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THE NORMANSKILL HYDROELECTRIC FACILITY FEASIBILITY ASSESSMENT

U. S. DEPARTMENT OF ENERGY
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J. Kenneth Fraser and Associates, P.C.
Consulting Engineers
Rensselaer, New York

Principal Investigator: James A. Besha, P.E.

Hydrologic Phase:	Robert A. Fraser, P.E.
Marketing Phase:	Michael E. Gilchrist
Configuration Phase:	Joseph Costanza, I.E.
Environmental Phase:	J. Daniel Wojick, L.A.
Licensing & Regulatory Phase:	James A. Besha, P.E.
Economic Analysis:	James A. Besha, P.E.
Implementation Plan:	Robert A. Fraser, P.E.

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INTRODUCTION AND OVERVIEW

The Normanskill Hydroelectric Facility Feasibility Assessment has been a multidisciplinary evaluation of the hydroelectric generating potential at the City of Watervliet Water Supply Reservoir and the associated recreational, environmental, historical, archeological and institutional constraints. In completing this feasibility assessment, many of the analyses have been performed concurrently. As an aid to understanding the completed feasibility assessment, a program flow chart (Figure 1) has been prepared graphically interpreting the various engineering analyses and their relationships.

Since much of the analysis has involved modeling of the various systems, a brief description of the generalized modeling process follows. The planning of water resource systems is dependent upon information regarding hydrologic phenomena. The data base available for such phenomena is seldom large enough to provide precise information and as a result are subject to uncertainties. These uncertainties can be reduced by the use of more extensive data bases. The delays in obtaining a more extensive hydrologic data base, however, is in the order of decades. A more feasible course of action is to develop and use mathematical models of certain processes in order to extrapolate information over time and space. The models, themselves, do not predict with certainty the values of specific variables at any one point in time. However, the information generated from such models can be generated quickly and objectively and can provide a quantitative measure of the quality of the generated information. The models used in this feasibility assessment are of two types, stochastic (Markov chain) and simulation type. The core and initial model used in this hydroelectric feasibility assessment is one which uses a stochastic process to generate sequences of hypothetical streamflows such that any streamflows can be regarded as an equally likely realization of any future flow sequence. This will be explained more fully in the hydrologic phases of the report. The second technique used extensively in this analysis is simulation. In this technique, the uncertainties, interactions and variables are stored in the memory of a digital computer. The simulation begins at a specified starting state and following that start, the combined effects of decisions, interactions, etc. cause the system to progress in simulated time. A vast number of calculations are performed in a short period by the computer. A major feature of this technique is time compression.

The various assessment tasks described hereafter are depicted as having been discrete and clearly defined modules which have been interconnected defining a program and giving an end result. Such clarity and definitiveness can never be obtained but is used as a convenience in describing the methodology.

The first major analysis performed was development of the stochastic model which was used to extrapolate the ten-year stream flow data base. The model yielded a hydrologic stream flow simulation over a 500-year trace. Following development of this model, multiple simulations involving the model were run as a means of developing the mass balance characteristics of the City of Watervliet water supply reservoir.

These multiple runs were performed using various combinations of water supply usage, draft assumptions, etc. as a means of defining the response of the reservoir system to water supply, hydroelectric generation and recreational demands.

Concurrently, following a detailed physical investigation of the site and as a result of several brainstorming sessions among all assessment participants, eight selected alternatives or schemes were adopted for further investigation. These eight alternatives were then methodically scrutinized and further defined. For each alternative, several values of pertinent variables were selected yielding further permutations of the basic eight alternatives. Eventually 78 alternatives, each with associated specific capital and operating costs were defined. Concurrent with this effort, data was collected on the City of Watervliet power consumption and costs for the past several years. This data along with pertinent assumptions on projected future energy consumption served as input to a computer model that evaluated, interpolated, extrapolated and analyzed the City's power requirements and yielded a "typical year" for energy consumption by the City of Watervliet municipal facilities.

The data from this energy use program as well as values representing the power production capabilities of the 78 alternatives and the result of numerous hydrologic reservoir system simulations served as input to a benefit value program. This benefit value program determined the economic benefits attributable to the 78 selected alternatives. The value in each case was a single cost (or savings) allowable to the City through reduced consumption of commercial power.

The results of the benefit value analysis were compared to capital, operating, and maintenance costs and ranked. This analysis was performed in an optimum configuration program which yielded net benefits as well as rankings based upon least cost for each of the 78 options. Implicit in this cost analysis were certain assumptions relating to bonding and discount rates, and cost escalation gradients. In order to properly determine the sensitivity of the analysis to these factors, multiple evaluations were made using a range for each of the factors.

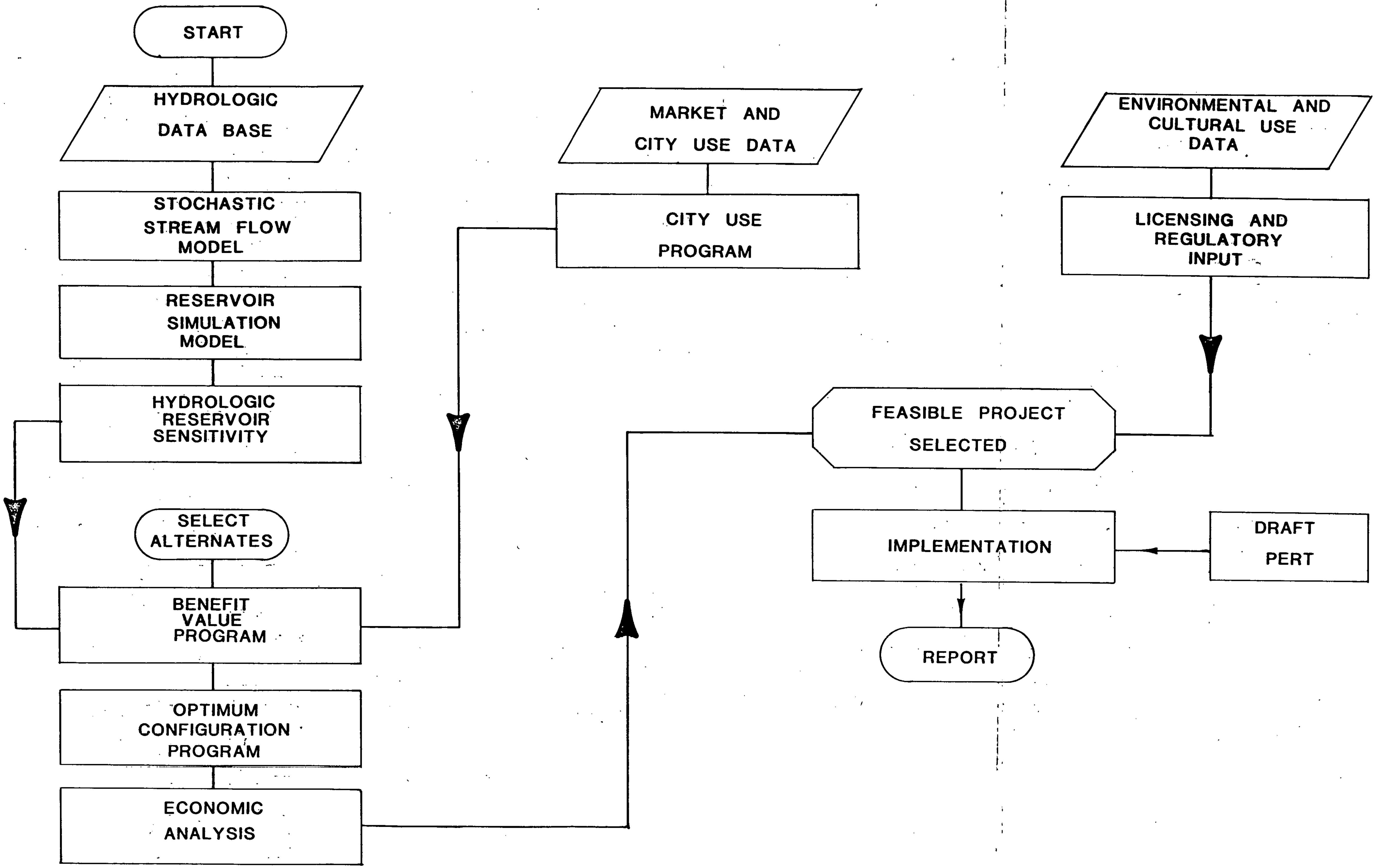
Concurrent with the configuration analysis, an environmental, cultural, historical, archaeological and recreational analysis was performed for the reservoir system in general and for several of the most promising alternatives specifically.

Using the data obtained from the environmental analysis as well as the most promising alternatives from the optimum configuration program, an economic analysis has been performed detailing the various costs, benefits and subjective values for two optimum hydroelectric alternatives representing both a rehabilitation type project and a new construction project as well as the baseline or no project alternative.

Implicit in this economic analysis are certain assumptions of bonding and discount rates, cost escalation gradients, life cycle periods and capital cost accuracy. A sensitivity analysis has been performed and is included which shows the response and conclusions of the economic analyses resulting from using a range of values for these variables.

Requirements for licensing and regulation have been determined. Data relating to scheduling, financing and planning are included in the implementation section.

The Synopsis and Recommendation section includes details about the recommended project and the pertinent economic criteria.



NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

ANALYSIS FLOW CHART

1

HYDROLOGIC - SEGMENT 1

Hydrologic Phase - Segment 1 was funded entirely by the City of Watervliet, New York as fulfillment of a portion of their cost-sharing commitment. This chapter was completed and issued as an autonomous report in September 1978.

Background and Scope

This Watervliet Reservoir Yield Analysis and Report was authorized by the City of Watervliet Common Council to ascertain the available water supply yield from the Watervliet Water Supply Reservoir located at French's Mills in the Town of Guilderland, New York. In addition, the need to predict the remaining life expectancy of the reservoir, as affected by sedimentation and eutrophication, is necessary in order to conduct long-range planning for future water supply requirements for the City of Watervliet, New York. A proposal was submitted on July 26, 1977 delineating three alternative schemes for accomplishing this water supply yield study. Alternative Three was chosen by the City Council as the most cost-effective alternative. Briefly stated, that alternative "would accept as given the volumetric capacity of the reservoir developed in 1912 by the original water supply engineers, Solomon & Keis. From this given reservoir capacity, the expected sedimentation and bank erosion deductions would be made. The sedimentation and bank erosion quantities would be developed and a physical spot verification of expected sedimentation would be attempted under this alternative....actual and synthetic stream flow and rainfall data would be used to conduct a safe yield analysis for the reservoir to determine the maximum safe water supply yield."

It was further noted, in the proposal, that long-term hydrologic data was thought to be generally unavailable but that as part of the yield study, "an exhaustive record would be made to augment the data base to the fullest possible extent.

Introduction

The Watervliet reservoir yield analysis has been completed in a manner outlined under the previous section. For purposes of this report, the component parts of the analysis will be briefly described. Detailed methodologies of the various technical elements of the analysis have been included as appendices in order to provide documentation to facilitate verification of this effort in the future. The modular analytical elements used in the determination of the water supply yield are as follows:

A. Data Base
B. Physical Survey
C. Stream Flow Synthesis
D. Watershed Soil Loss
E. Capacity Determination
F. Yield Analysis
G. Error Analysis
H. Future Impacts

Following discussion of each of these component parts, a section entitled Conclusions has been prepared, summarizing the results of this analysis.

Data Base

The Normans Kill watershed has been considered as a possible water source since the early Nineteenth Century. Most early studies dealt with the possible use of the Normans Kill watershed as a potable water supply for the City of Albany. A report prepared in 1850 by Mr. William J. McAlpine [Ref. 72] dealt, in general, with several possible sources of supply, covering the Normans Kill only briefly. The only flow gauging noted by McAlpine is a single value of 8.218 mgd for the Normans Kill at French's Mills. McAlpine further states that the gauging was not performed by him and "are supposed to be the result of one or two trials only." Furthermore, he states, "It is not believed to be possible to ascertain the minimum flow of a stream, without very careful examinations continued over a considerable period of time"[Ref. 72].

The second serious consideration for use of the Normans Kill as a water supply resulted on March 16, 1891 of the submission of a report to the Albany Common Council by a Special Water Commission, appointed and authorized by the State Legislature, which recommended the adoption of a plan for securing additional water supply from the Normans Kill. The Common Council noted in the public record that the estimates of flow appeared "unexpectedly large" and after deliberating, decided that the "practicability of the entire project depends to no small extent upon the accuracy of these estimates [Ref. 64]. The Council then recommended that the Special Commission undertake a further study including measurements of the possible stream flow. It should be noted that the initial measurements made for the Commission by Mr. J. Herbert Shedd, were thought to be highly suspect since the R. D. Wood & Company, who employed Mr. Shedd, was thought to be desirous of securing the contract for constructing the proposed impoundment. The revised estimates prepared by this special commission showed that the Shedd estimates were, in fact, 550% higher than that found during subsequent testing. To confuse things more, the Common Council noted that through a "curious oversight, the safe yield computation neglected to take into account the 51 million gallons per day that would have had to have been released from the impoundment to furnish the existing mills located at a point downstream" [Ref. 68]. Discussion of the Normans Kill as a source of supply at that time also involved serious consideration regarding the suitability of the water due to its bacteriological quality. This concern, in 1891, was for the most part fueled by the rapidly changing composition of the watershed in the late 1800's from a primarily forested area to agricultural usage. It should be noted that the entire data base that was used for discussion at that time involved so-called "average" daily flows which were actually based on single daily measurements over a time period thought to be no longer than a year. The methodology by which this sparse data was transformed into a "safe yield" was extremely simplistic, being based on intuition and judgment rather than on any mathematical analysis.

The Albany Special Water Commission further investigated Lake George, Warner's Lake, Thompson's Lake, Kinderhook Creek, and Schoharie Creek as potential sources of water supply. In addition, several underground sources were investigated. The Albany Common Council eventually selected the Hudson River as a source of supply.

The designer and engineers of the existing Normans Kill impoundment and dam, Messrs. Solomon, Norcross & Keis (hereinafter referred to as "Keis" attempted to determine the available yield by approaching the problem as one of cause and effect. Basically, Keis' safe yield was developed on the basis of a rainfall-runoff ratio. Keis' method assumed that certain portions of the monthly rainfall would run off and be displayed as stream flow. He used percentages ranging from 4% in July and August to 85% in March for the runoff ratio. Keis's average rainfall ratio is 39.9% which he compared favorably to the 48% ratio determined for the Croton (New York City) watershed and a 56% ratio determined for the Philadelphia, Pennsylvania watershed. From examination of all known data, it cannot be determined upon what basis Keis assumed the relative monthly proportions. It should also be noted that this method, while innovative in the early part of this century has been shown to be of little value since the relationship between rainfall and runoff is considerably more complex than a simple ratio. The mechanism of relating rainfall to runoff involves numerous parameters such as watershed area, soil types, soil porosities, geological composition, distribution of storm events, etc. At present, the state of the art is such that highly accurate rainfall runoff prediction models are valid only for extremely small watersheds under tightly constrained circumstances. In any event, Keis never totally addressed the problem of determining a probable safe yield. The amount of water supply required for the City of Watervliet at that time was 4.0 mgd. The facilities were designed with this amount in mind, but through what may have been an oversight, it appears that the designer neglected to account for the large additional water supply requirement for the hydraulaic pumping of the water. From various letters, charts, and graphs on file with the New York State Resources Commission, it is evident that the State Water Resources Commission was concerned with this although the final decision did not allude to it. As a result of this computational oversight and due to an apparent lack of adequate turbine operating rules for reservoir operation, it was reported in June of 1918 in a report to the New York State Health Department that during the early months of 1918, the Watervliet reservoir's supply was exhausted. The deficit for several months was supplied from the Hudson River. Based upon charts and computations made at that time, it is surmised that the supply was exhausted due to continued operation of the hydraulaic turbines throughout the 1917 year even though rainfall for that year was substantially below normal and the relative volume of water required for operation of the turbines had predictably increased in magnitude as water surface elevation in the reservoir dropped. It is calculated that water use by the City of Watervliet for potable supply and for hydraulic pumping during the latter months of 1917 exceeded 40 million gallons per day.

In 1925, a report was prepared by Nicholas Hill for the City of Albany in regard to Albany's future water supply requirements. One option discussed in the Hill report was construction of a dam on the Normans Kill downstream from the existing Watervliet impoundment. Stream flow data upon which Hill developed his calculations was limited to the data gathered for the 1891 Shedd Report. Hill projected estimated minimum flows using comparative hydrology for consecutive periods of one month to twenty-four months duration. The estimated flows were then compared to the actual 1891 flows. The estimated flows were lower than actual flows although Hill indicated the inclusiveness of the comparison due to the meager 1891 data.

In 1964, a study prepared by Parsons, Brinkerhoff, Quade & Douglas (hereinafter referred to collectively as "Parsons") [Ref. 75] for the City of Watervliet dealt briefly with the probable safe yield from the impoundment. Parsons' calculations are based upon an observation in the year 1963, during the drought period of the early

1960's, that a continuous withdrawal of 4.3 mgd from the reservoir was maintained without lowering the reservoir water surface elevation. Parsons therefore then conservatively estimated minimum stream flow to be 3.3 mgd. Parsons correlated this assumed minimum stream flow to "firm yield" by simply relating the amount of storage in the reservoir based upon an assumed number of days with minimum inflow. Parsons' analysis was pedicated upon drought (no rainfall) periods of 90 and 120 days. Based upon these rather simplistic assumptions, a firm yield assuming 90 days of minimum inflows was calculated to be 21 mgd, whereas for 120 days, the firm yield would be 16.6 mgd. Parsons also investigated the determination of safe yield by the method of comparative stream hydrology. Comparing the curves of yield per square mile versus available storage for three other watersheds in the region, Parsons projected a safe yield of 0.18 mgd per square mile of watershed for the Normans Kill. The report thereafter concluded that "20 mgd is a reasonable estimate of the firm yield of the Watervliet Reservoir." It should be noted that the scope of the 1964 water supply report was limited and detailed investigation of the firm yield was not mandated.

Prior discussions of historical data base serve to illustrate the lack of accurate long-term data and the ill-defined methodologies by which previous decisions on the Normans Kill watershed were made. Current state of the art techniques utilizing sophisticated mathematical modeling still require an accurate data base, although of shorter duration. The data base used in this analysis is derived from five sources and is thought to have excellent reliability and accuracy.

The first data source was the record of stream gaugings on the Normans Kill and Hunger Kill performed by the U.S. Geological Survey. These stream gauging stations are permanent installations constructed in 1967 which continuously record flows in each stream on a year-round basis. The gauging stations are extremely well designed and accurate. Data obtained from this source included daily stream flow averages for the period from October 1967 through September 1977.

The second data resource was the Watervliet Pumping Station operational log prepared [Ref. 96] from 1964 to the present by the current pumping station superintendent, Mr. Charles Luckey. Prior to Mr. Luckey's appointment, daily operational logs were not kept. Mr. Luckey's logs provided us with extremely detailed and accurate information relating to reservoir water surface elevations and mode of operation. Through analysis of Mr. Luckey's daily logs in relation to the U.S.G.S. daily stream flow data, a composite stream flow input into the Watervliet reservoir was determined.

The third data resource was detailed soil loss analysis performed by the U.S. Soil Conservation Service as part of a statewide conservation needs inventory [Ref. 30]. This soil loss was performed on a watershed basis for the entire state as a means of determining the severity and extent of soil loss through erosion in the State. Both raw and final data from the Soil Conservation Service offices in Albany and Schenectady Counties were used in our analysis to determine calculated soil losses and expected soil loss input to the reservoir.

The fourth data resource was the Land Use Natural Resources (LUNR) inventory [Ref. 18] prepared by the State of New York. This land use data allowed the definition of sub-watershed areas that were excluded from the SCS soil loss inventory.

The fifth data base resource was extensive rainfall data available from 1820 to the present furnished by the National Oceanic and Atmospheric Administration from the recording stations in the Albany vicinity.

Physical Survey

The first stage of the physical survey involved comparison of the boundaries depicted on the original reservoir land taking map prepared in 1912 by Solomon, Norcross & Keis with aerial photography taken in 1977 for the Albany County tax base mapping project. The general reservoir outline was found to correlate fairly well with the Solomon, Norcross & Keis map except where bank erosion had taken place in certain areas. Generally, these areas were defined by steep clay banks of Hudson silt composition, as verified by on-site investigation.

A second facet of the physical survey involved the extraction and analysis of core samples from the reservoir bottom in ten locations. This sampling was performed by Empire Soils Investigations, Inc. An analysis of the samples to determine unit weights and submerged unit weights was undertaken to verify and calibrate the sedimentation load model subsequently developed.

The third facet of the physical survey involved spot soundings performed by a survey crew in five different areas of the reservoir. These areas called "ranges" were transverse survey lines from which cross-sections were plotted. These actual cross-sections were compared to cross-sections plotted from Solomon, Norcross & Keis' original land taking map and are shown as Figures 3 and 4. A comparison of these cross-sections on a statistical basis permitted further definition of the actual siltation that has taken place in the reservoir in the 62 years since its construction.

