities will be based on the facilities in service at the time of the transfer. In determining the emergency transfer capabilities, it is assumed that a less conservative margin is justified.

Transmission transfer capabilities shall be determined under the following conditions:

4.1 Normal Transfers

4.1.1 Stability Conditions

Stability of the pool bulk power system shall be maintained during and after the most severe of the conditions stated in a, b, c and d below. Also, the system must be adequate for testing of the faulted element by manual reclosing after the outage and before adjusting and generation.

a. A permanent three phase fault on any element with due regard to reclosing facilities.

b. A permanent phase to ground fault on any of the phases of two adjacent circuits on a multiple circuit tower with due regard to reclosing facilities.

c. A permanent phase to ground fault on any generator, circuit, transformer, or bus section with delayed clearing and with due regard to reclosing facilities. This delayed clearing could be due to breaker, relay system or signal channel malfunction.

d. Loss of any element.

4.1.2 Steady State Conditions

a. For the facilities in service during the transfer, voltages, line loading and equipment loadings shall be within normal limits.

b. Voltages, line loading and equipment loadings shall be within applicable emergency limits for the system load and generation conditions that exist following a disturbance specified in 4.1.1.

4.2 Emergency Transfers

4.2.1 Stability Conditions

Stability of the pool bulk power system shall be maintained during and after the most severe conditions stated in a and b below. System conditions may be adjusted before the faulted element is tested.

a. A permanent three phase fault on any element with due regard to reclosing facilities.

b. Loss of any element.

4.2.2 Steady State Conditions

a. For the facilities in service during the transfer, voltages, line loading and equipment loadings shall be within applicable emergency limits.

b. Voltages, line loading and equipment loadings shall be within applicable emergency limits following a disturbance in 4.2.1.

5. TRANSMISSION FOR GENERATION UTILIZATION

The transmission system resulting from the implementation of these standards shall be reviewed to assure the full utilization of any generating capability required under reasonable operating conditions.

6. POSSIBLE BUT IMPROBABLE CONTINGENCIES

Studies will be conducted to determine the effect of the following contingencies on the bulk power system performance and plans will be developed to minimize the spread of any interruption that might result.

a. Loss of the entire capability of a generating station.

b. Loss of all lines emanating from a generating station, switching station or substation.

c. Loss of all circuits on a common right-of-way.

d. Permanent three phase fault on any element with delayed clearing and with due regard to reclosing facilities. This delayed clearing could be due to breaker, relay system or signal channel malfunction.

e. The sudden dropping of a large load or major load center.

f. The effect of severe power swings arising from disturbances outside New England.

APPENDIX "A"

LIST OF DEFINITIONS

1. EMERGENCY

An emergency is assumed to exist if firm load may have to be dropped because insufficient power is available. Emergency transfer limits are applicable under such conditions.

2. LIMITS

a. Normal Limits

These limits are dependent on the policies of individual members of NEPOOL for normal system operation and subject to standards which may be developed for all New England.

b. Emergency Limits

These limits depend on the duration of the occurrence, and on the policy of the individual members regarding loss of life to equipment, voltage limitations, etc.

Short time emergency limits are those which can be utilized for at least five minutes.

The limiting condition for voltages should recognize that voltages at key locations should not drop below that required for suitable system stability performance, and should not adversely affect the operation of the interconnected systems.

The limiting condition for equipment loadings should be such that cascading will not occur due to operation of protective devices on the failure of facilities.

3. <u>FIVE-MINUTE RESERVE</u>

Five-Minute Reserve is that portion of unused generating capacity which is synchronized to the system and is fully available within five minutes, plus that portion of capacity available in shut down generating units, in pumped hydro units and by curtailing interruptible loads which is fully available within five minutes.

4. <u>"WITH DUE REGARD TO RECLOSING FACILITIES"</u> is intended to mean that recognition will be given to the type of reclosing; i.e., manual or automatic, and the kind of protective schemes insofar as time is concerned.

5. <u>ELEMENT</u>

An element is defined as a generator, circuit, transformer, breaker or bus section.

APPENDIX "B"

DEVELOPMENT OF NEPOOL RELIABILITY STANDARDS

The New England Power Pool Agreement dated September 1, 1971 provided under Section 7 for the formation of a Planning Committee and states in paragraph 7.9, "Following appropriate studies, the Planning Committee shall from time-to-time recommend to the Management Committee proposed reliability standards for the bulk power supply of the parties."

The Planning Committee in carrying out its assigned duties at this time believes that the recommendations of this report provide for a reliable and efficient bulk power system. However, the accumulation of additional data from actual operating experience may produce a better basis for a statistical analysis which will result in revised improved standards of pool reliability at a minimum cost to the parties.

These recommendations are consistent with the Northeast Power Coordinating Council's "Basic Criteria for Design and Operation of Interconnected Power Systems" and the NPCC "Bulk Power System Protection Philosophy."

The Planning Committee has taken into consideration the steady state and transient requirements it feels the New England Power Pool network must meet with respect to both generation and transmission. Possible contingencies affecting these requirements have been included in the design objectives attached hereto.

APRIL 1986

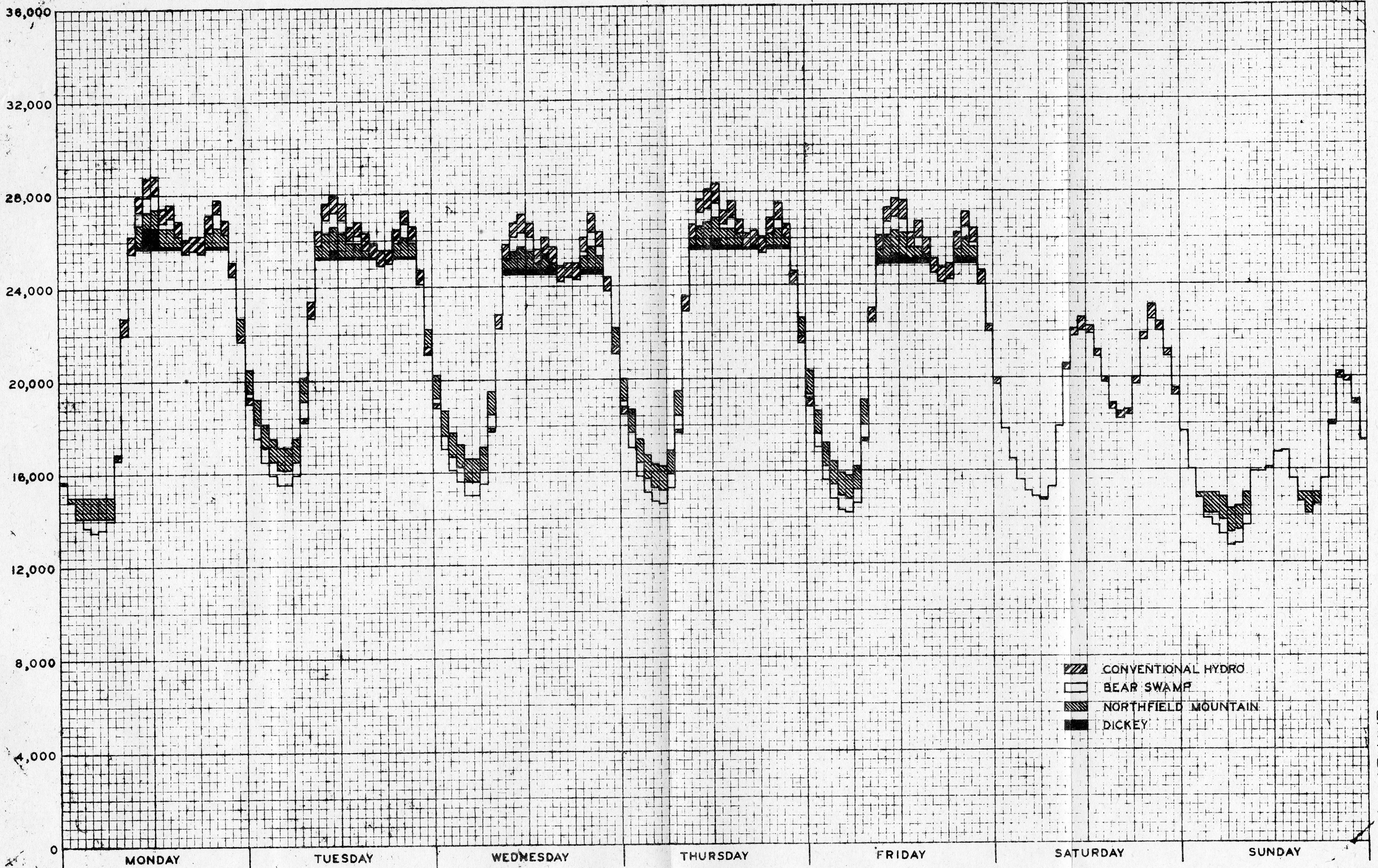


EXHIBIT 7

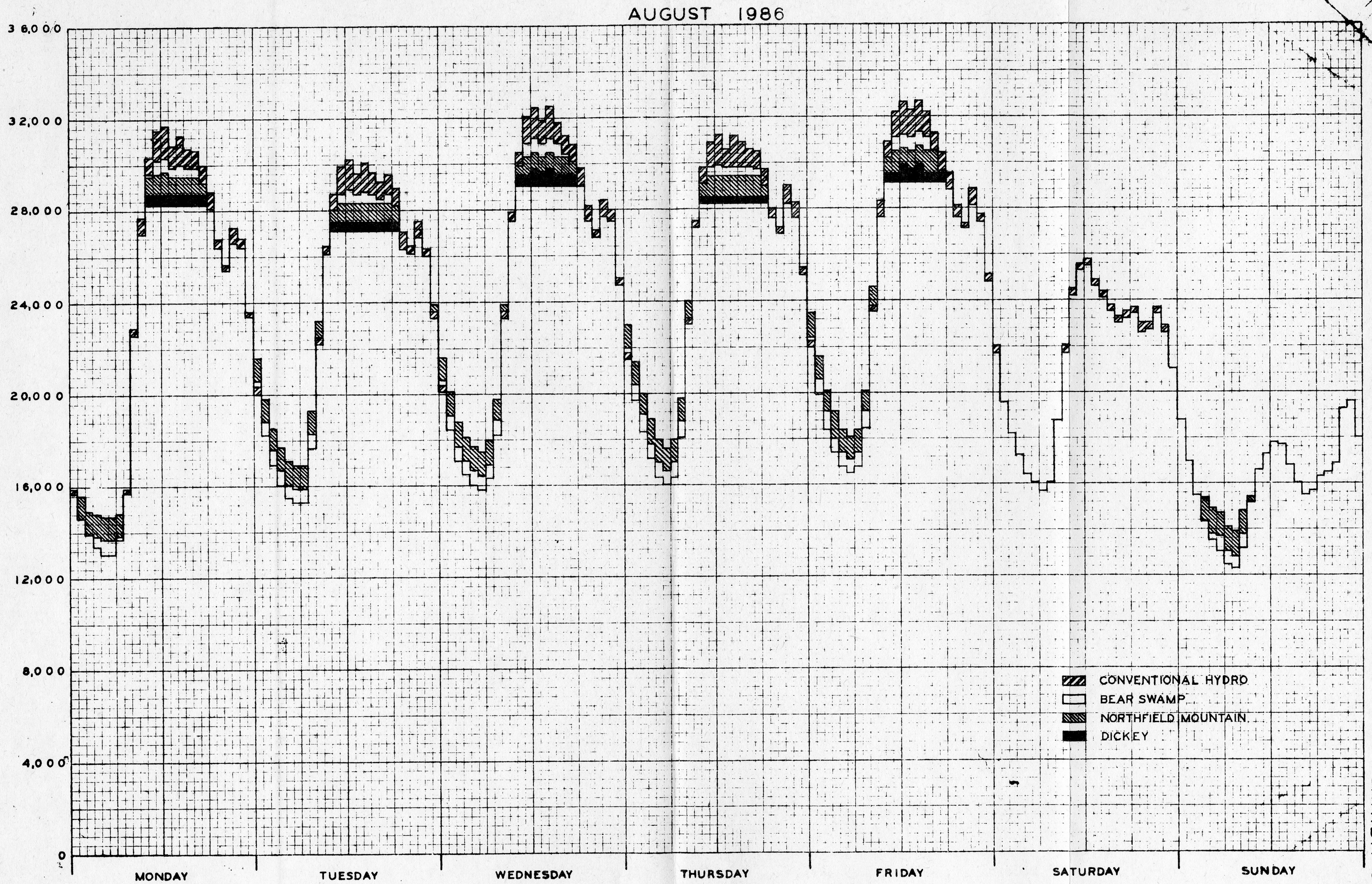

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EXHIBIT 8

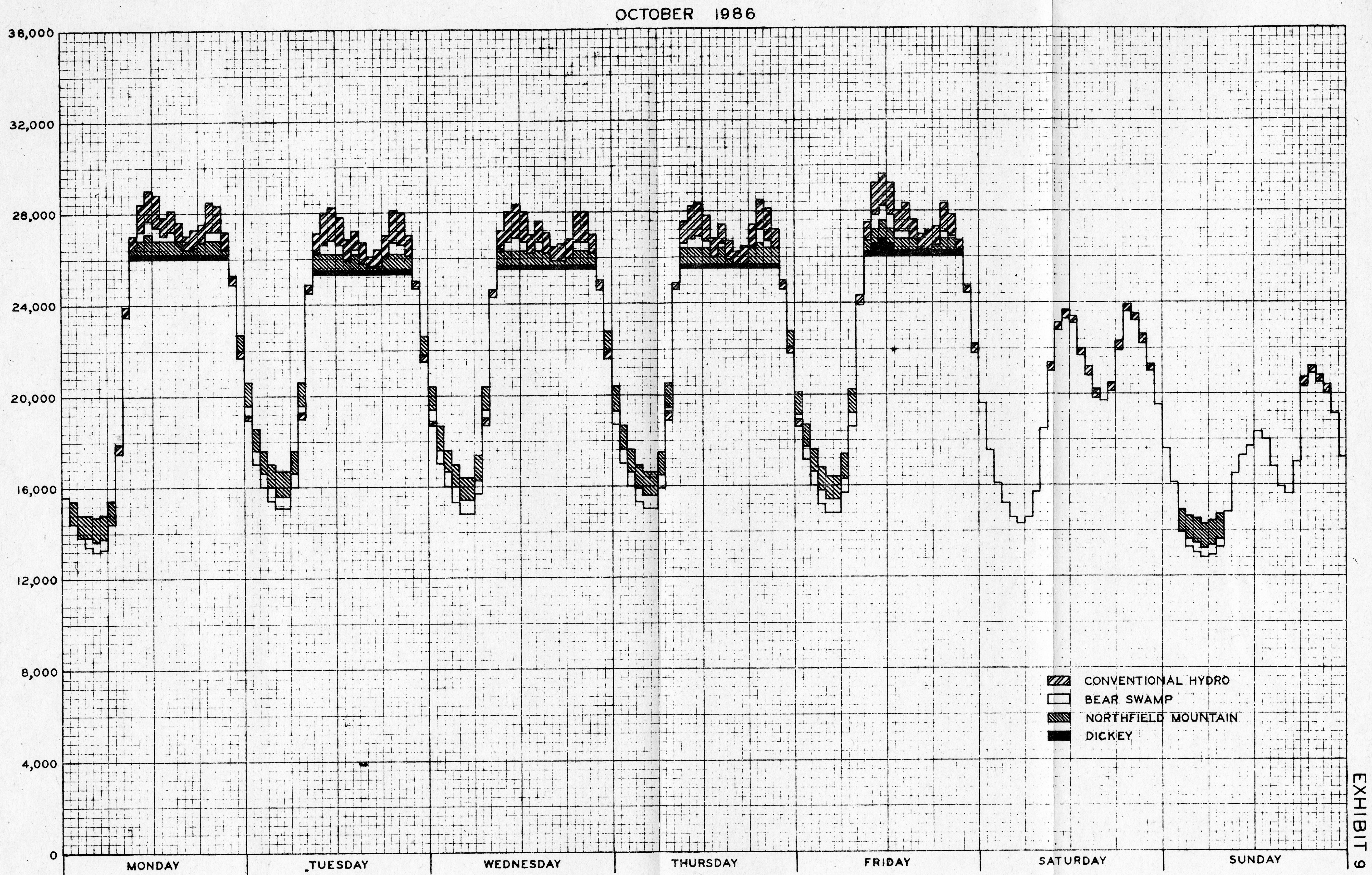
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EXHIBIT 9