Stream Flow Synthesis

A calculation of a reservoir safe yield requires a reasonable data base of stream flow over an extended period of time. As noted previously, no long-term stream flow data exists for this watershed. The methodology used in our analysis was developed in the 1960's at Harvard University and involves what is today known as "operational hydrology." This approach differs from conventional comparative hydrology in that the data used in the analysis is derived from the specific waterhsed in question. This data is further manipulated and augmented by statistical methods to create a reliable and accurate long-term model of stream flow. Comparative hydrology, on the other hand, relates safe yield or parameters in one watershed with those empirically determined through long-term monitoring for another watershed, ignoring the multitude of differences between them. The term "synthetic hydrology" although used frequently in this report and other publications, is not a totally satisfactory designation because it connotes that fictitious stream flow values are created in such a way that they could not occur at the site. This is not an accurate portrayal. The data generated is not actually expected to be observed, but serves as a substitute data base to further derive other mathematical models which are then used to determine the storage-yield relationships. In this analysis, the stream flow synthesis derived its data base from ten years of monthly reservoir stream inflow values determined from available records. Based upon examination and analysis of these values, a statistical relationship was developed that adequately represented this historical record. Using these historical records as a model, additional synthetic records were generated, representing stream flows for a 500-year period. These flows were partially comprised of a deterministic component representing the historical sample and partially of a random component representing the statistical model assumed. The 500-year synthetic record is statistically identical in most respects to the 10-year record from which it was modeled. It should be noted that while the 10-year historical record is not an extremely long period from which to model stream flow, based upon extensive research to date, it is believed to be adequate.

Watershed Soil Loss

As a means of determining the actual physical capacity reduction of the reservoir by sedimentation, a watershed soil loss model was constructed. This model relies upon the Universal Soil Loss Equation developed by the U.S. Department of Agriculture and now in general use. From this model, an expected annual soil loss in the watershed was developed and was further related to the actual amount of soil transported by streams and deposited in the reservoir. This model, while representing the expected soil loss in a specific year (in this case 1974) can be extrapolated backwards and forwards to arrived at a probable sedimentation load presently in the reservoir and an expected sedimentation load in future years. These extrapolations are based upon assumptions concerning continued land use, conservation practices, etc. Data used in the construction of this model was furnished by the United States Soil Conservation Service (SCS) offices in Albany and Schenectady

Counties. The bulk of this data was prepared by the SCS offices for a state-wide soil loss inventory prepared recently. For purposes of our model, the SCS raw data was spot-verified and disaggregated to exclude portions of the watershed not tributary to the Watervliet Reservoir. Disaggregation of excluded areas was performed using the New York State Land Use Natural Resources Inventory.

A total annual soil loss was further disaggregated into monthly soil loss. Sediment transport mechanisms delivering soil loss to the reservoir were re-evaluated on a monthly basis, and reservoir trap efficiencies were likewise re-evaluated. Comparison, on a monthly basis, was necessary due to the extreme range of values of monthly stream flows versus reservoir capacity. The extreme range in this case results from the relatively small physical capacity of the Watervliet Reservoir in relation to the overall watershed area. Computation of annual sedimentation of the Watervliet Reservoir was made on the basis of the calculated monthly loadings.

Using empirical submerged soil densities and sediment densities dervied during the physical survey portion of the study, sediment volume was then computed. Distribution of the sediment was further predicted using the Area-Increment procedure to apportion expected sedimentation buildup over discrete elevations of the reservoir bottom.

Capacity Determination

The problem of determining the present physical capacity of the reservoir was approached in several different ways.

The physical capacity of the reservoir which was determined by Solomon, Norcross & Keis from the topographic survey which they prepared for the reservoir construction, was examined in an attempt to arrive at a statistical measure of error to be applied to the original capacity. As described in the Physical Survey Section, aerial photography confirmed that the water surface area of the reservoir as outlined on the original topographic survey map was of acceptable accuracy. It was assumed, therefore, that the accuracy of all other topographic contours within the impoundment could be assumed to have acceptable accuracy as well. Since the original topographic survey was based upon a 5 foot contour interval, the elevations depicted on the topographic map statistically could be a half interval or 2-1/2 feet higher or lower than that shown. Independent computations of capacity versus contour elevation were made under this study using the original topographic mapping. Similarly, computations were made using the assumptions of a consistent half-interval contour error. This computation yielded a capacity based upon the original topographic mapping, which we have called "Keis Mean", "Keis High", and "Keis Low" in the graphical representation found in Figure 5. The Keis High capacity is the most liberal estimate of original capacity assuming that all topographic elevations were actually lower than depicted. The Keis Low capacity is a conservative estimte of reservoir capacity based upon the opposite assumption.

The reduction in reservoir capacity which was predicted by the watershed soil loss computation for the reservoir's sixty-two year history, and also for a one-hundred year period, was then applied to the original reservoir capacity curve. The resulting family of capacity curves representing the reservoir's original 1916 assumed capacity, as well as the projected 1978 and 2016 curves, are represented in Figure 6. The total volume reductions based upon soil loss computations correspond favorably with losses determined empirically for this type of reservoir and watershed. The total reductions are 7.5% and 12% for a 62-year and 100-year life, respectively.

A second method of capacity determination was based upon the physical survey taken over five selected ranges of the reservoir. Sediment buildup found over these ranges in relation to bottom contour as shown on Keis' topographic map were proportionally distributed over all sections and elevations of the reservoir in order to derive a revised capacity curve based upon these actual physical soundings. The physical capacity determined by this method corresponds rather closely with that determined by the theoretical soil loss method. These capacities are depicted graphically in Figures 6 and 7.

Yield Analysis

For a determination of "safe" yield, we have adopted the probabilistic approach now favored. This approach relates the safe yield of the reservoir to the relative frequency of deficit to be expected. By using the record of synthetic stream flows, a reservoir storage simulation model was developed. This model used the 500 year synthetic stream flow record and assumed draft rates to compute the amount of cumulative storage deficit or overflow for each month of the 500 year trace. The frequency of storage deficits, or the number of times in the 500 year record that a given storage volume would be inadequate at a given draft rate was determined. The results of the probabilistic yield analysis are presented graphically in Figure 8. The graph shows the relationship between required reservoir capacity, water supply yield, and the reliability that the yield is "safe." For example, a reliability of 99% for a selected uniform draft rate implies that the corresponding reservoir capacity or storage deficit would be exceeded once in 100 years at that draft rate whereas a 99.8% reliability implies that the capacity will be exceeded once in 500 years. For most water supply discussions, a 98% or 99% reliability is normally assumed as a conservative factor. This is owing to the fact that during periods of drought, water use could generally be curtailed as a means for stalling system failure.

Recent research [Ref. 28] indicates that the economic dislocation associated with drought is extremely minor even at the 95% reliability factor. In a study of several Massachusetts communities following the early 1960's drought, economic dislocation resulting from the drought was approximately $5.00 annually per capita. It seems prudent, however, for planning purposes to assume a higher reliability factor of say 99%.

Discussion of Error

In any scientific analysis the analytical results must be tempered with an understanding of the potential errors inherent in the data and methodology employed.

Potential errors in this hydrologic analysis can be classified as judgmental, observational or analytical.

Judgmental error is based in the judgment of the analyst where subjective considerations must be given to selection of certain coefficients and variables. A good example of judgmental error source is in the selection of the so-called conservation practice factor used in the Universal Soil Loss Equation.

Observational error results when data being gathered by an observer is recorded inaccurately, usually visually, and goes undetected.

Analytical error is associated with inaccuracies inherent in the analysis itself. These errors result from the simplification of algorithms necessary for computations and from imprecise assumptions or equations required to be able to mathematically represent a process.

Mathematical determination of the magnitude of the range of potential error of the second and third type is possible but is beyond the scope of this study. Determination of judgmental errors is also possible using various methods of psychological testing. For purposes of this study, we have attempted to identify all recognizable sources of error and subjectively discuss them as to probability of occurrence.

A tabulation of errors and probability of occurrence is included as Appendix F following this chapter.

<u>Future Impacts</u>

The major factor relating to future changes in the capacity of the Watervliet Reservoir is the land use patterns in the Normans Kill watershed. As depicted on Figure 10, the Normans Kill watershed upstream from the Watervliet Reservoir lies largely in the Town of Guilderland and the Town of Rotterdam. A small portion of the watershed lies in the Town of Wright, Schoharie County. The present land use patterns in the watershed are similar to those of the last 62 years. Change has taken place primarily relating to the development of cropland and an ebb and flow of woodland in the watershed over the past three-quarters of the century. From what can be gleaned from historical sources and from recollections of the Soil Conservation Service personnel, the total makeup in agricultural land today is not unlike that of 30-40 years ago. It is surmised that erosion conditions today may be somewhat intensified due to the mechanization of agriculture in the watershed. However, the majority of cropland in the watershed is used for dairy farming and thus is not highly cultivated. The loss of woodland to agriculture is thought to be minimal. Approximately 40% of the watershed area is classified as forest lands. The primary impact of land use changes in the watershed have been the intensification of land uses associated with the urban use category. At present, approximately 28,600 acres of the total watershed area of 139,100 acres are classified as urban land use. While the bulk of this urban land use lies in the eastern portion of the watershed downstream from the Watervliet Reservoir impoundment, the historical trend has been for a slow westward movement of the urbanization (suburbanization) into portions of the watershed tributary to the reservoir. Up to now, most of this urbanization of the watershed has been through road construction and single family and multiple family residences. It is expected, however, that development of large tracts for apartment complexes will occur in the near future. This trend toward urban use affects the rainfall runoff ratio and the sedimentation rate. It is interesting to note that in this particular watershed due to its large size in relation to the reservoir capacity, the effect of changes in the rainfall runoff patterns due to urbanization will be largely undetectable due to the immense size of the watershed. Sedimentation, however, as a by-product of the increased runoff rates will be noticeable due to the generally silty nature of the soils and unstable bank condition of the major streams.

The second major impact upon the reservoir capacity is the accelerating eutrophication of the reservoir. This natural process in the life cycle of a body of water has as its causative components; sedimentation, increased vegetative growth, and increased flow of nutrients into the impoundment. The effects of this eutrophication are two-fold. The first, the gradual deterioration of water supply due to proliferation of algae growth and lessening of oxygen available for natural cleansing and growth of desirous life forms, will not be detailed in this report. It is obvious, however, that this reduction of water quality will cause a significant cost escalation as more advanced treatment methods become necessary to satisfy the stringent requirements of the U.S. Safe Drinking Water Act.

The major effect of eutrophication, relating to this study, is the tendency of the eutrophied reservoir, with a preponderance of vegetation, to significantly increase its rate of sedimentation. Heavy vegetation causes velocity reduction through areas of the reservoir allowing deposition of sediment. A greater portion of the sediment delivered to the reservoir passes through the reservoir during periods of high flows, being kept in suspension by high velocities and carried over the dam. It has been calculated that during the spring months of March and April, the trap efficiency, or the proportion of suspended material the reservoir retains rather than passes is as low as 60%. This is due to the high flows resulting from the large watershed. Increased vegetation in the upper reaches of the reservoir, however, will substantially reduce the velocity in that region and increase the trap efficiency throughout the year, increasing sedimentation. The trap efficiency of the Watervliet Reservoir presently ranges from a calculated 60% in March and April to a high of 92% in August. This coefficient can be expected to increase and hence significantly increase the sedimentation rate of the reservoir if steps are not taken to maintain the reservoir free from vegetation.

The third possible future impact involves the changing of the method of operation of the reservoir. This will be further discussed in the analysis and report for the Normanskill Hydroelectric Facility. As presently operated, the reservoir levels throughout the year do not vary greatly. In a typical year, the water surface of the reservoir may drop no more than 5 feet below the normal high water elevation at the top of the flashboards. Should the operating rules of the reservoir be modified to allow increased withdrawals for water supply or increased withdrawals from reservoir pool storage for hydraulic pumping or for generating hydroelectric power, the pool elevations might be significantly lowered. This would occur, in the latter case, if discretionary use were made of the storage pool capacity available in the reservoir for hydroelectric generation. Increased water supply demands would affect water levels since water supply would be taken on an annual basis and would draw from this pooled storage capacity regardless of water level. Wide fluctuations in the reservoir water surface elevation will affect both the amount of sediment in the reservoir and the distribution of the sedimentation in the reservoir. As presently operated, the reservoir is assumed to have a Type II reservoir depth versus capacity configuration as defined by the U.S. Bureau of Reclamation. This type of reservoir has been empirically determined to build up sediment and distribute sediment in certain patterns. With the water surface levels fluctuating greatly, these patterns associated with Type II reservoirs will change. Further analysis of these changes will be accomplished in the Hydroelectric Facility Report.

Conclusions

The following conclusions are offered for each module of the hydrologic analysis:

Data Base - No significantly useful stream flow data is available from the historical record prior to 1967. The meager data available was used as a guide and historical reference but could not be used analytically. An excellent stream flow data base was available from U.S.G.S. for the period 1967 to 1977 for the Normans Kill and the Hunger Kill. Excellent data relating to land use and soil conservation in the watershed is available and was used extensively in this analysis.

Physical Survey - The photogrammetric examination of the existing reservoir shoreline coincides closely with that depicted by Solomon, Norcross and Keis. Deviations from the original shoreline occur at points of bank erosion. The limited depth soundings taken correlate closely with predicted volumetric losses due to sedimentation. The composition of core samples retrieved from the resevoir sediments is typical for reservoirs of this type and size.

Stream Flow Synthesis - A long-term (500 year trace) record of stream flow has been stochastically developed. It is believed to be an accurate representer of stream flow conditions for low flow considerations. The response of the model for high flow (flood) conditions has not been determined. Furthermore, the model can be recalibrated and its accuracy improved with the further stream flow data expected from the existing U.S.G.S. gauging stations. This stream flow model will be used with modification and refinement as the cornerstone of the hydroelectric generating scheme model and operating system.

Soil Loss - The watershed soil loss is termed "excessive" by the United States Soil Conservation Service as it relates to agricultural practices. However, the soil loss and resulting reservoir sedimentation are typical for a watershed of this type and land use. A further definition of the soil loss problem will be forthcoming in 1979 when the Soil Conservation Service has completed a Special Study under the Coopeeative River Basin Plan for the Normans Kill watershed. This data will be of use for conservation planning but it is not expected to materially affect the capacity or yield determinations of this report.

Capacity Determination - The several methods used in determination of the existing physical capacity (volume) of the reservoir yield results of similar magnitude. With the reservoir elevation at 259 (full reservoir) taken as a reference, the available active storage calculated by Solomon, Norcross & Keis in 1916 was between 1320 and 1690 million gallons with 1530 million gallons as the mean capacity (Figure 5). Decrementing this mean capacity for calculated sedimentation, the usable storage is 1450 million gallons at the present time (Figure 6). Based on spot soundings, the capacity is determined to be 1360 million gallons. It is this figure (1360 mg), thought to be conservative, that is used for determination of the probable water supply yield of the impoundment.

Yield Analysis - The "maximum yield" of the reservoir for water supply purposes is defined as that amount which can be continuously withdrawn with a specified likelihood of failure. The definition of failure is an empty reservoir. The maximum amount of drawdown (lowering) of the water surface is limited by the physical position of the water intake at the reservoir.

Specifically, for the Watervliet Reservoir, as depicted on Figure 8, the safe yield with a 99.8% reliability (0.2% probability of failure) is 12 million gallons per day. A 0.2% probability of failure is one year in 500 years. Similarly, the safe yield at 98% reliability (one year in 50) is 14.3 mgd.

It should be understood that the utilization of maximum yield does not imply available supply of a consistent quality of water, since extreme drawdown conditions will certainly affect water quality adversely.

Discussion of Error - Sources of error pertinent to this analysis have been identified and minimized to the greatest extent possible. Further adjustment and refinement of the reservoir model deveoped should be directed in part toward refinements in accuracy of the model at high flows.

Future Impacts - There are considerable future impacts upon the Watervliet Reservoir. An impact of prime importance is the further intensification of land development. Establishment of watershed rules and regulations should be undertaken with the cooperation of the Town of Guilderland. The quality and quantity of water from this impoundment are related to land use in the watershed.

The reservoir is a capital asset with an economic life dependent upon the proper operation and maintenance of the facility. As a man-made facility interfacing with the natural forces of eutrophication and sedimentation, the reservoir can serve its intended uses only through man's intelligent and considered intervention.

APPENDIX A

STREAM FLOW SYNTHESIS
&
PROBABLE YIELD ANALYSIS METHODOLOGY

The relatively short period of available historical records made direct interpretation of stream flow records ineffective in assessing a probability distribution of available reservoir yield. The statistical correlation between rainfall records and watershed runoff records was found to be poor and a generation scheme based upon the ample rainfall records was also ruled out. Likewise, correlation beteen the reservoir watershed runoff and other stream flows for which longer historical records were available was inconclusive and a streamflow analysis by comparative hydrology was not used.

It was therefore decided that a flow simulation scheme would be used in the study so that a lengthy synthetic record of reservoir watershed yield could be available for analysis. Although not an actual historical record, the model would statistically resemble the comparatively short historical record and have the distinct advantage of adequate length and variety.

The reservoir watershed runoff model that was selected for simulation is a Markov model having the statistical properties that resulting flows have a deterministic component and a random component. It is the property of a normal Markov process that elements in a generated series have correlation to elements preceding them. In this instance, flows representing monthly mean reservoir watershed runoffs were generated and the persistence correlation was limited to one month, the simplest form of Markovian flow model. That is to say, the model assumes that the entire influence of the past on the current flow value is reflected in the previous flow value. The deterministic component of monthly flows, therefore, is a linear auto-regressive form of the historical sample's monthly mean plus the persistence element which correlates the model's previous month's departure from its sample monthly mean to the current month's departure in proportion to the standard deviation of the historical monthly flows. The random component of monthly flows is computed using a random standard normal deviate series. This series of random numbers has the statistical properties of a normal frequency distribution with a zero mean and unit standard deviation. The magnitude of the random component is a function of sequential random numbers from the series, the correlation to the previous month's flow and the standard deviation of the historical flows for that month. The normal distribution of the random standard deviate series imparts to the synthetic flow sequence also a normal distribution. Likewise, the standard deviation of the historical monthly flows is preserved in the model by factoring it into the computation. A discussion of how the type of frequency distribution was determined and the means of arriving at the historical record flows is described in subsequent paragraphs.

The generation of the random normal standard deviate series employed the computer's capability of generating random numbers having a uniform distribution. A series of 600 numbers was generated in each sequence by the computer program for use in computation of 50 years or 600 months of flow, since flow sequences were generated and stored by the computer program in 50-year blocks. Six hundred totals each of six uniformly distributed random numbers ranging from 1 to 1,000 are first determined. These random totals have an approximately normal distribution. Subtracting the mean value of these 600 normally distributed random totals from each total and then dividing each element of the resulting series by the standard deviation of the series, we are left with a series of 600 random numbers having a frequency distribution which is approximately normal and having a zero mean and unit standard deviation.

A digital computer was used extensively in the computation. The computer was equipped with approximately 42,000 bytes of available active memory and was programmed in APL programming language. A 500-year flow sequence was generated in 50-year increments containing 600 monthly values each and was stored on magnetic tape files requiring 5,000 byte blocks each of floating point storage. The generation of 500 years of synthetic flow records required approximately four hours of running time exclusive of determination of model statistical parameters based upon analysis of historical records.

The following is an outline of all sequential steps taken and of the most important assumptions made during the progress of the study in order to accomplish the probabilistic determination of water supply yield at the existing Watervliet Reservoir:

1. United States Geological Survey Water Resources Data was researched in order to obtain runoff records for the entire period of record by months from October 1967 to September 1977 for the 131 square mile drainage area of the Normans Kill measured downstream from the dam in Guilderland near State Highway 155.

2. Similarly, recorded flows were gathered for the same period for the eight square mile drainage area for the Hunger Kill, tributary to the Normans Kill upstream from the Normans Kill gauging station and downstream from the Watervliet Dam.

3. The operator's log at the Watervliet pumping station was researched for the entire period of all notations regarding water level elevations in the reservoir and other miscellaneous information regarding water supply usage and turbine operation. This information was correlated with monthly stream flows for the record period.

4. The net monthly mean reservoir inflows for the ten-year period were computed based upon the recorded flows in the Normans Kill downstream from the dam. Additions to the basic flow in the Normans Kill were made for water diverted from the reservoir for the City of Watervliet in the Town of Guilderland for water supply purposes and also for increases in reservoir storage due to increased water level in the reservoir from month to month. Subtractions were made from the basic flow for recorded stream flows in the Hunger Kill as well as for that portion of the Normans Kill drainage area downstream from the dam and upstream from the gauging station. The assumption that this downstream area contributed 9.82% (11/112) as much runoff as the reservoir watershed was used.