DECEMBER 1985

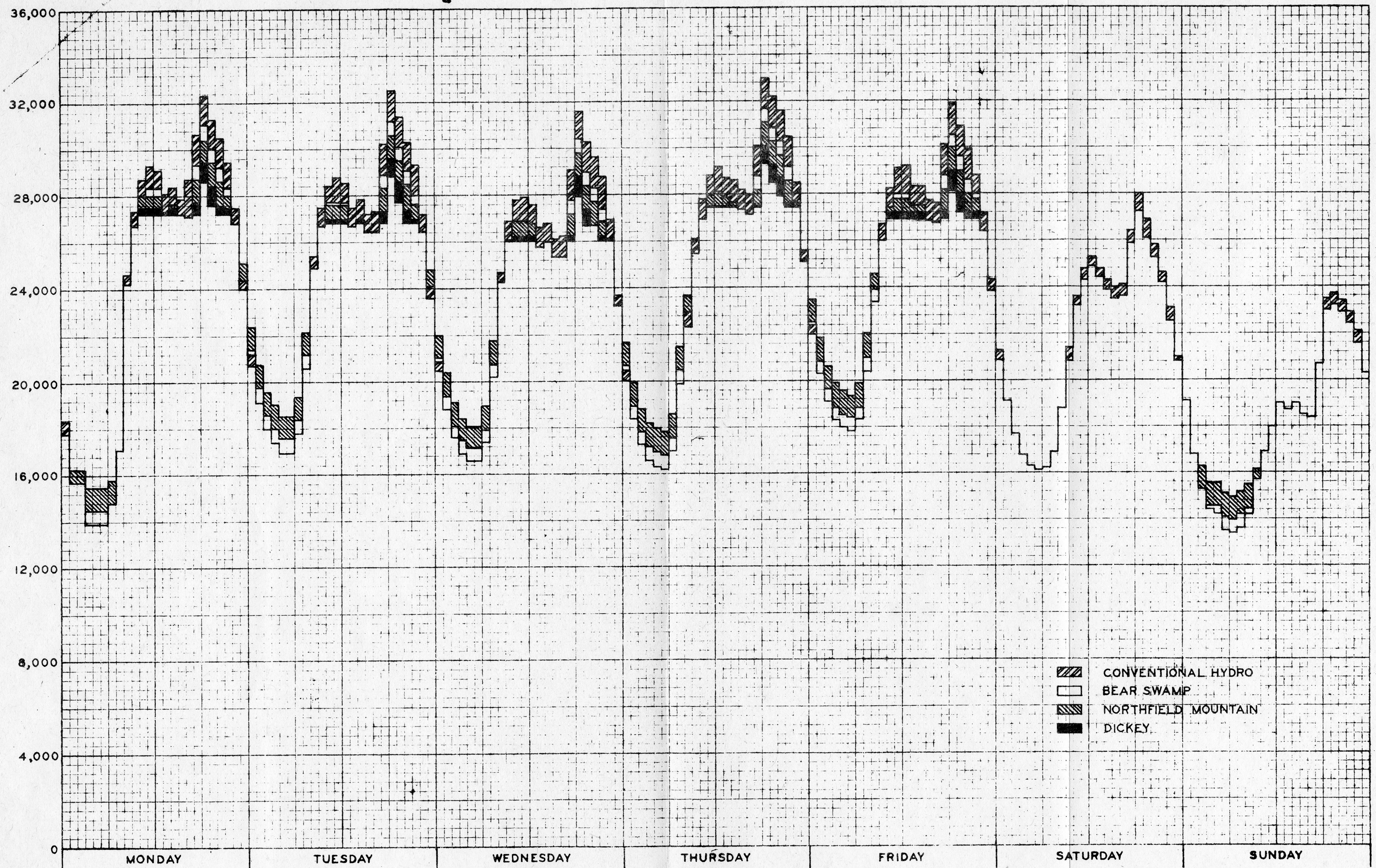

EXHIBIT 6

[redacted]