5. Sample frequency distributions for mean monthly runoffs and the natural logarithms of these runoffs were plotted in order to determine a representative frequency distribution of stream flows for each month for use in stochastically generating simulated monthly mean runoff sequences. Although there were only ten historical values for each month on which to base the choice, the assumption of a log-normal frequency distribution appeared to adequately represent the historical record of reservoir inflows.

6. Lag-1 statistical serial correlation coefficients were determined for the historical ten-year record correlating the logs of the mean monthly inflows for a given month and those for its preceding month. This correlation is a measure of the tendency in the historical sample, and thereafter in the stochastically simulated model, for a departure in a given month from its sample monthly mean to be repeated in the following month by a similar departure from its monthly mean. The samples referenced in this case are the natural logs of the historical inflows.

7. The computer program was then developed to simulate (generate synthetic values of) monthly mean reservoir runoffs for an extended time period using a stochastic Markovian Lag-One seasonal model assuming log normality of distribution. A stream flow synthesis for a 500-year period was thereby produced resulting in a 6000-month synthetic record of monthly reservoir inflows which had the statistical properties that the frequency distribution of its logarithms was normal, and the means, standard deviations, and Lag-One serial correlation coefficients of the logarithms of the monthly mean flows matched that of the historical record. The synthesized sample was otherwise completely random. The Lag-One serial correlation coefficients correlating logarithms of the mean monthly flow for January through December with its preceding month that were determined and used in the simulation were .73, .50, -.29, .09, .18, .62, .67, .20, .52, .82, .26, and .15, respectively.

8. Using the 6000-month record of inflow simulation, a reservoir operating model using computer was run assuming a uniform monthly draft rate taken from the reservoir for several sample draft

rates. The amount of reservoir storage deficit below full for each of the 6000 months at each draft rate was tabulated. In each case, the reservoir was found to have refilled by March so that no operating deficits below full reservoir were carried through the following year.

9. From the deficit tabulation at various draft rates, the frequency distribution of reservoir storage deficits was determined versus uniform draft rate from the reservoir. That is, the number of times in 500 years of stream flow synthesis that a storage volume requirement would be exceeded at draft rates of 6, 10, 14 and 18 mgd was tabulated and plotted.

10. Finally, the reservoir deficit analysis was plotted in a form which demonstrated the reliability of safe, uniform yield of the simulated water supply versus the reservoir capacity required to realize this yield. A reliability of 99% implies that the required reservoir capacity would be exceeded once in 100 years at the indicated draft rate, and the 99.8% reliability implies once in 500 years.

11. This probablistic approach must be recognized as representing the reliability of a given yield in the 500-year reservoir streamflow simulation. The validity and accuracy of the risk analysis are naturally dependent upon the validity of the various assumptions hereinbefore explained. We are obviously limited by the brevity of the historical record to verify assumptions of the log normalcy and to accurately determine the long-term mean, standard deviation, and Lag-One monthly correlations and the validity that the historic record period is representative statistically of much longer period. We feel that for low flow considerations of this report, that the period is sufficiently representative for values for mean and standard deviations to yield proper results. The most significant factor in determining safe yield of the reservoir is the probability that extreme low flows in a given month will be repeated for 3, 4, 5 or even 6 months in succession, and the most significant factor in this determination is

the Lag-One monthly serial correlation of flows. The synthesized flows are extremely random with only correlation coefficients influencing the persistence or tendency for low flows to follow low flows.

The alternative to this method of analysis is comparative stream flow hydrology from a similar stream with a long record of historical flows, and we feel that the necessary assumptions in utilizing such an alternative method are likely to be significantly inaccurate or inappropriate.

APPENDIX B

SOIL LOSS DETERMINATION METHODOLOGY

The soil loss analysis was based upon computations for sheet erosion and stream bank erosion for the entire Normans Kill watershed. As defined by the Soil Conservation Service, sheet erosion includes geological, natural, normal, rill, sheet and splash erosion. Gully and wind erosion are considered insignificant and are not included in this analysis.

The analysis uses the Universal Soil Loss Formula developed by the U.S. Department of Agriculture. Raw data compiled by the Albany and Schenectady County Soil Conservation Service offices was obtained for purposes of our analysis. The raw data includes estimations and quantification of parameters on an area basis for numerous capability subclasses and dominant soil types. This raw data includes "K" factor estimation (soil erodibility), slope length, slope, and "C" factor (conservation practice). Since the Albany County raw data includes portions of the Normans Kill (watershed No. 177) basin downstream from the Watervliet impoundment, a disaggregation of those areas downstream was made. The disaggregation was done on a small scale (several acres) basis using New York State Land Use Natural Resources (LUNR) inventory mapping. Upon a base map of the sub-basin area on which "K" factors were noted, overlay maps were superimposed. These overlay maps consisted of (1) capability subclass and dominant soil characteristics mapping, and (2) predominant land use (LUNR data). From this disaggregation, a tabulataion corresponding to the total Albany County Normans Kill sub-basin tabulation was prepared. Soil loss for the watershed tributary to the Watervliet Reservoir was defined as Albany County total plus Schenectady County total minus Albany County disaggregation portion. Spot verification was made of both Albany and Schenectady County raw data to verify the validity of the data. Certain correction factors for non-contributing areas such as ponds, lakes and rivers were made to the raw data. Arithmetic manipulation of the resulting data matrix yielded a quantification of the total tons per year for the watershed tributary to the Watervliet Reservoir. A separate calculation for stream bank erosion was performed using stream bank erosion quantities determined by Soil Conservation Service. Total annual soil loss was then proportioned for each month of the year based upon a percentage of precipitation falling during that month. Minor correction factors for winter months were made. A sediment delivery ratio was then applied to these monthly figures. The sediment delivery ratio is an empirical ratio based upon watershed size that yields the percentage of soil loss actually entering and transported by the major stream courses in a watershed. The result of the soil loss analysis is a determination of the total tons delivered to the entrance of the reservoir for each month of the year.

APPENDIX C

SEDIMENTATION ANALYSIS METHODOLOGY

Using the data developed under the soil loss portion of the analysis, a sedimentation rate, or number of tons delivered to the reservoir on a monthly basis, was determined. Trap efficiencies for the reservoir were calculated similarly on a monthly basis. This trap efficiency was calculated on a monthly basis because of the wide variation in stream flow from month to month. The trap efficiency determination was developed by Brune [Ref. 31]. It is an empirical coefficient whose value is a function of the ratio of reservoir volume to mean flow. Using the twelve monthly trap efficiencies thus calculated, a value for the number of tons retained in the reservoir for each month of the year was obtained. These twelve values were summed, giving an annual sedimentation load in tons per year.

Conversion of this annual sedimentation rate into expected volumetric changes was then performed. The density of soil deposited in the reservoir is dependent upon the constituency of the soil. General guidelines for particular watersheds and reservoir types relating to percentages of silt, clay, etc. were obtained. As a check on these empirically developed values, field sampling of in-place sediments was performed, using a Pfleder sediment sampler. The recovered core samples were visually classified and tested for moisture content, specific gravity and grain size distribution. The determined values were then used in standard soil state calculations to derive unit weights. The unit weights and specific densities of the samples taken were then manipulated to yield a sediment density calculated to be 62.7 pounds per cubic foot. Since further consolidation of sedimentation occurs over a time, an average weight at the present time (T = 62 years) was determined using the relationship:

$$W_T = W_T + .4343\ K\ [\ \frac{T}{T-1}\ (\log_e T-1)]$$

where W_T equals weight at T years

W_1 equals initial weight

K equals constant based on a grain size analysis of the sediment.

Further calculation to determine the weight at 100 years was similarly made. By dividing the annual sediment retained in the reservoir by these average weights, the volume displaced by sediment was thus determined.

Distribution of this calculated sediment volume over all elevations of the reservoir was made using the Area-Increment Procedure. This procedure is basically an iterative procedure for distributing the volume loss proportionately over all elevations.

APPENDIX D

PHYSICAL SURVEY METHODOLOGY

A physical survey was performed on the reservoir to yield in-place data relating to sedimentation and also for verification of actual depths. The methodology for the sediment determination is discussed in Appendix C "Sedimentation Analysis Methodology". Spot depth soundings were performed for verification of actual volume loss by the following method:

The reservoir was divided into six component areas. These component areas were generally wide areas separated by narrow channels. Across each of these areas and across several of the channels range lines were established. These range lines consisted of a base line extending from one side of the reservoir to the other. The base lines were documented so that they can be relocated and checked in the future for additional sedimentation calculations. Using an electronic distance meter (EDM), located on one shore, the sounding boat completed a traverse to the other shore. At predetermined intervals soundings were made using a line and sinker method and the distance to the sounding point was measured by the EDM. This field survey took place during a period when the elevation of the reservoir was below full capacity (flash board height) so no head water calculations were necessary. In addition, the entire field survey for soundings was performed on a calm day so that no wave-induced elevation errors occurred. Pool elevation was then transferred to a physical benchmark located at the dam. Using the spot hydrographic data thus obtained, cross-sections for each range were plotted and were compared with cross-sections derived from the original topographic survey performed by Solomon, Norcross & Keis, Engineers. These cross-sections are presented as Figures 3 and 4.

APPENDIX E

CAPACITY DETERMINATION METHODOLOGY

The physical capacity of the reservoir was determined by several methods. Due to the limited financial resources and due to other logical considerations, a complete field topographic or hydrographic survey could not be made. Capacity versus elevation curves were developed for three different conditions.

The first condition was simply a capacity versus elevation curve using Keis' original topographic analysis. A curve was developed utilizing Keis' topographic values exactly as shown on the original mapping. Two additional curves were also developed using these contours but assuming a possible error of plus or minus one-half contour interval or 2-1/2 feet. The three curves thus developed were referred to as "Keis' mean", "Keis' high", and "Keis' low" capacity curves (Figure 5).

The second condition is a graphical representation of capacity versus elevation using the original "Keis' mean" contour data decremented by sedimentation calculations to yield a reduced capacity curve projected for 62 years (at present time) and for 100 years (expected capacity in the year 2016).

The third condition for capacity determination utilized the physical hydrographic data obtained over the five sample ranges. Each range was compared to a calculated cross section derived from Keis' original topographic survey. A percentage change was calculated for each elevation and the resulting gross reductions by cross-section were then tallied proportionally to reservoir areas in relation to the ranges. A composite capacity curve was thus developed yielding cumulative volumes vs. elevations. The results of this condition for volumetric determination are presented in Figure 7.

It was found that the capacity curve determined by soil loss, Figure 6, and the capacity/elevation curve developed as a result of cross-sectioning, Figure 7, correspond closely. Also noted on each of the graphs is the minimum water surface elevation necessary to supply water to the City of Watervliet via the intake rack located on the Watervliet dam as well as to the Town of Guilderland via the lowest intake opening on the Guilderland Water Pumping Station and intake structure. Usable capacity is thus defined as the volume of water stored above elevation 240 in the reservoir. Storage below elevation 240 is termed dead storage and is unavailable for draft.

L - Low occurrence
M - Medium "
H - High "

APPENDIX F

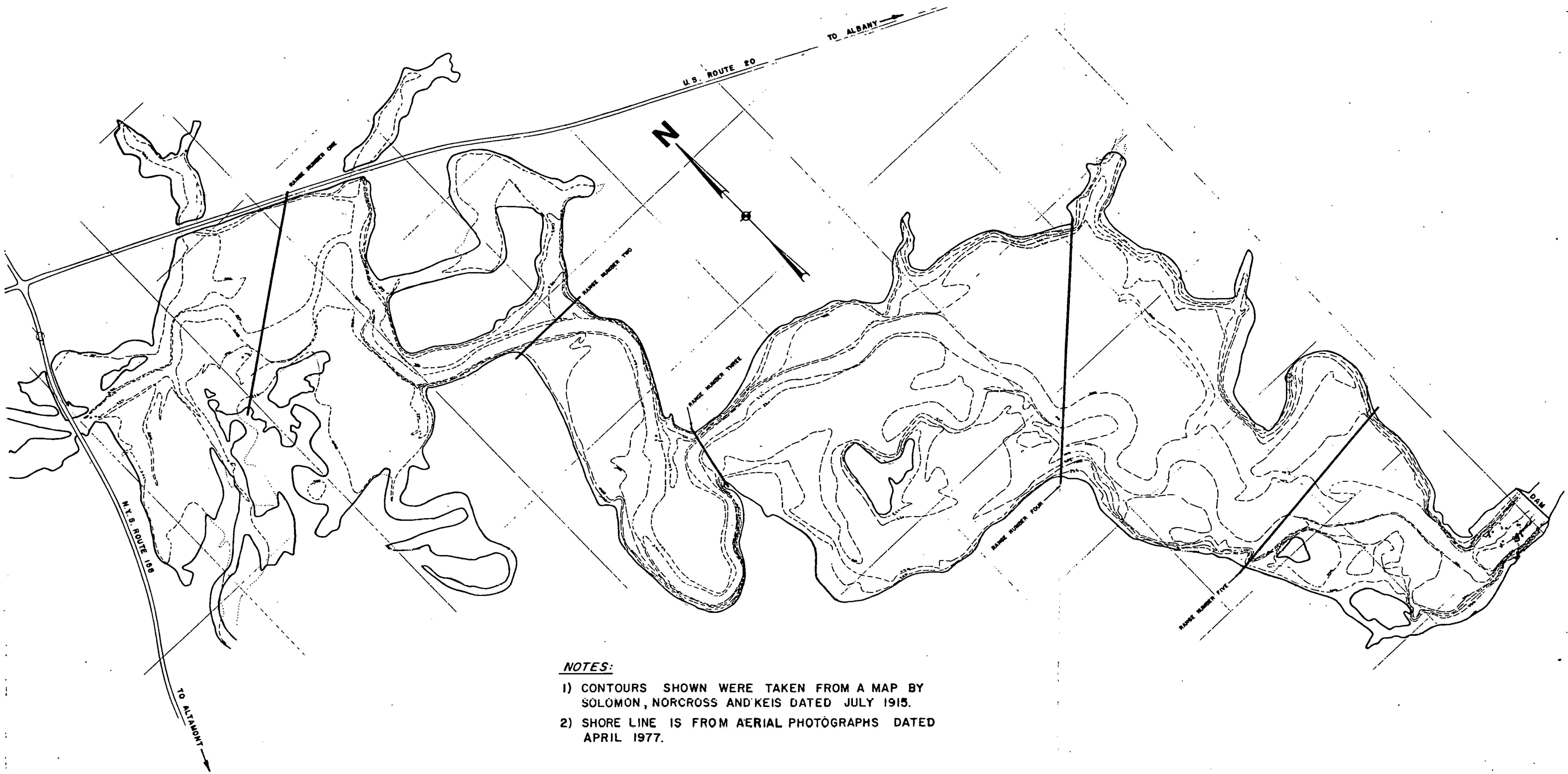
RECOGNIZED ERROR - OCCURRENCE

Analysis Module	Errors: Judgmental	Errors: Observational	Errors: Analytical	Comments
U.S.G.S. Flow Data	L	N.A.	M	High error probable on high flows only.
Operator Logs	L	M	N.A.	Numerous data points minimize sensitivity. Data verifiable by other sources.
S.C.S. Soil Loss Data "K" factor	L	N.A.	L	Multiple observers minimize errors.
"C" "	M	N.A.	N.A.	
"R" "	L	N.A.	L	
"P" "	M	N.A.	N.A.	
Area	L	N.A.	N.A.	
Rainfall	L	L	L	
Land Use Data (LUNR)	H	L	L	Multiple observations and small scale minimize errors. Most errors relate to resolution of non-structural (non-urban uses. For this study differentitation of the type not significant.
Photogrammetric evaluation	N.A.	L	L	
Sediment sampling	L	H	L	Multiple records, verifiable with other data.
Hydrographic survey	M	L	L	Selection of ranges sensitive to judgmental error.
Historic record	See data base above.			
Frequency distribution	M	L	L	Multiple season model minimizes error.
Computational method	L	L	L	

APPENDIX F

RECOGNIZED ERROR - OCCURRENCE

Group	Analysis Module	Errors: Judgmental	Errors: Observational	Errors: Analytical	Comments
Soil Loss	SCS Soil Loss Universal equation	N.A.	N.A.	M	Universal model is empirical.
CAPACITY DETERM.	Sediment distribution	L	N.A.	M	
CAPACITY DETERM.	Capacity/Elevation curves	N.A.	N.A.	L	
YIELD ANALYSIS	Reservoir operation simulation	L	L	L	Computational algorithms use digital computer and are based on simple arithmetic computations.
YIELD ANALYSIS	Failure density	L	L	L	



NOTES:

1) CONTOURS SHOWN WERE TAKEN FROM A MAP BY SOLOMON, NORCROSS AND KEIS DATED JULY 1915.
2) SHORE LINE IS FROM AERIAL PHOTOGRAPHS DATED APRIL 1977.

CITY OF WATERVLIET RESERVOIR, LOCATED IN TOWN OF GUILDERLAND

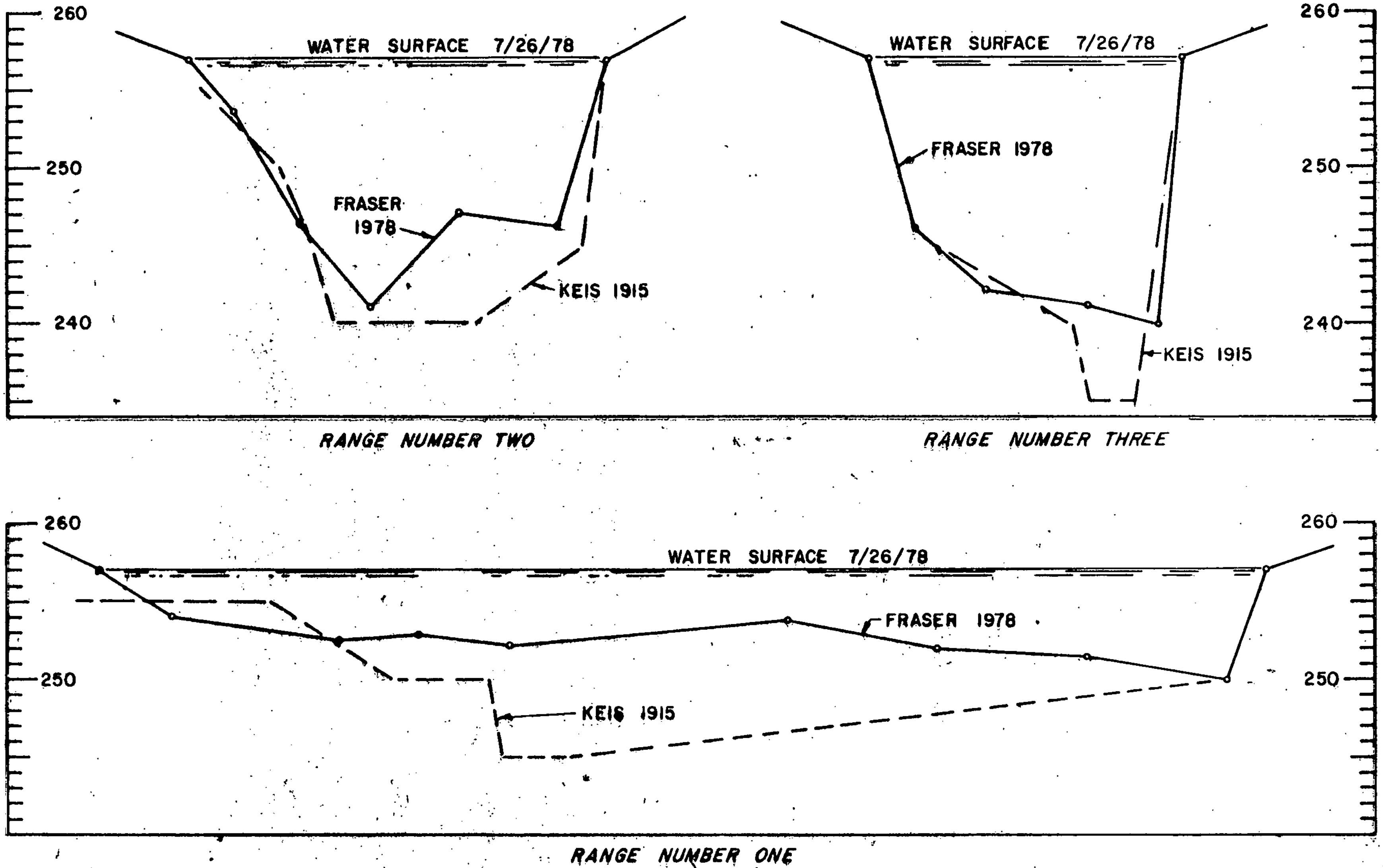
SCALE: 1" = 727.3' ±

2

RESERVOIR CONTOURS

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



PROFILES

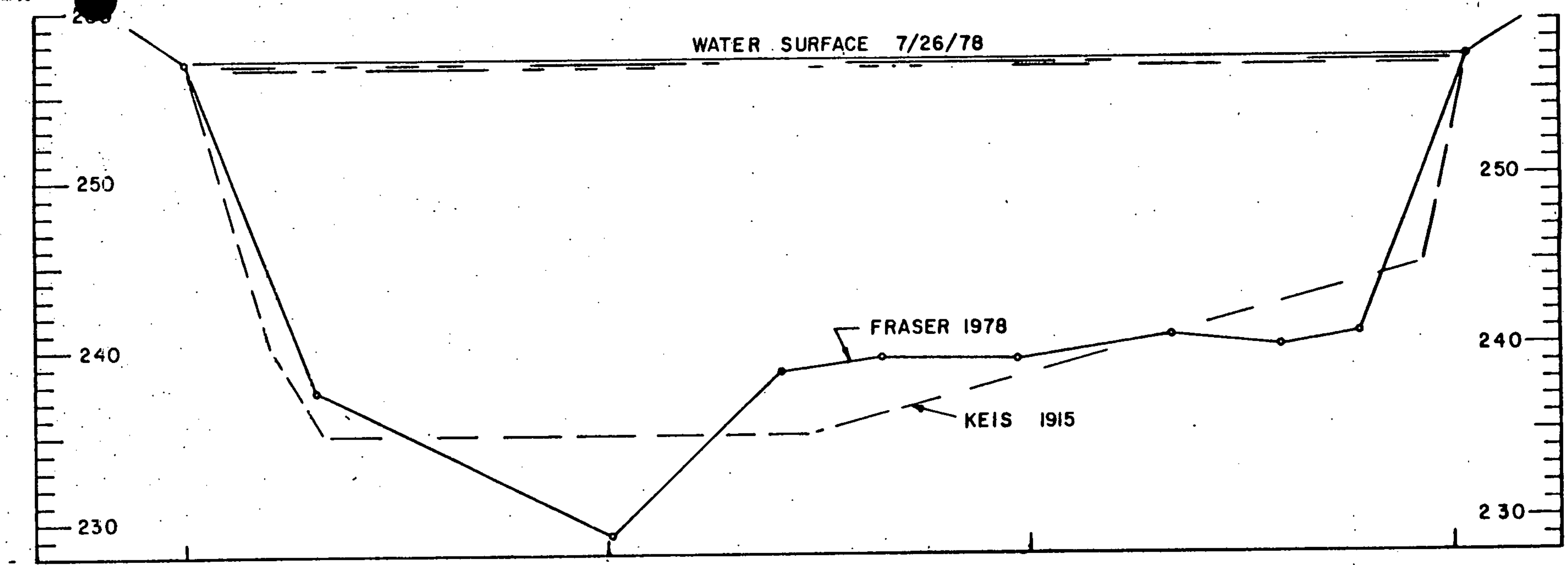
SCALE: VERTICAL 1" = 10'; HORIZONTAL 1" = 200'

NORMANSKILL HYDROELECTRIC FACILITY

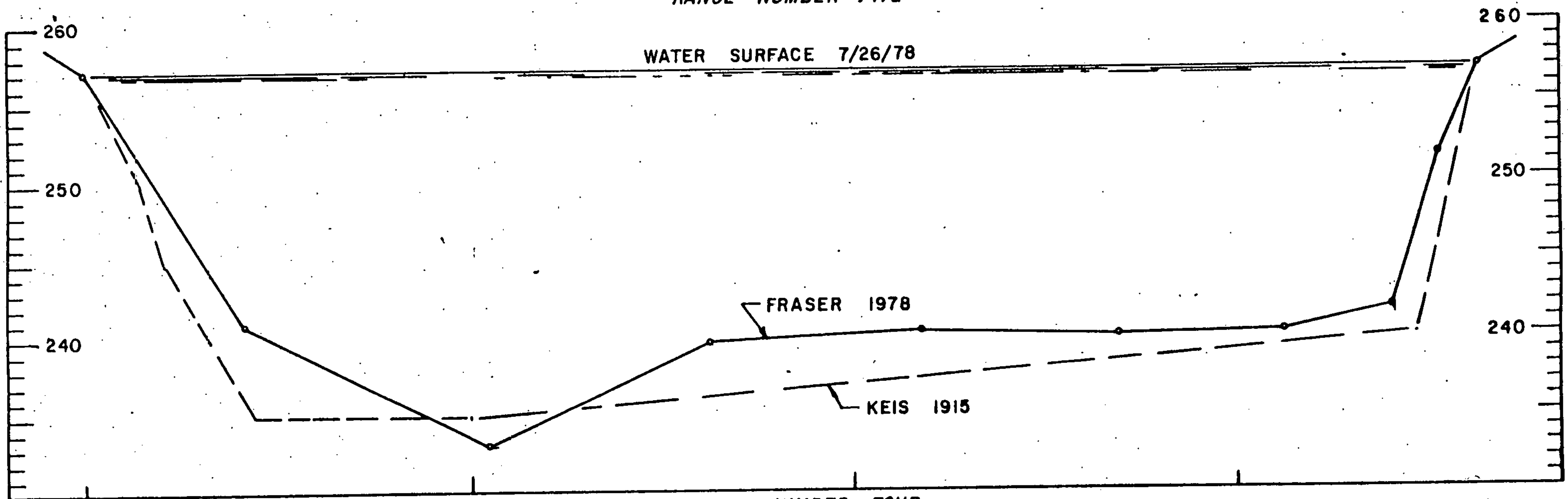
FEASIBILITY ASSESSMENT-EW-78-F-07-1765

RESERVOIR PROFILES

3



RANGE NUMBER FIVE



RANGE NUMBER FOUR

PROFILES

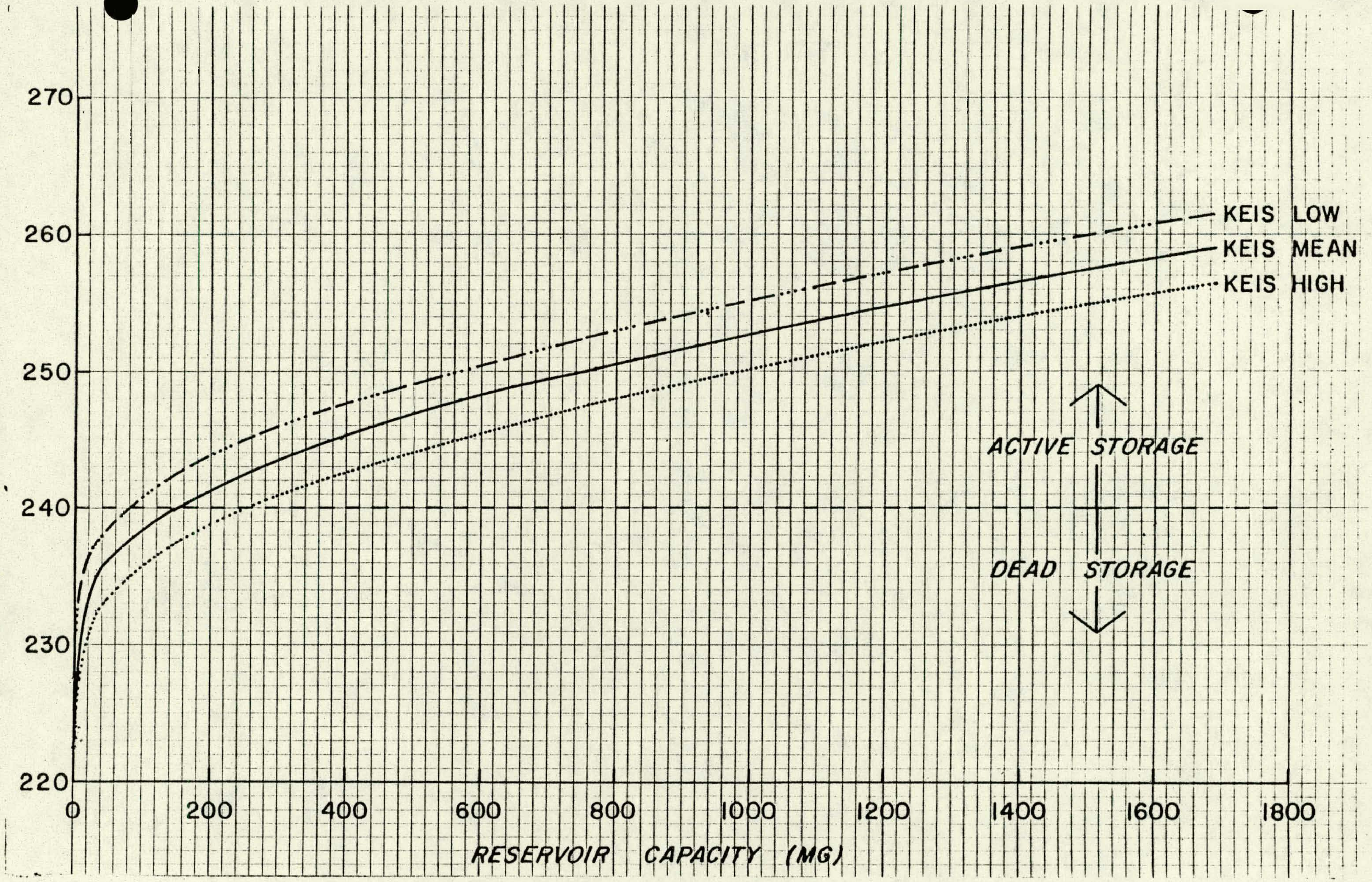
SCALE: VERTICAL 1" = 10'; HORIZONTAL 1" = 200'

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

RESERVOIR PROFILES

4

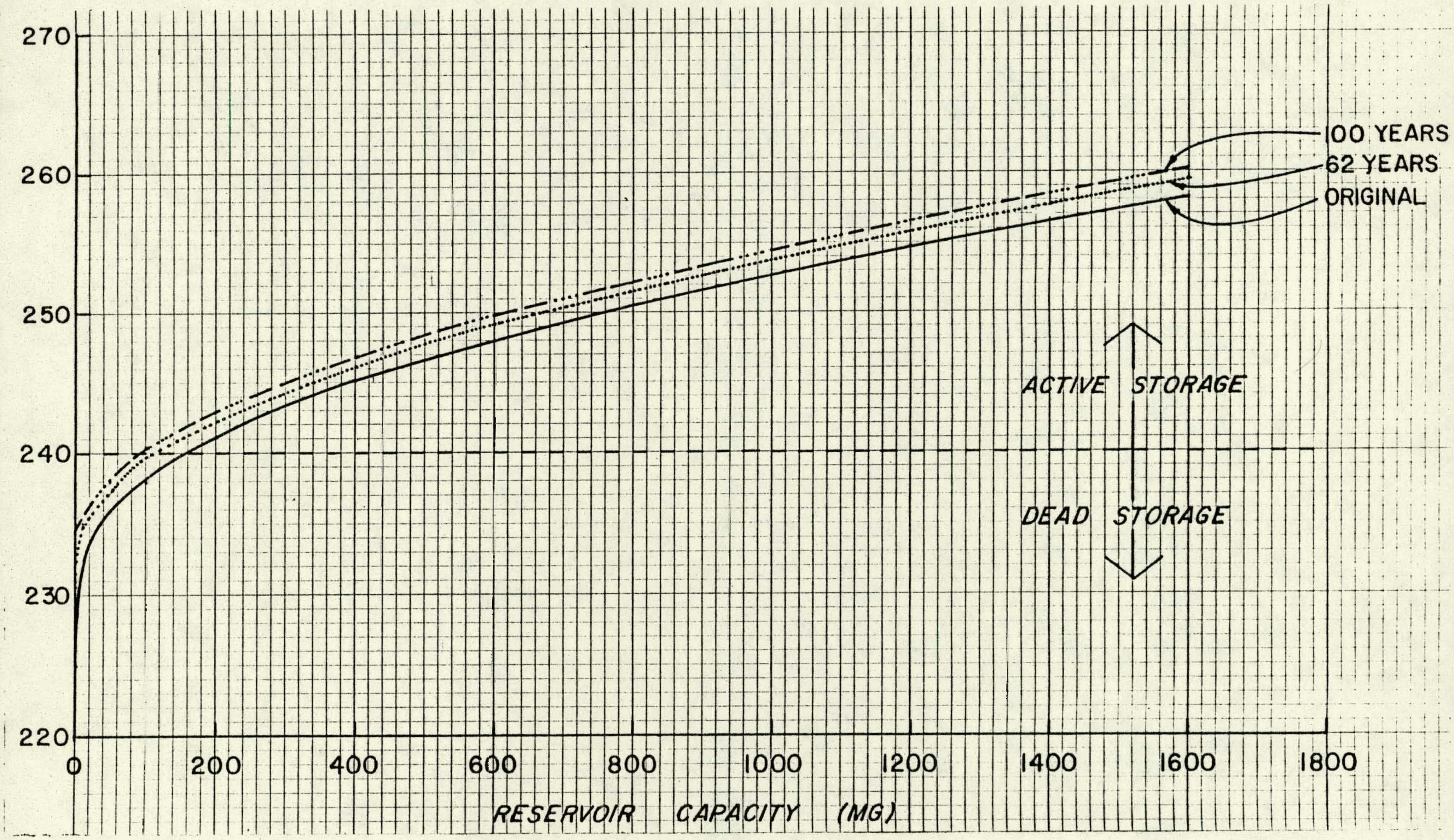


NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

RES. CAPY. vs SURFACE ELEV. (KEIS)

5

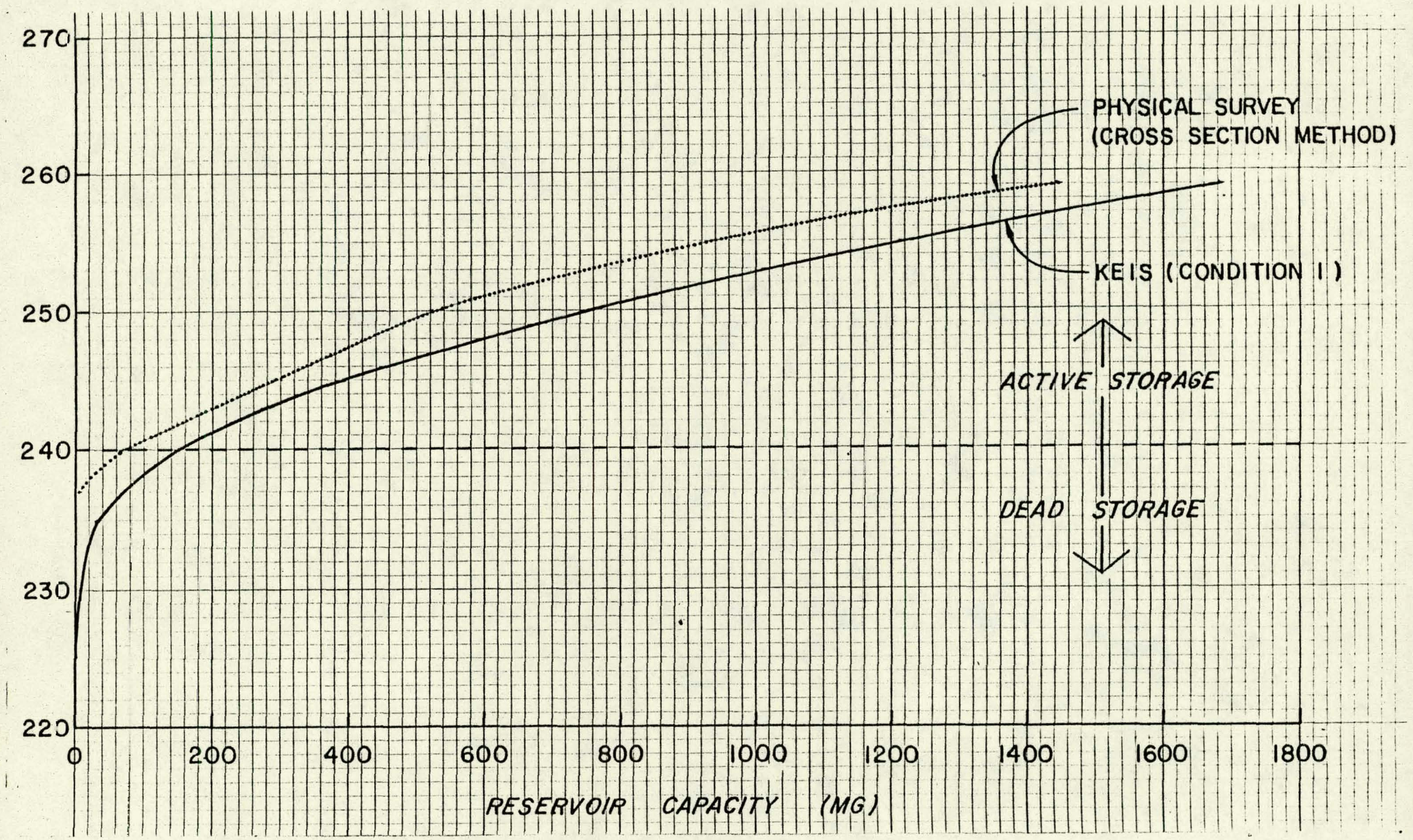


NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

RES. CAPACITY vs SURFACE ELEV. (PREDICTED)

9

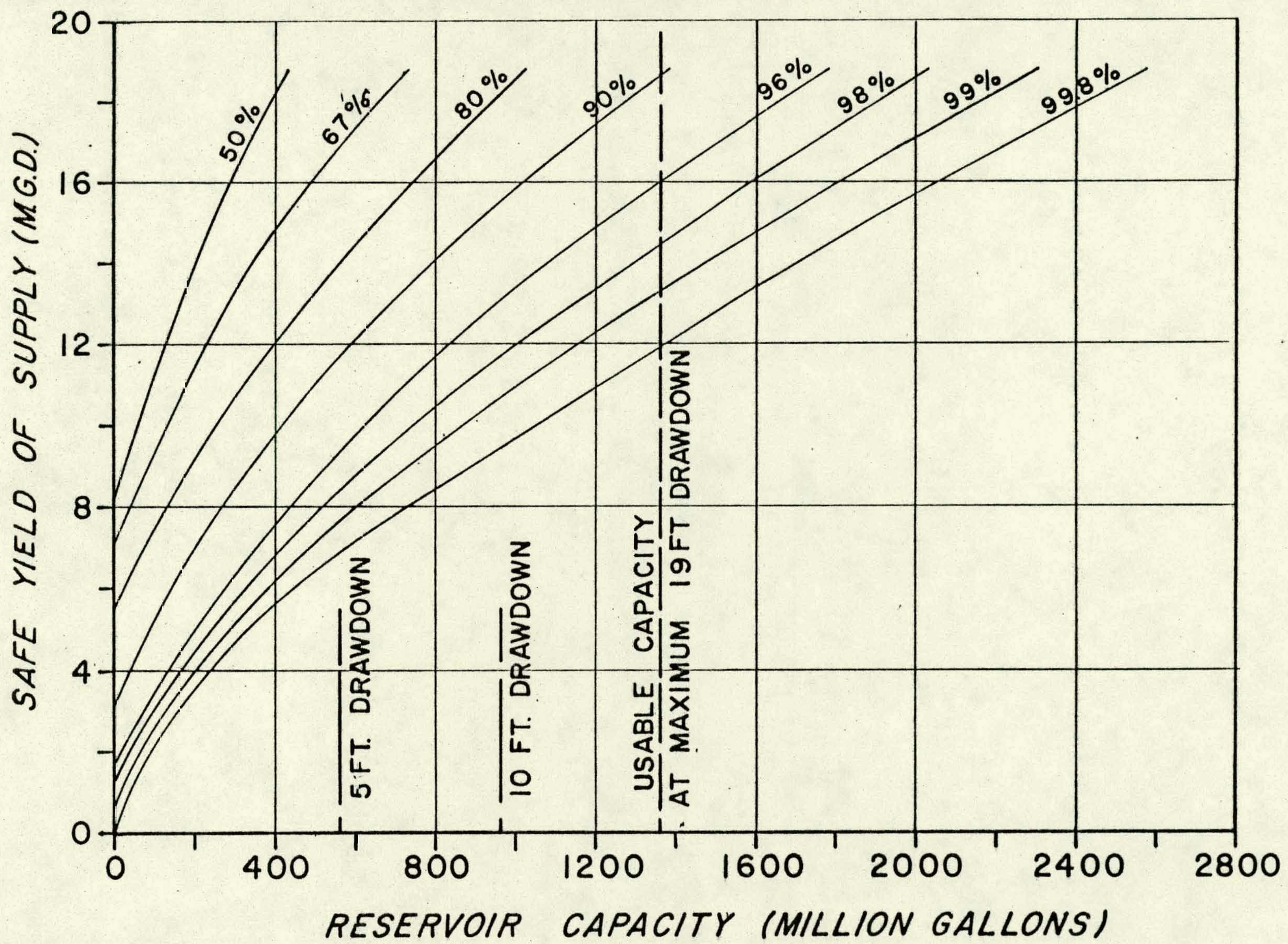


NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

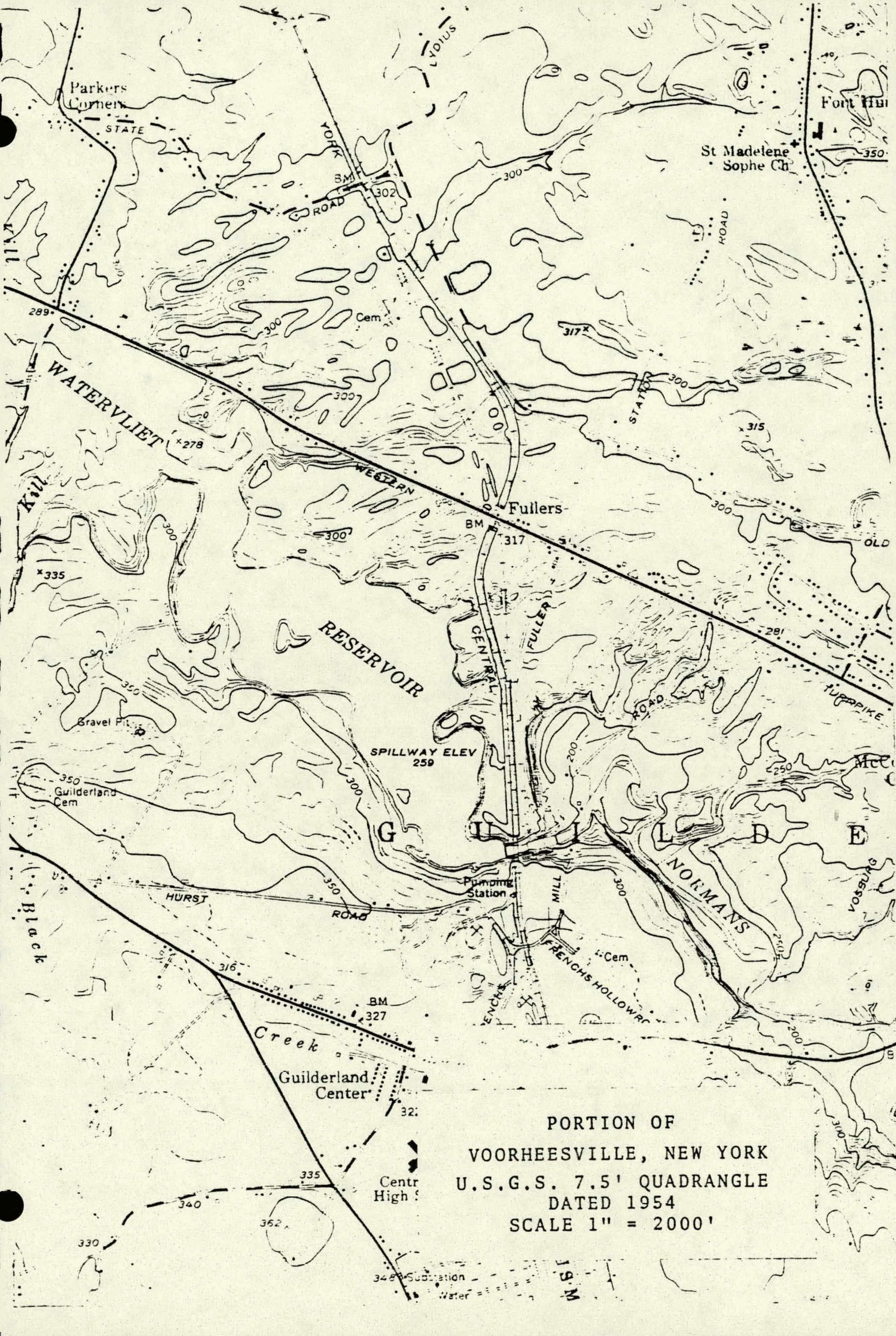
RES. CAPY. VS SURFACE ELEV. (MEASURED)

7



RELIABILITY OF WATER SUPPLY YIELD vs. RESERVOIR CAPACITY
BASED ON 500 YEAR STOCHASTIC RUN-OFF MODEL

NORMANSKILL HYDROELECTRIC FACILITY FEASIBILITY ASSESSMENT-EW-78-F-07-1765	WATER SUPPLY RELIABILITY	8



PORTION OF
VOORHEESVILLE, NEW YORK
U.S.G.S. 7.5' QUADRANGLE
DATED 1954
SCALE 1" = 2000'

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

USGS QUAD LOCATION

9

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

DRAINAGE AREA

MAP INDICATING
DRAINAGE AREA TRIBUTARY
TO THE
WATERVLIET RESERVOIR

HYDROLOGIC - SEGMENT TWO

Data Base

Segment One of the hydrologic phase investigated the various elements of the existing Normans Kill impoundment as it relates to the community as a continuing source of municipal water supply. Therein, an attempt was made to quantify certain of the physical aspects of the reservoir such as magnitude and rate of siltation of the original impoundment, its remaining usable capacity and the effects of land use and age on the water quality for present and future users of the resource.

The water supply yield of such a water resource cannot be quantified as a single fixed number. The water originates in the hydrologic cycle in nature and enters the impoundment as watershed runoff from rainfall. It is affected by evaporation, transpiration, soil absorption and percolation, freezing and melting and a myriad of other factors. The quantity of runoff is largely a natural phenomenon and is partially random and partially predictable. Because of the random component of watershed runoff, it is misleading to try to describe the yield of a water resource without some corresponding explanation of the probability that a yield can be relied upon.

Our approach to determining the water supply yield of the Normans Kill impoundment recognized the tremendous variation in stream flow and the extreme importance of the storage capacity in the yield determination. Figure 8 (Chapter 2) displays the relationship which we concluded exists between the safe yield of the impoundment and the probability or confidence level that the impoundment will not be depleted by more than the capacity shown in millions of gallons.

Limited by the fact that the 10 year daily record of stream flow for the Normans Kill by the United States Geological Survey was gathered downstream from the dam, this record was of little assistance in determining the flow into the impoundment on a daily basis since reservoir levels on a daily basis were unknown. With the help of the log maintained by the operator of the existing water pumping station at the site, we were able to determine with reasonable accuracy the reservoir levels at the beginning of each month during the period of record and thereby to determine the monthly mean runoff available at the impoundment during that period. It is important hereafter to keep in mind that the actual stream flow data base for this water resource facility is therefore limited to 10 years of monthly mean flows from the period commencing October 1967 through September 1977.

Knowing that the runoff record for a 10 year period would not contain the worst combination of low flows which could be expected over a much longer period, we adopted an approach described in Chapter 2 to expand the data base statistically to enhance its usefulness. The statistical methods are described in considerable detail in Appendix A of Chapter 2. In the course of developing Chapter 2 of this report, a data base of 500 years of monthly mean watershed runoff values was derived by simulation. The simulated data retained all the important deterministic statistical parameters of the shorter historical record while also being capable of displaying a randomness found in natural phenomena.

The relationship displayed in Figure 8 is based on the entire data base of 6,000 monthly values for the 500 year simulation. A 500 year data base was required to develop the accuracy displayed in the probability curves. The water supply aspects of the Normans Kill impoundment concentrated on the lower range of water supply yield rate and a very high range of confidence. As one can see from Figure 7, the confidence level that a given drawndown will not be exceeded drops dramatically as one increases the yield of the reservoir.

In this segment of the report, we must determine the selection of the optimal design configuration of a hydroelectric generating facility and must answer the question whether such optimal configuration is economically feasible to construct. In contrast to the maximum reliability demanded for the water supply yield, it is not a prerequisite that a hydroelectric generating facility operate continuously. The criteria for optimal selection of the hydroelectric facility configuration is dependent on economic choices based on maximizing benefits or return on investment in the form of sale of power or reduction of current power costs, and simultaneously minimizing the costs necessary to achieve those benefits.

Determination of power producing capability is a function of a large number of variables relating to machine configurations, location, etc., but it is initially dependent on the quantity of water available to be committed to this purpose. It is our desired purpose to be able to express the benefit parameters for various configurations which will be investigated in terms of annual or monthly averages.

In determining such averages, it is a tempting but an erroneous oversimplification to utilize simple monthly or annual average runoff rates. Power production is limited by the machine configuration to a fixed maximum rate while the quantity of water which is allocable to hydroelectric generation may be available at an extremely wide range of rates depending upon reservoir storage and stream flow. A stream flow sequence may be comprised of many different combinations which produce the same average flow but which result in considerably divergent total energy output because of the random occurrence of flows which may be too great to be able to be utilized by a particular configuration. For this reason, the averages which we ultimately develop are in fact the result of mathematically modeling a given configuration through a long term sequence of simulated data and then determining the average or representative resulting parameter value for each month in the period, instead of utilizing a simple streamflow average. Economic benefits from power generation are likewise not determinable by prior averaging of stream flows or of turbine running times because of a discontinuous energy benefit rate structure. Inherent in this rate structure is the anomalie that the extreme high and low values of power production which contribute to an average value are in fact accruing benefits at extremely different rates.

A sufficiently large data base to give adequate variety to the data and to be consistent with the historical runoff record is required for use in the hydrologic computations for the hydroelectric generation study phase of this report. A 500-year flow simulation became available as a by-product of the Segment One study. We have chosen to use only the first 50 year block of this 500-year record as being adequate for purposes of the hydroelectric feasibility assessment since the time required to perform the extremely high number of trial computations using a greater length of data than a 600 month sequence would be prohibitive and would not significantly alter the results.

Since our computations in this study are monthly in nature, we have prepared a series of graphs (Figures 11-22) to display certain aspects about the data base for each month as used in each segment of the study. Each graph represents the data for a particular calendar month. The data is displayed using a logarithmic vs. probability scale since it was determined as described in Segment One, that the most representative distribution for the data points was log normal, or that the logarithms of the data points tended to have a normal distribution. The ten discrete data points represent a plotting of the historical record of flows determined by methods discussed in detail in Appendix A of the preceding chapter and arranged in such a way that each of the ten points taken in order of magnitude is plotted in the middle of its respective decade of cumulative probability of values being less than that value.

A distribution of values when plotted on logarithmic probability paper can be considered to be log normal if it can be reasonably assumed that they tend to define a straight line. This assumption was in fact made and incorporated into the process of modeling the data. Line A on each of Figures 11-22 depicts an idealized normal distribution statistically representative of the ten historical data points. The line crosses the median or 50 percentage point at a value whose logarithm is the mean of the logarithms of the ten data points. Two additional points on this line are then produced by computing the standard deviation of the logarithms of the ten values, adding and subtracting it from their mean and plotting the value whose logs are those numbers at points which are one standard deviation or 34.13% above or below the median respectively. The line thus determined is a representation of the distribution of data points using the mean and calculated standard deviation of the logs of the original data. The detailed computation as described in Appendix A of the preceding chapter describes how the simulation process using the computer was completed. Line A therefore represents the true distribution of data points that would be produced for a simulation of infinite length for each month. Our 500 year simulation is of sufficient length to approximate this line extremely closely. As described in Appendix A, distributions for each month are not independent, but contain a factor which reproduces the correlation between subsequent months of the historical record into the simulated record.

As explained previously, it was determined that a 50 year segment of the 500 year simulation was sufficient for the purposes of this segment of the study. The smaller subset of the 500 year sampling will naturally show some variations from the sample taken as a whole. Line B on Figures 11-22 is an idealized representation of the distribution of the data points in the 50 year simulation block. This line was produced in a manner similar to that described above using the mean and standard deviation of the logarithms of each element in the distribution. There are minor variations between the distribution of the 50 year Subset and that of the 500 year sample, however, uniformity has been adhered to in using the 50 year synthetic record in this segment of the analysis. We feel that the reliability of our computation has been greatly enhanced through the use of this simulation technique and that the 50 year synthetic record reasonably represents and augments the limited 10 year historical record.

We have discussed and presented individually the probability distribution for each calendar month, but have not conveyed a sense of continuity from one month to the next. Figure 23 displays the amount of monthly mean runoff available based on the 10 year historical record for each calendar month expressed in terms of the probability that such runoff rate will not be exceeded. We have presented this information with respect to probability levels of 10, 30, 50, 70 and 90 percent where the 50 percent or median level is the most likely value to occur and there is an 80 percent probability that the monthly average value for any randomly selected month will fall between the 10 and 90 percent values. We have attempted to impart a continuity to these confidence levels by sketching continuous curves for each in such a way that integration of the area under the curve approximates the numerical integration of the discrete values taken as constants during each month. We do not imply that an actual occurrence at any level will be followed by one at the same level the following month. There are factors correlating the tendency of such persistence to exist which vary from month to month and which is detailed in Appendix A preceding. It is sometimes helpful to be aware of the fact that the mean or average value of a sample of flow values having a log normal distribution is not equal to the median or most likely occurrence. In any of the monthly distributions the mean is always higher due to the existence of less frequent but disproportionately higher flow rates.

We have indicated on each monthly graph of data base frequency distribution (Figures 11-22) the mean value of the 50 monthly mean inflows to demonstrate distinction between the median and the mean for the 50-year simulation.

It is often of interest to relate the effectiveness of a water supply in terms of the mean annual runoff which enters it. The proportion of a stream's mean annual flow which can be utilized for water supply is primarily a function of the volume of storage capacity of the impoundment and the distribution of inflow occurrences. It is often desirable to develop a reliable use of at least 50% of a stream's mean annual flow for water supply. To do so, however, might require a usable impoundment storage volume of approximately 30% of the total annual runoff. The first 50 years of the 500 year monthly mean inflow simulation has been utilized in Segment Two of the hydrologic phase of this report as its data base. The mean annual flow of this 50 year sample is 4,852 billion cubic feet or 36,290 billion qallons. This value is 2.37% higher than the mean of the 10-year historical record. This fact can be attributed to the existence of infrequently occurring but disproportionately higher values in the larger sample which is to be expected. This total mean annual flow is equivalent to 154.8 cubic feet per second when it is expressed in terms of a uniform flow throughout the calendar year. The Normans Kill Impoundment has a maximum usable capacity of less than 1,400 million qallons or less than 3.8% of the total annual runoff.

Spillway Capacity and Overflow Potential of Existing Facilities

Under the National Dam Safety Program, the Department of the Army, New York District, Corps of Engineers, required by letter dated March 31, 1978, a Phase I Inspection Report to be submitted evaluating the safety of the Watervliet Reservoir Dam. The report [Ref. 102] dated July 05, 1978 was prepared by Tippets-Abbett-McCarthy-Stratton and evaluated the flood potential of the site and the capacity of the facility to withstand such flooding. We will not duplicate the computations of this referenced report, but we will cite its stated conclusions as they pertain to evaluating the safety of the dam.

Based on a maximum possible head of water on the dam with the reservoir water surface at an elevation equal to the top of the end walls of the dam 8.5 feet above the spillway, and assuming a weir coefficient of 3.8, the referenced report cites that the 324 foot long spillway has an overflow capacity, assuming no flashboards, of 30,500 cubic feet per second or 280 cubic feet per second per square mile of drainage area.

The referenced report further points out that no continuous flow records were maintained for the Normans Kill prior to 1967, but that indirect discharge measurements taken after August-October 1955 floods indicated a maximum discharge of 13,300 cubic feet per second downstream at Slingerlands from a 169 square mile drainage area which the authors transposed to an equivalent value of 10,900 cubic feet per second or about 96 cubic feet per second per square mile at the dam. At the U.S.G.S. gauging station established at Westmere in October 1967, the reported extreme maximum discharge for the 131 square mile watershed during a period of record through September 1977 is 5,580 cubic feet per second or about 50 cubic feet per second per square mile.

The Dam Safety Inspection Report concludes its Hydraulic/Hydrologic discussion in section 5 with the following evaluation: "The spillway capacity without flashboards is 79 percent of the estimated Standard Project Flood and with about 1.5 feet flow over the abutments it would pass the entire flood. As the dam is located in a confined valley with rock abutments, overflow of the abutments will not cause significant erosion or undermine the foundation of the dam. Therefore, from a hydraulic and hydologic standpoint the spillway capacity is considered adequate."

Flow Duration

Traditionally, hydroelectric generating facility machine configurations and sizes are determined with a very heavy reliance on a graphical display of stream flow versus percent of time or probability that the stream flow will be less than that value. We feel that this approach is inapplicable here and is insensitive to the cost rate structure of the various alternative machine configurations, the discontinuous nature of the benefit rate structure, the individual usage requirements, marketing constraints and a large number of individual factors unique to this location, situation and owner.

Initial Operational Model

Having created a data base of 50 years of monthly average runoff records, it was next necessary to determine how this data might be advantageously utilized. The study certainly would generate many different possible hydroelectric generating configurations, each with a variety of combinations of element sizes at different costs. The initial task would be to select the optimum combination of component elements to make a complete operating facility. The optimization process must be based primarily upon economic considerations, weighing the costs of various alternatives against their corresponding benefits. Costs consisting of initial capital costs and future costs in the form of labor and annual maintenance can be estimated with reasonable accuracy. The benefit side, or the return on investment, is the more difficult to assess since it requires a determination of the market value or credit accruable to the owner for the electrical energy which the facility as configured might be capable of producing. The economic benefits which result from the production of electrical energy cannot be determined knowing only the pertinent physical aspects of the various alternatives which will be investigated. It is first necessary to relate the quantification of the electrical energy production to the hydrologic factors, that is the availability of the natural resource, water.

The best method of investigating the performance of this type of an operating system is to mathematically model the intended operation and sequentially simulate the operation through each of the 600 months of synthetic data, making such simplifications as are necessary to enable computation to be made. We therefore developed a computer program to simulate the operation of a hydroelectric generating facility. The purpose of the program was to make a record of the length of time that the facility could operate and produce power for each month of the data period. It would be necessary to assess the effect that varying the volume of impoundment allocated to hydroelectric power generation would have on the calculated schedule of operation and power production. The initial model, therefore, was set up as a mass balance between inflows to the impoundment, drafts from it for water supply and hydroelectric power, and changes in volumetric storage of the impoundment, operating consistently under specified constraints.

The program permitted specification of the following variables:

1. The daily water supply requirement was assumed to be constant for each month of the computer run. A value of six million gallons daily was generally used and is a value which is unlikely to be exceeded in the near future.

2. The hydraulic flow rate to be used by the generating equipment was assumed to be held constant whenever the equipment is in operation.

3. The maximum permissible drawdown of reservoir level below the top of the flashboards is the level below which the turbine operation is required to cease. Water supply requirements, however, continue to be withdrawn from the reservoir regardless of reservoir level. It is therefore possible to have storage deficits in excess of that specified during periods where inflows into the reservoir are less than the amount being withdrawn for water supply.

The following additional assumptions were incorporated into the initial operating model in order to facilitate computation:

1. Inflows into the impoundment for each month are assumed to be uniform through the monthly period. This assumption is idealized and results in the calculation of maximum running times and power production because short duration peak flows which might pass over the dam uncaptured when the reservoir is full may not be reflected. A modification to this assumption is dealt with in a subsequent section.

2. Turbine operation is assumed idealistically to be unlimited in its on-off cycling during periods where inflows are insufficient to run the turbines continuously without lowering reservoir storage below shutoff level. In actual operation, controls would be set up to establish a minimum differential starting and stopping level, and some types of turbine equipment

would be capable of operating at variable flow rates down to perhaps 10% of their maximum rates so that inflows in this low range could be captured for power production with minimum cycling. This computational assumption will therefore contribute little error in determining the equivalent running time of the turbine at its assumed flow rate.

3. Reservoir storage volume is assumed never to exceed the full reservoir level, nominally taken as elevation 259 at the top of the flashboards. Excess inflows into a full reservoir in any period are lost over the dam and are assumed to be not recoverable.

The program computes the number of days that the turbine is capable of operating at its selected flow rate without drawing reservoir storage below the specified level during each month using the simulated inflows. The residual reservoir storage volume is calculated at the end of each month and is then used as the starting point for the following month's operation. The number of operating days for the following month is then calculated using the new starting reservoir volume and the next sequential monthly mean inflow rate from the flow simulation. The computer output provides a 50 year summary stating the three variables specified and listing the number of operating days at full capacity for each month of the 50 year sequence, the total number of operating days for each of the 50 annual sequences, the minimum and maximum month end reservoir storage deficit below the full reservoir level expressed in millions of gallons for each 12 month sequence, and the average number of operating days for each month and each year of the 50 year sequence.

A large number of program runs (simulations) were made to gain information over a range of turbine capacities from zero to 800 cubic feet per second and for various specified maximum drawdown levels. Based on these results, we have plotted as Figure 24 the relationship between the average annual number of days a turbine comfiguration can operate at full capacity, the turbine flow rate, and the maximum amount of reservoir level drawdown permitted for turbine operation. It must be remembered that this graph presents an arithmetic average condition over a fifty year simulation period and that extreme variations in operating time exist from one year to the next. This graph does not tell us anything about the distribution of operating days during the year. As anticipated, the graph shows us that a greater number of operating days can be achieved annually by reducing the turbine size and by increasing the amount of storage which can be allocated to turbine operation.

<u>Refinements To The Operational Model</u>

Reliable stream flow data is available only on a monthly average basis. Our initial operational model made an assumption that daily inflows in any month were uniform throughout that month. This was admittedly an inaccurate assumption and we acknowledge that the turbine operating times and power produced are maximized under such an assumption as demonstrated by the following hypothetical example.

Suppose for example, that the mean monthly flow for a sample 30 day month was approximately equal to the turbine capacity of say 200 cfs, but that the inflows actually occurred in such a way that 60% of the runoff for that month occurred uniformly during the first six days of the month while the remaining 40% of the monthly inflows occurred uniformly during the remaining 24 days of the month. Assuming that the inflows were uniform during the month, we would conclude that the turbine would run 30 days during the month. Based on the actual inflow distribution, however, we would conclude that the reservoir level would begin to fall after the sixth day, dropping the level in the reservoir approximately three feet in approximately a five day period causing the turbines to cycle near the maximum drawdown level while running approximately 50% of the remaining time in the month. In the actual case, the turbines would have operated approximately 20 days for that month or only two thirds as much time as that determined assuming uniform inflows. If high flows occur, however, while the reservoir level is low, they will to some degree, be captured to replenish previously depleted storage.

The uniform inflow assumption used in our initial operational model needed to be modified to make the results more closely reflect non-uniform rates of inflow during any month. We chose to modify the simulation model in such a way that the monthly computation of turbine running time would be based upon the same total inflow for the month but the inflow would be assumed to occur during two periods, one as a uniform high flow period and the second as a uniform low flow period. Analysis of the frequency distribution curves of mean inflows for each month pointed out for instance that for October approximately two-thirds of the total reservoir inflow could be accounted for by only 20% of the months. In contrast, approximately one-third of the total inflows for the month of March were accounted for by the highest 20% of the values. It seemed somewhat reasonable, therefore, that a realistic distribution of flows within a given month might in some way attempt to maintain the same relationship in the daily distribution for our operational model. We were able to approximate this relationship by using the following method.

Each month was assumed to have a base inflow equal in magnitude to the 20 percentile flow which can be determined using Figure 23. The high flow for the month is assumed to occur during the first 20% of time in the month. The magnitude of the flow during the high flow period was taken to be equal to the base flow plus three times the amount that the monthly average flow exceeds the base flow. Flow during the remaining 80% of the month was taken to be equal to the base flow plus one-half the amount by which the monthly mean flow exceeds the base flow. Flow during each of these two portions of the month is assumed to be uniform at those rates, with 60% of the month's excess over the base flow situation assumed to be uniformly distributed during the first 20% of the month. We feel that this modification to the operational model is reasonable, is an improvement over the uniform inflow assumption, and is necessarily simple to be able to carry out the computation.

Many program runs were made using the modified operational model over the same range of input variables as were used with the initial operational model. We have taken the results determined by simulated operation with the modified operational model as being representative of the running times which might be reasonably expected over a 50 year period for various power generating configurations. We have plotted in Figure 25 the relationship between the average number of days a turbine configuration can be operated at full capacity, the turbine flow rate, and the maximum amount of reservoir level drawdown permitted for turbine operation. As predicted, this graph shows a reduction in operating days from Figure 24 because of the modified inflow assumption. The reduction, however, is not as dramatic as one might have expected.

Figure 26 includes typical simulation output which display the 50 year monthly summaries of simulated turbine operations at 50, 100, 200, 300, 400, 500, 600 and 800 cfs turbine capacity predicated on a maximum reservoir drawdown level of three feet, and maintenance of a domestic water supply of 6 million gallons daily. The results displayed on these sheets form a basis for the later determination of economic benefits for the many alternative configurations.

Conclusions

We have determined that operation with an increased permissible reservoir drawdown will result in lengthier operating times. We must now determine whether the increased operating times will be beneficial to the operation, or whether it is safe from a water supply point of view or desirable from an environmental or recreational point of view to operate the reservoir at levels significantly below the full level.

The amount of power that can be generated by any given turbine configuration can be calculated by the expression:

$$\text{Power} = \text{Head} \times \text{Flow} \times \text{Efficiency} \times 0.08461$$

where head is the net head in feet to be utilized by the turbine, flow is expressed in cubic feet per second, and efficiency is expressed as a decimal. The various configurations to be investigated will all have their own unique set of each of these parameters. It is desirable at this point to make some power computations requiring the application of some uniform assumptions. Let us assume that there is a net head of 60 feet available which is a similar value for many of the alternative configurations. Further assuming that a typical efficiency value for most of the configurations is 80%, we can therefore express the total power output from our hypothetical generating facility knowing the amount of time that the machine will operate and the flow rate utilized by the turbine. We have prepared Figure 27 which graphically shows the power which might be developed by our hypothetical turbine based upon the average number of operating days from our 50-year simulations and various turbine capacities. The graph demonstrates the fact that the maximum amount of power is generated under the uniform monthly inflow assumption made in our initial operational model.

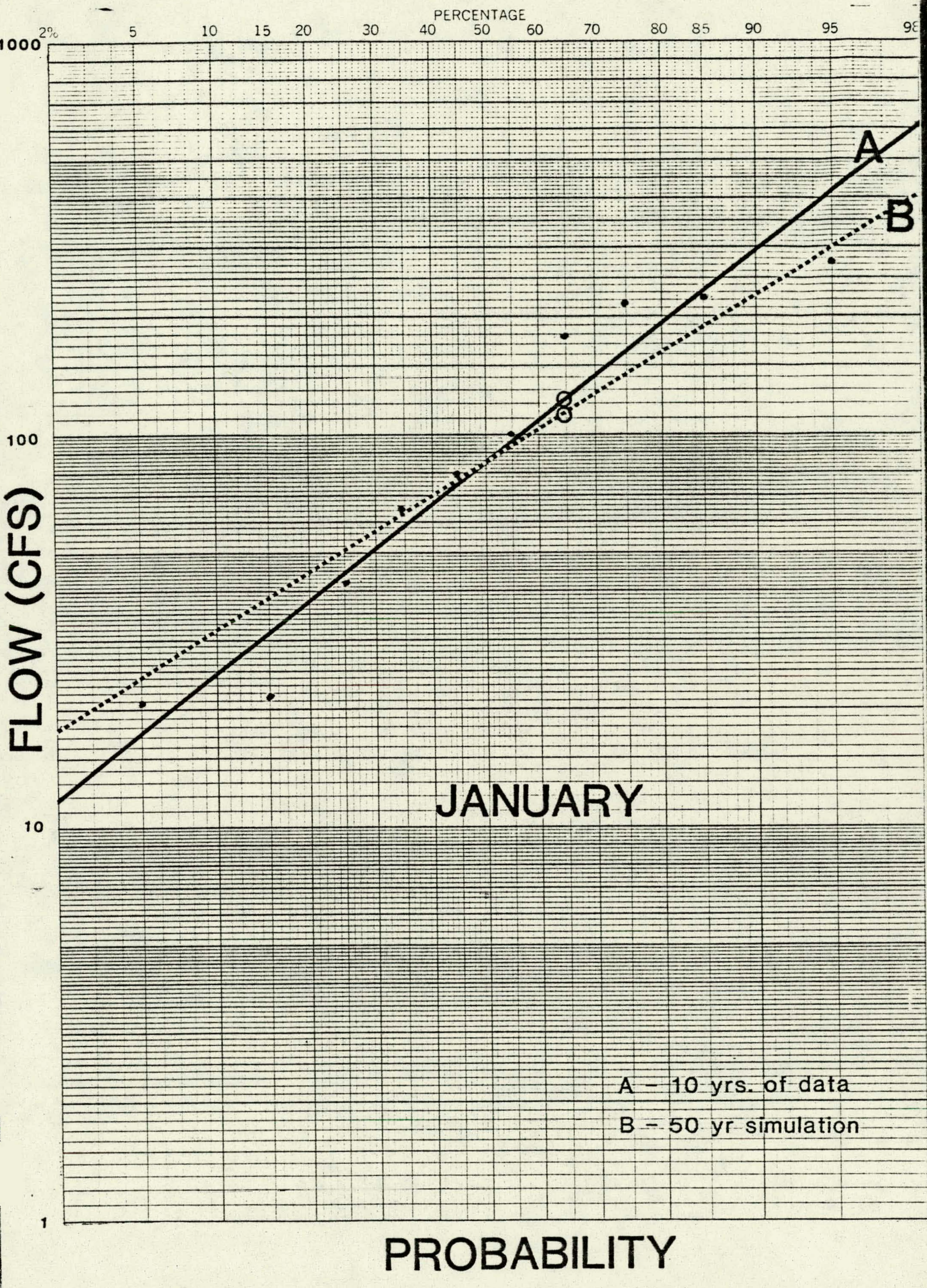
In order to be able to make computations, it was necessary to make an assumption regarding the average head of water available on the turbines under conditions of operation where increased reservoir drawdowns are permitted. Inspection of the many simulations has indicated that the reservoir would be operated at least two-thirds of its operating time at or near the maximum drawdown level. For purposes of this computation, therefore, we have made an assumption that the average drawdown during any of the simulations will be two-thirds of the allowable drawdown for turbine operation. Assuming that 60 feet of net head is available to the turbine when the maximum drawdown available is specified as 3 feet, we have graphed the average annual power available versus hydraulic turbine capacity. The average number of operating days in that computation is taken from from the computer printouts of Figure 26. It can be seen that less power is actually available when an increased amount of drawdown is permitted because the lowering of water level in the reservoir reduces the net head available on the turbine by an amount which more than compensates for the increased turbine running time. Therefore, we find that there is no advantage or necessity in the production of power to permit extremely large drawdowns in the reservoir. We would conclude that is undoubtedly desirable to allocate up to 3 feet of drawdown to be available for generation of hydroelectric power so that storage is available for short-term variations in daily flows but that additional drawdowns are unwarranted. This conclusion allows the establishment of future operating rules so that water supply and recreation will not be adversely affected while maximum benefit is being taken for hydroelectric generation. With regard to water supply, allocating approximately 3 feet or 350 million gallons from the top of the reservoir for hydroelectric production might cause the safe yield of the reservoir for water supply at a 99 percent reliability based upon maximum deficit of 1,200 million gallons to be reduced from 12 mgd to 10 mgd. This relationship is determined from Figure 8 and discussed in Segment One.

Using the same assumption that 60 feet of net head would be available for turbines operating at 80% efficiency and limited by a maximum reservoir drawdown of 3 feet, we prepared Figure 28 which is a graph showing the average amount of power which might be able to be produced for a wide range of hydraulic turbine capacities. We have attempted to impart continuity to the graph using a method similar to that described previously for Figure 23. The set of curves are useful to help us visualize the relationship between power produced in various times of the year and machine size in terms of flow rate. It is interesting to note the larger machine sizes can produce no more power than the smaller machine sizes during periods of low runoff when the smaller machine is capable of utilizing all the available inflows. The larger machine configurations are advantageous particularly during the spring months when high flows normally occur and would otherwise be lost over the dam by the smaller machines. The limiting power production value indicated on Figure 28 for the 50, 100, and 200 cfs machines during March and April show that machines of those sizes can be expected to operate continuously at peak capacity during that period in most years. For the sake of comparison, we have also superimposed on Figure 28 a line which represents the amount of electrical energy consumed by facilities owned by the City of Watervliet during the corresponding calendar periods of a calculated typical year. We have also indicated on Figure 28 the average daily power which could theoretically be generated if all water passing over the dam could be utilized. All power production computations for Figure 28 are uniformly based on the 50 year reservoir simulation and the same head and efficiency assumptions. This Figure conveys considerable visual information comparing machine configuration sizes with the power requirements of the city and the ultimate capability based on available water.

Using the same power generating parameters that were used in Figure 28, Figure 29 summarizes on an average annual basis for the 50 year simulation period the total electrical power in megawatt hours which could be generated in turbine configurations having a hydraulic capacity from 0 to 800 cubic feet per second. The maximum amount of power which could be generated utilizing all flows over the dam regardless of the magnitude of those flows is shown as a solid line across the top of the graph at a value of 5,177 megawatt hours. The figure shows relatively large incremental gains in the amount of power that can be produced by an increase in turbine capacity at the low end of the turbine capacity scale, while reflecting very small incremental gains by corresponding increases in turbine capacity at the higher end of the turbine capacity scale.

Having determined that reservoir levels need not be significantly depressed for optimum hydroelectric power generation, it is increasingly obvious that the dual usages of the Normans Kill Impoundment site for both municipal water supply and hydroelectric power generation are compatible. It was previously mentioned that the usable impoundment volume was less than 3.8% of the total annual watershed runoff. This proportion is very small and effectively limits the uniform reliable water supply yield of the reservoir to less than 12% of the mean annual flow leaving a very large quantity of water which cannot be impounded and which otherwise escapes unused from this site dissipating its energy in its passage over the dam to the streambed below.

The generation of hydroelectric power at this site will divert water through turbines which would overflow the dam converting the otherwise wasted energy of this flow into beneficial electrical energy.



MONTHLY FLOW PROBABILITY

NORMANSKILL HYDROELECTRIC FACILITY

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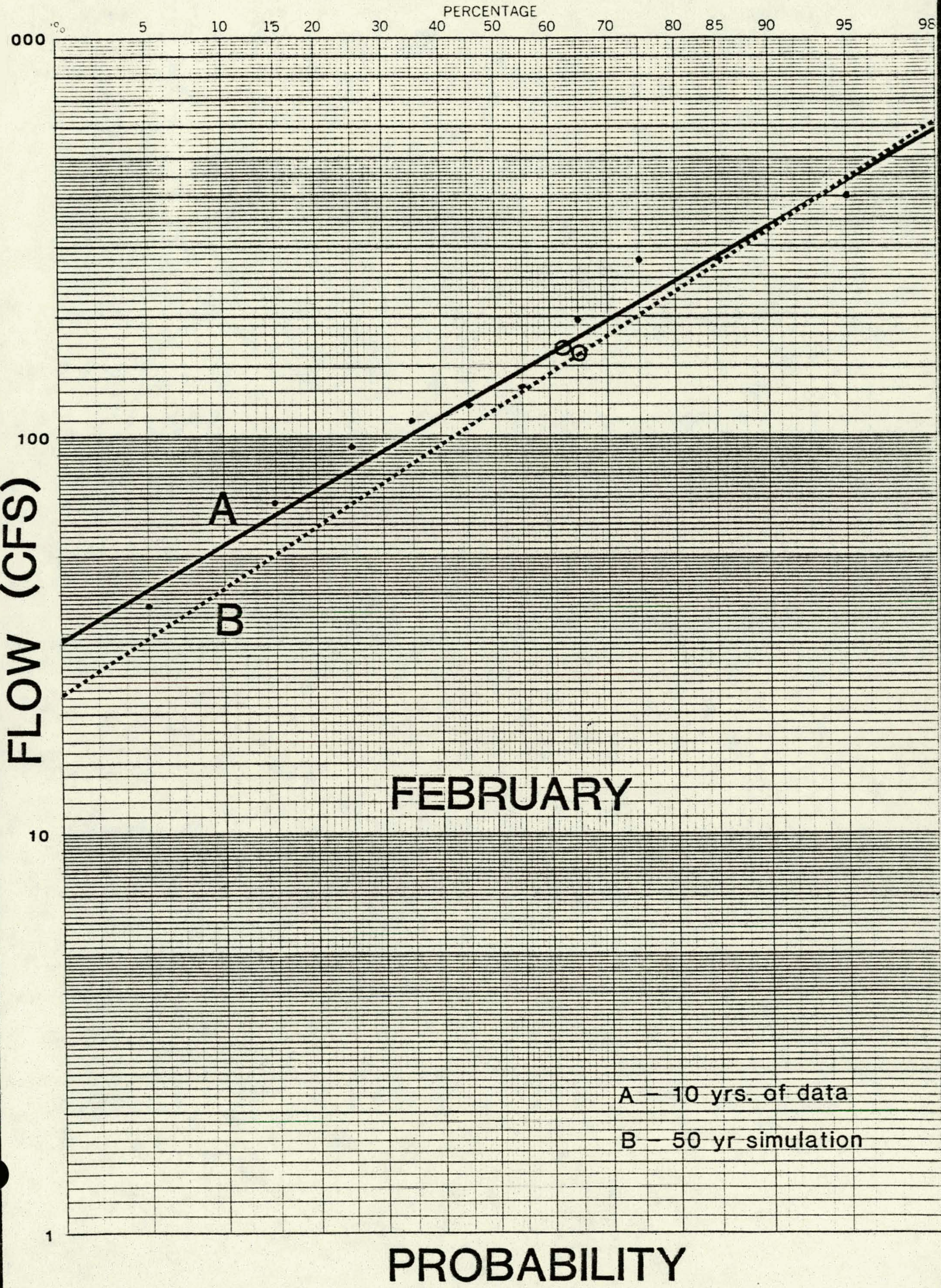
MONTHLY FLOW PROBABILITY



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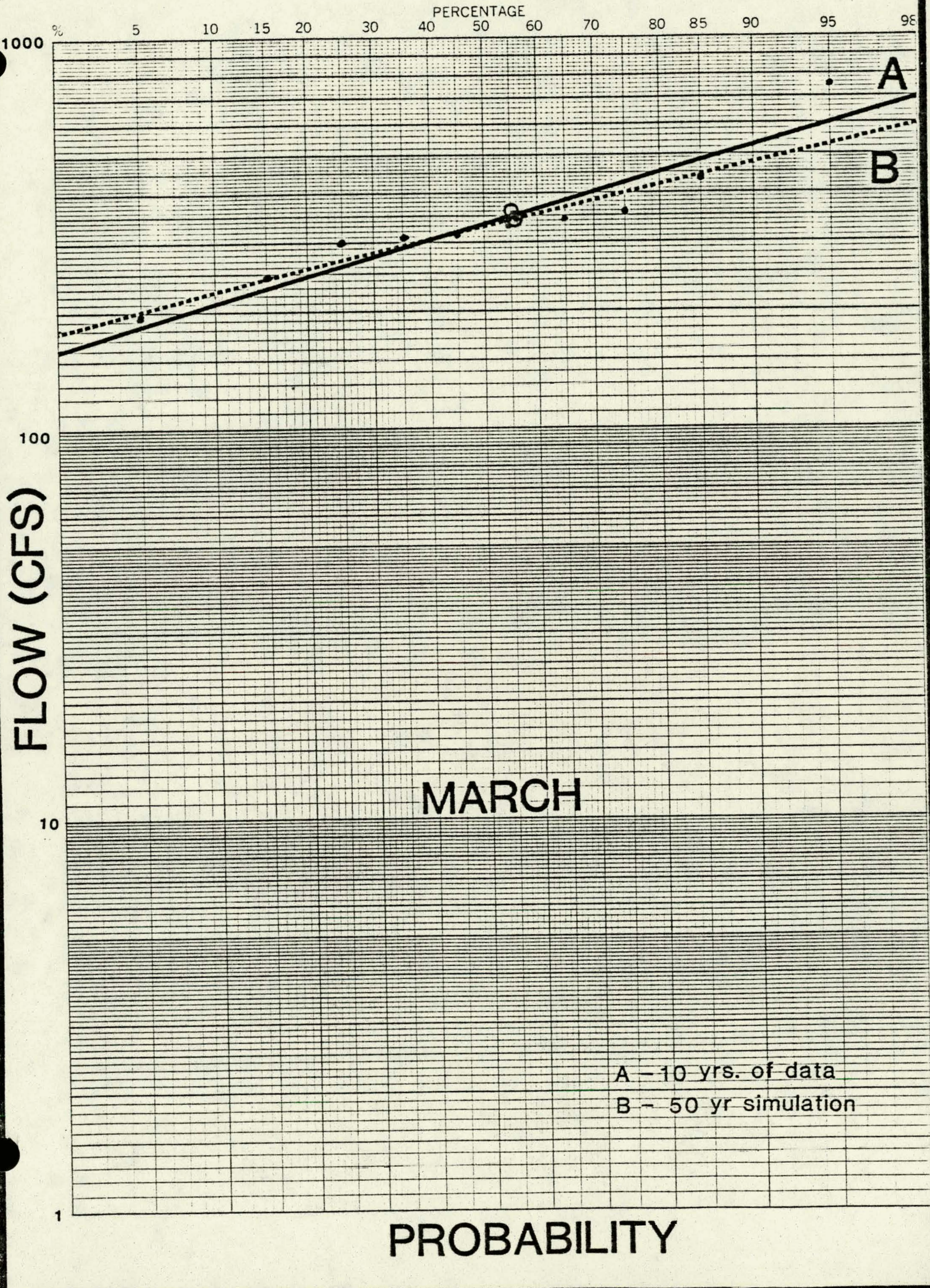

MONTHLY FLOW PROBABILITY

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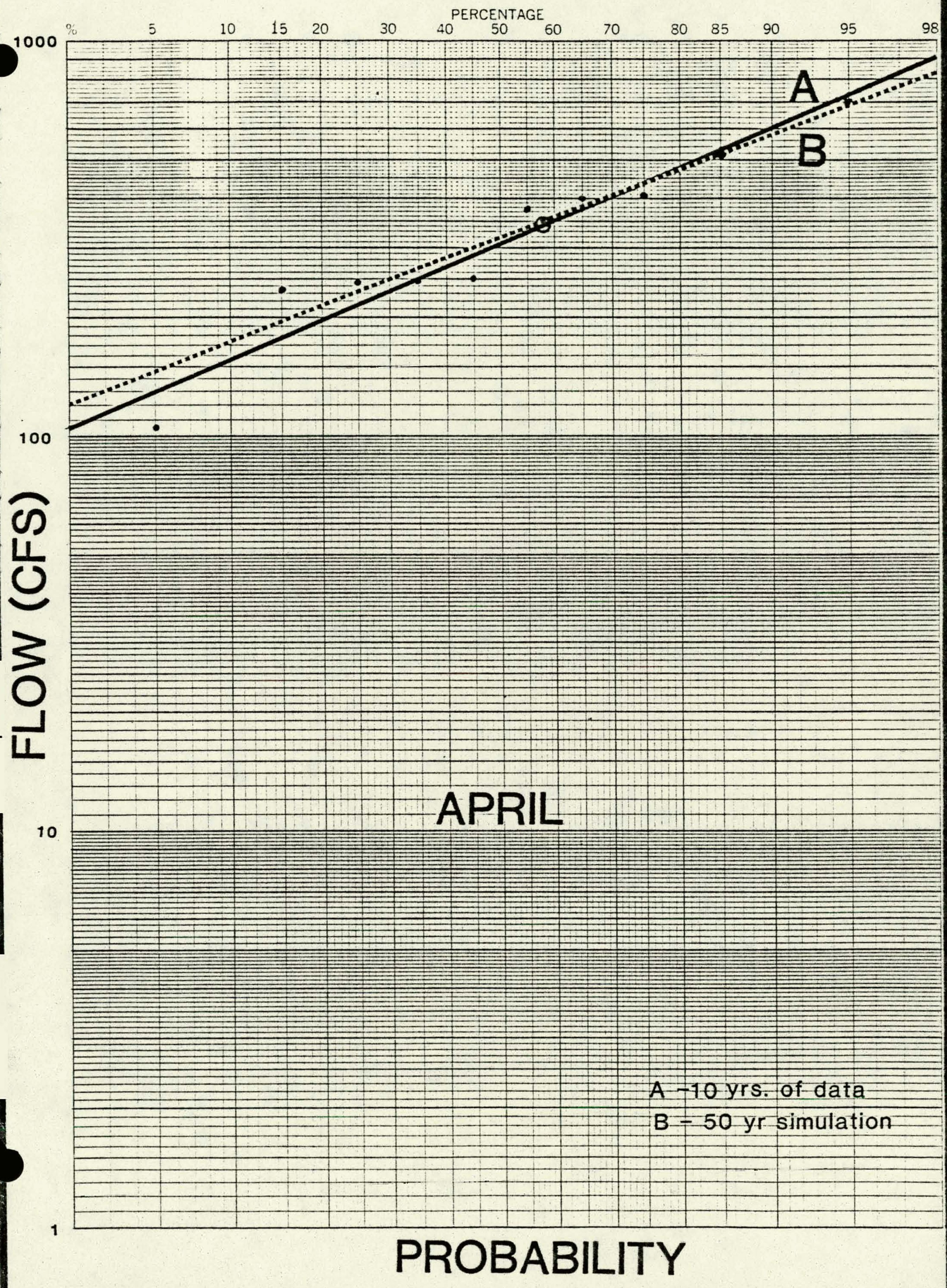

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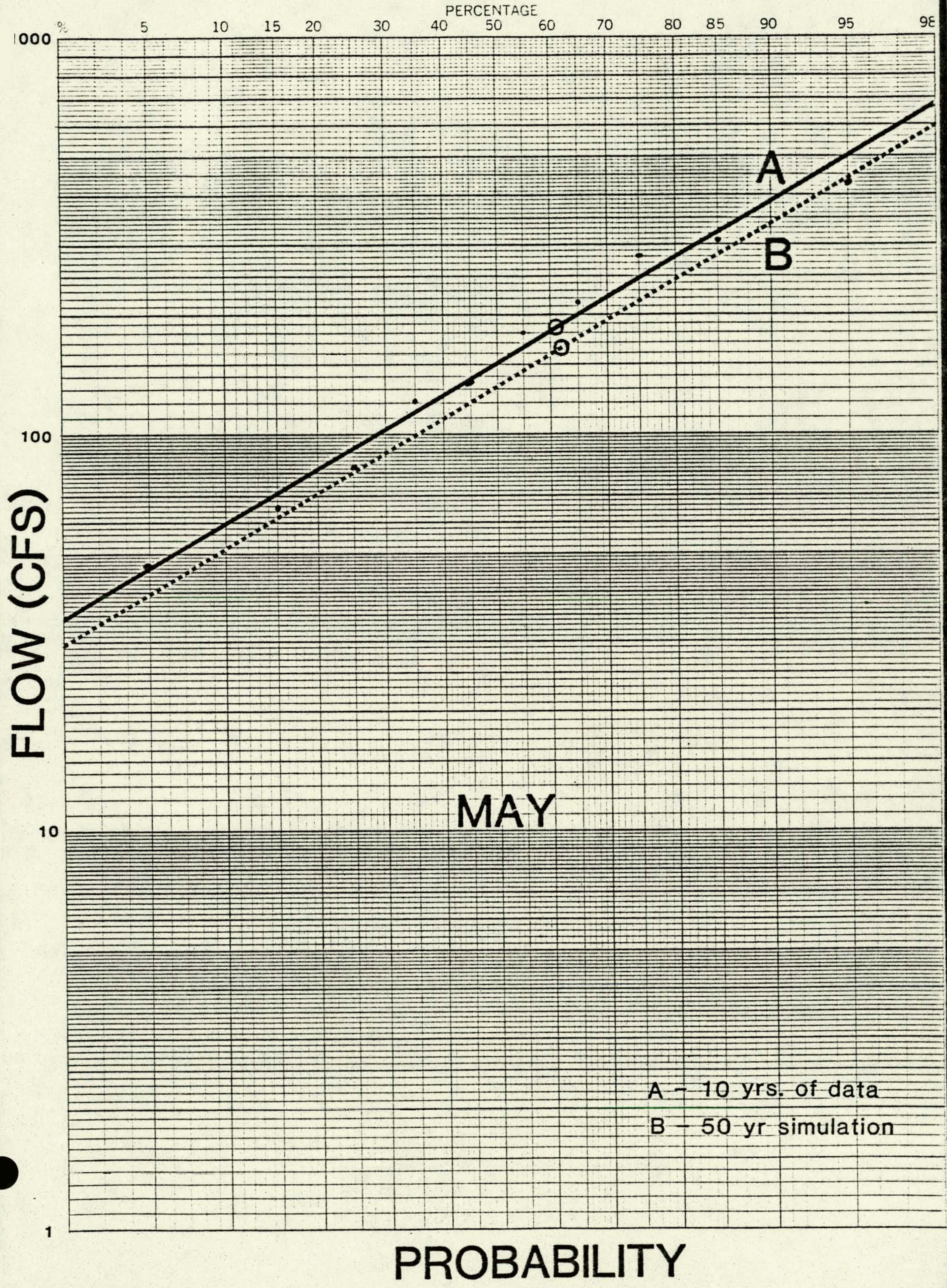

MONTHLY FLOW PROBABILITY

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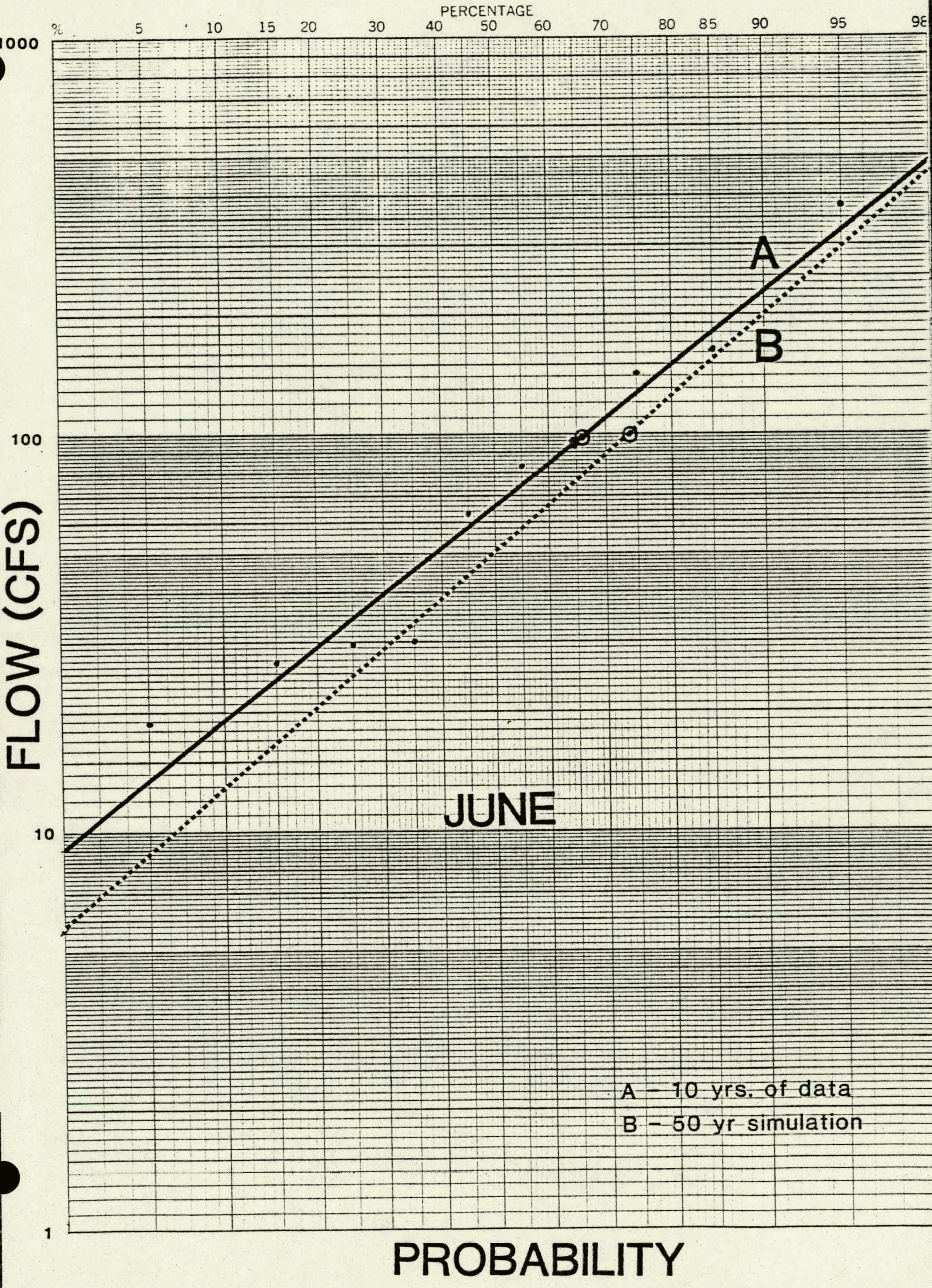

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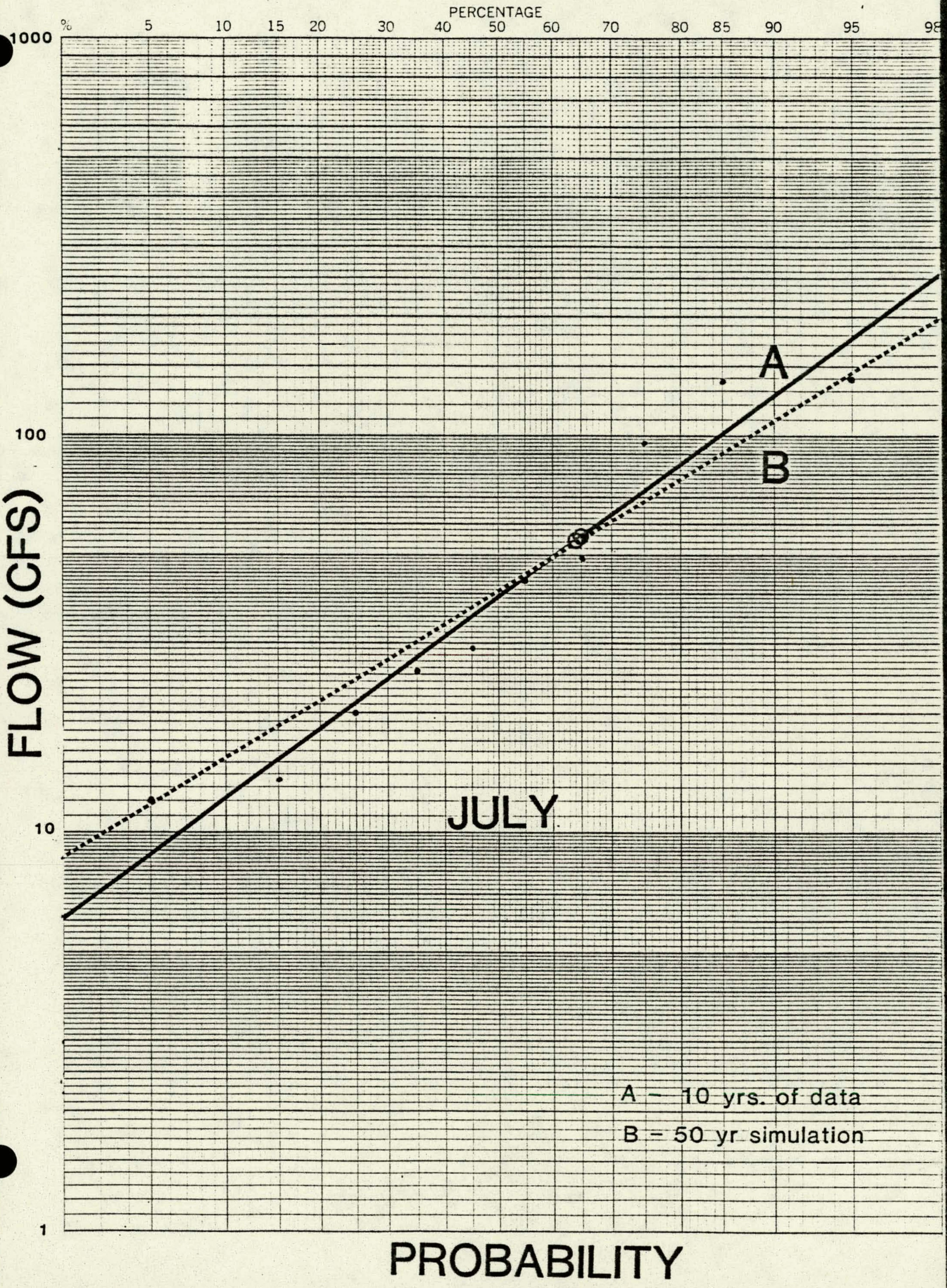

MONTHLY FLOW PROBABILITY

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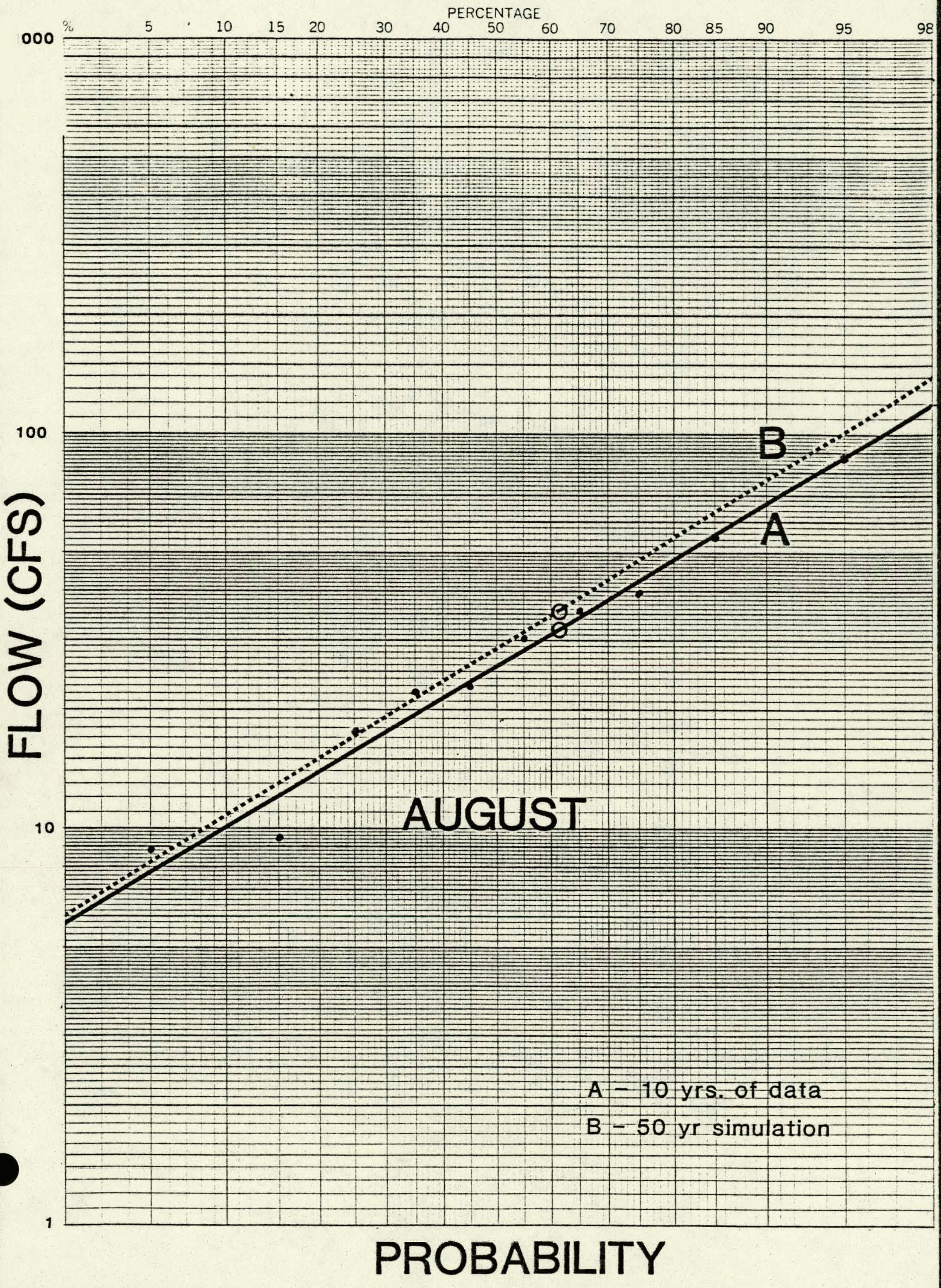

MONTHLY FLOW PROBABILITY

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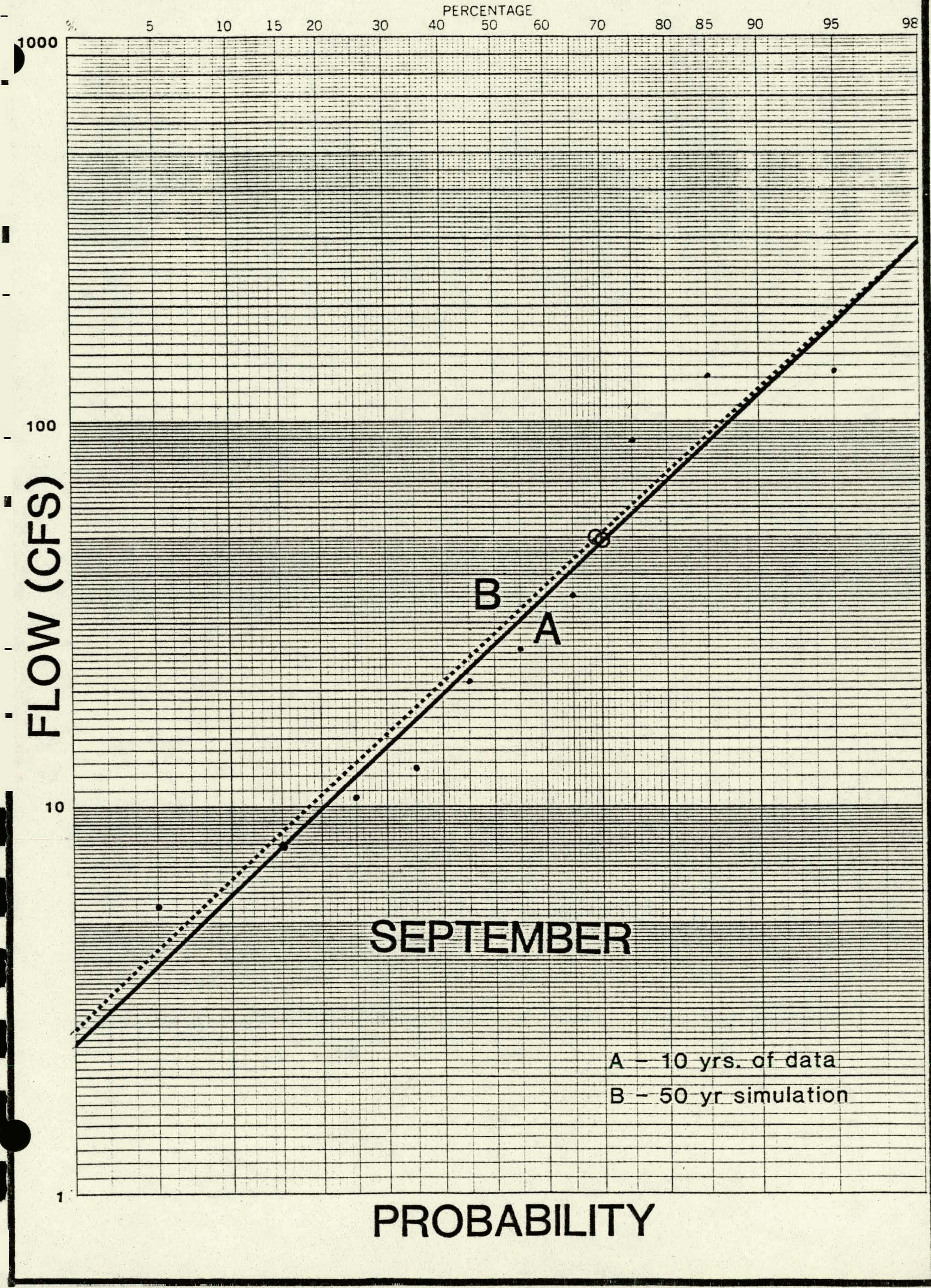

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NORMANSKILL HYDROELECTRIC FACILITY

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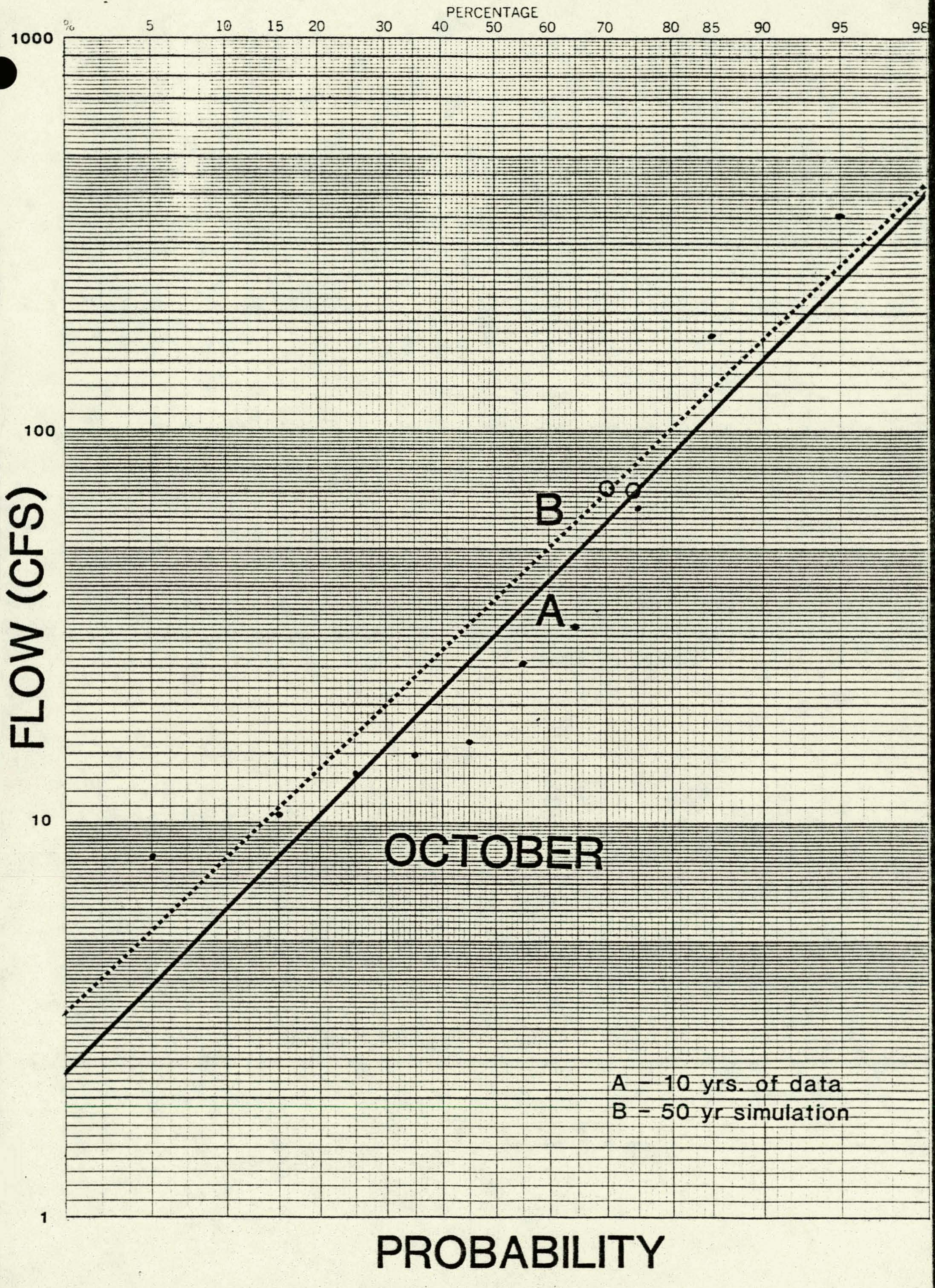
MONTHLY FLOW PROBABILITY



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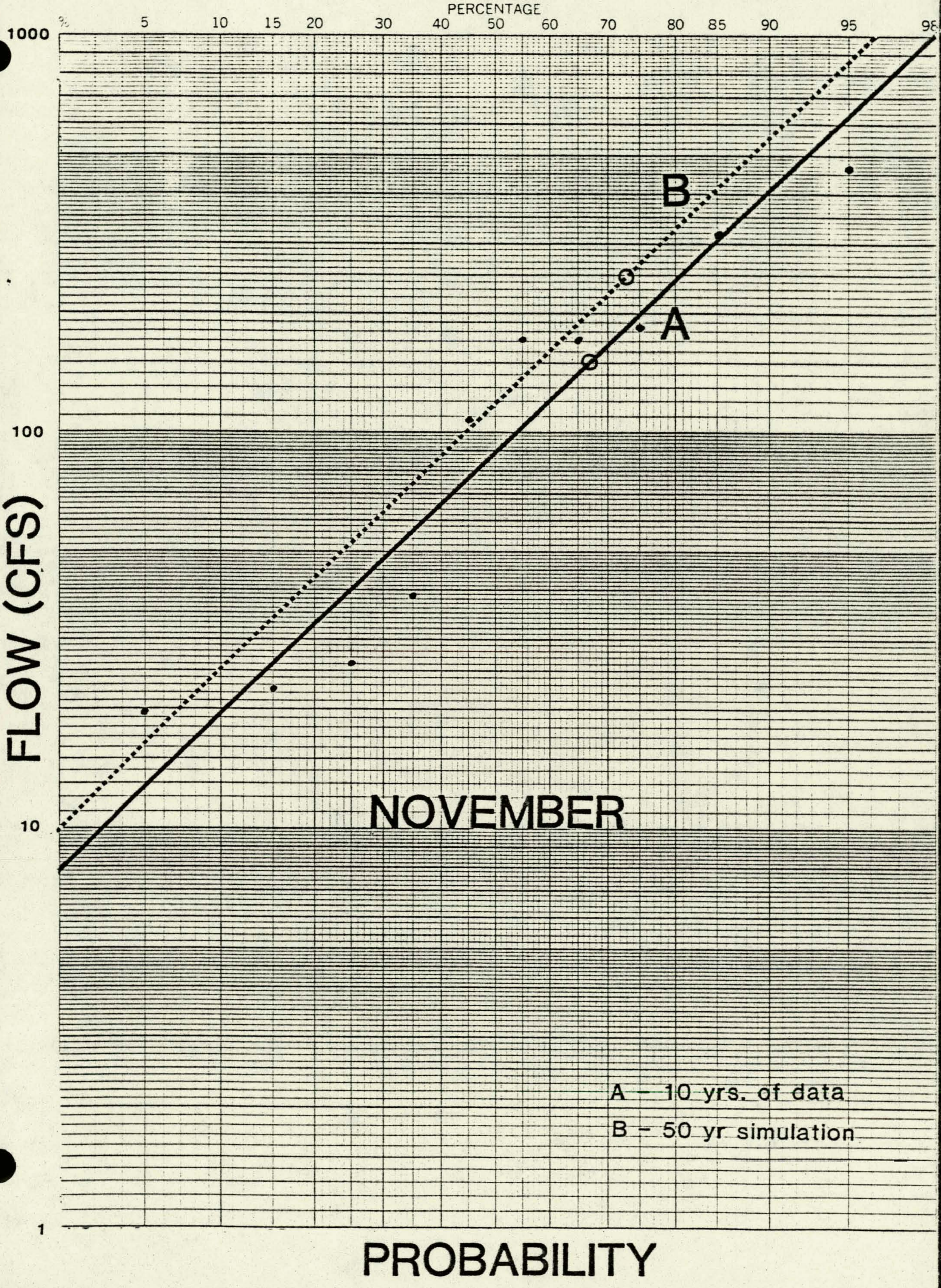

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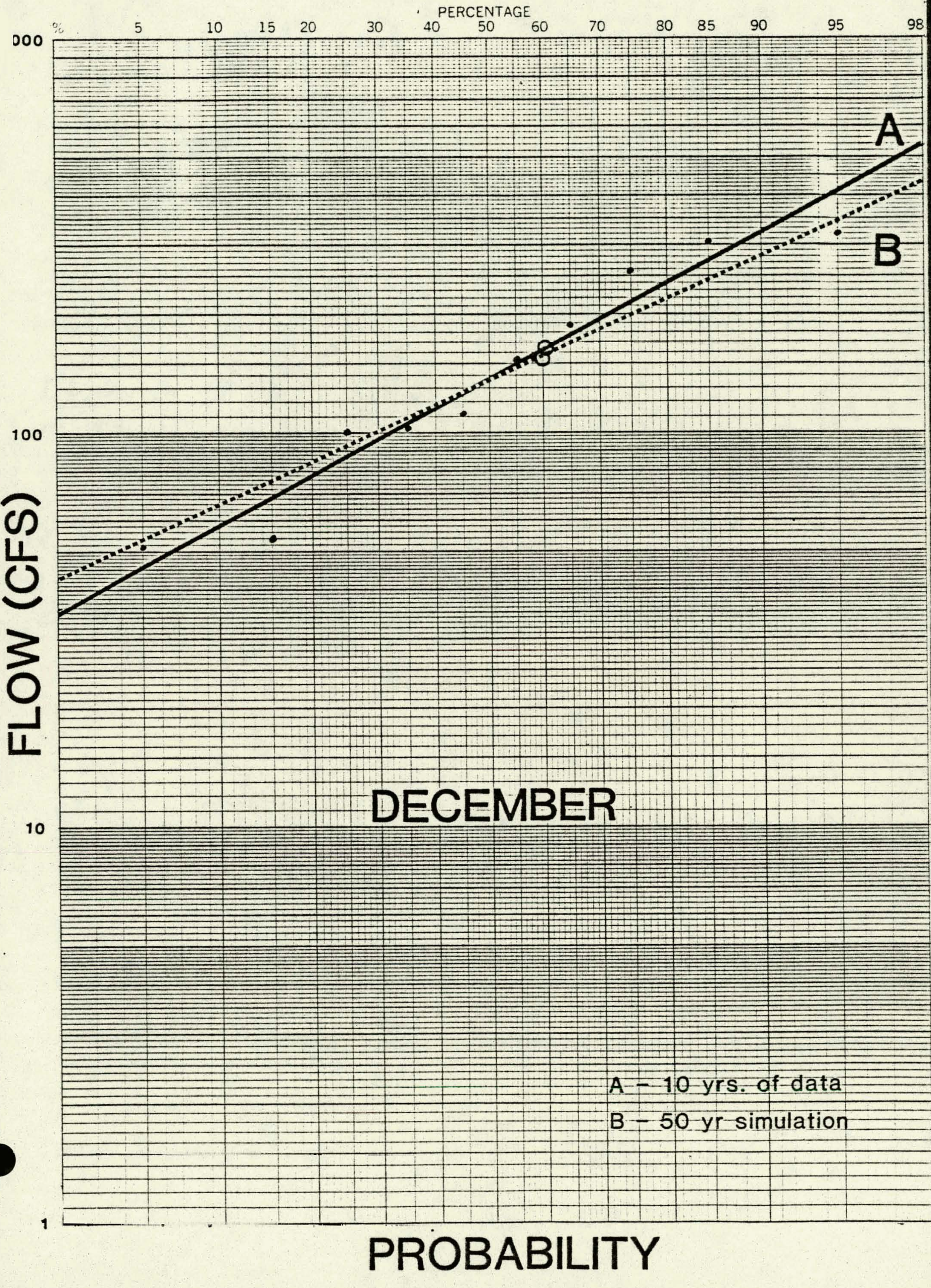
MONTHLY FLOW PROBABILITY

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

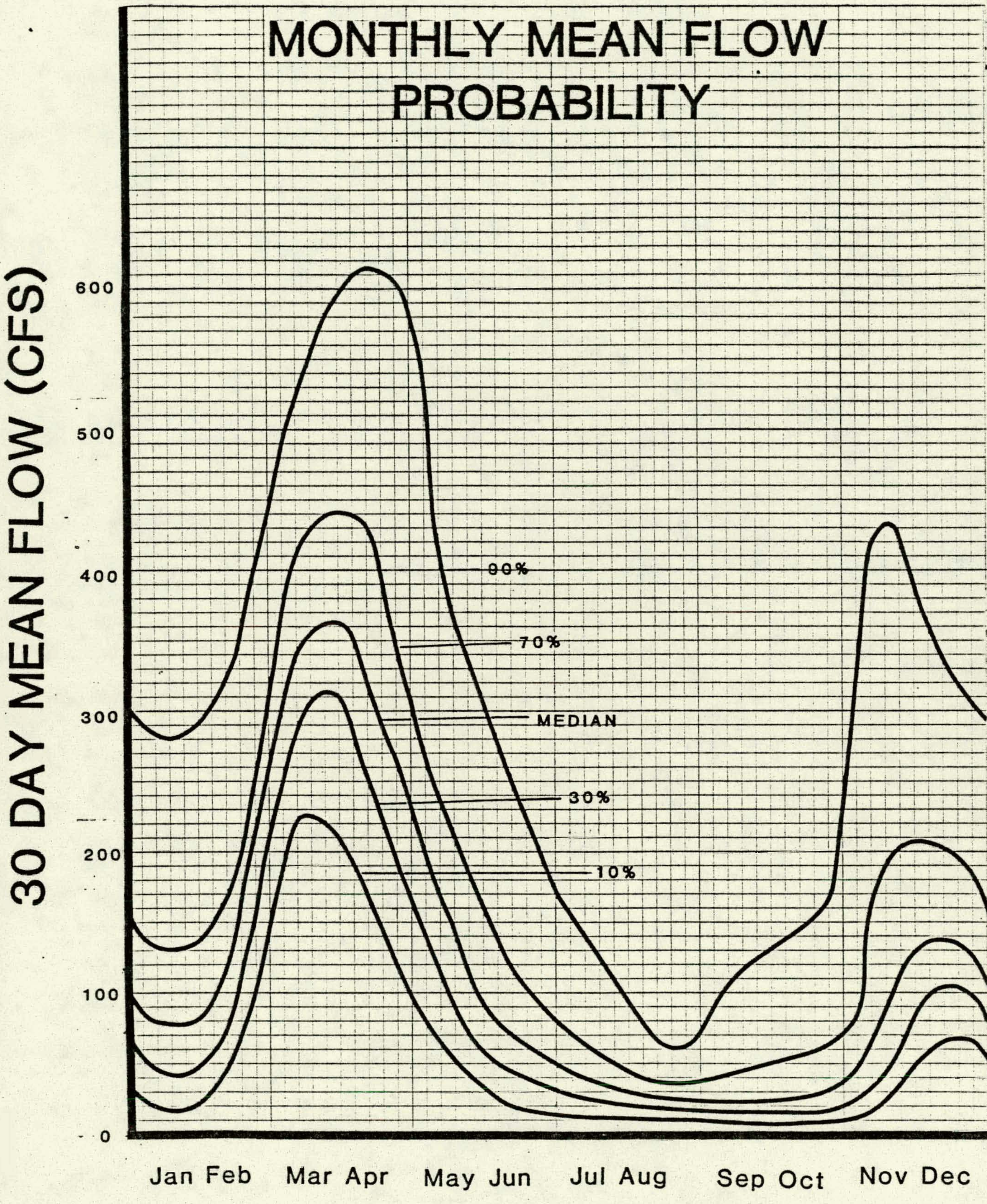
MONTHLY FLOW PROBABILITY



NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

MONTHLY FLOW PROBABILITY



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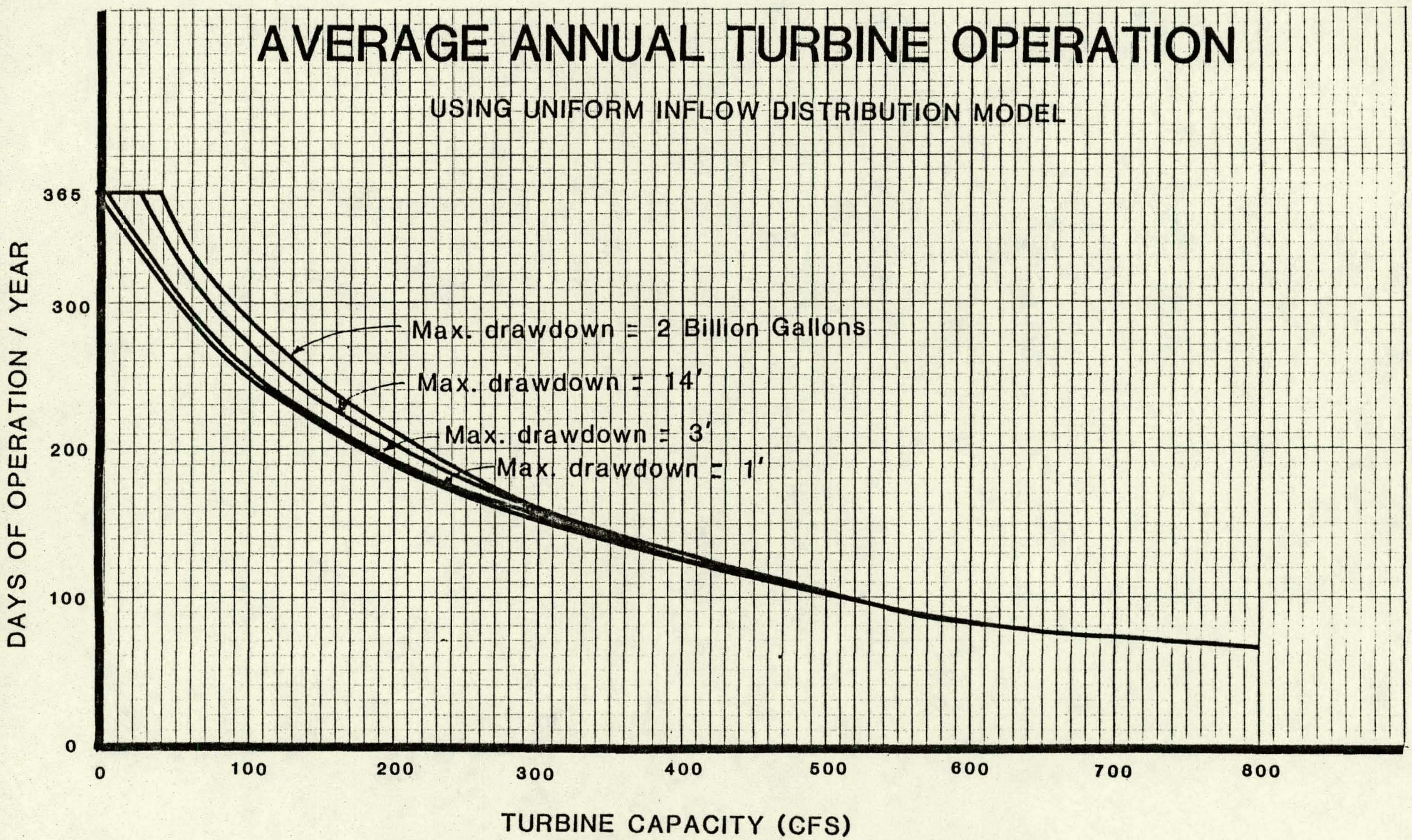
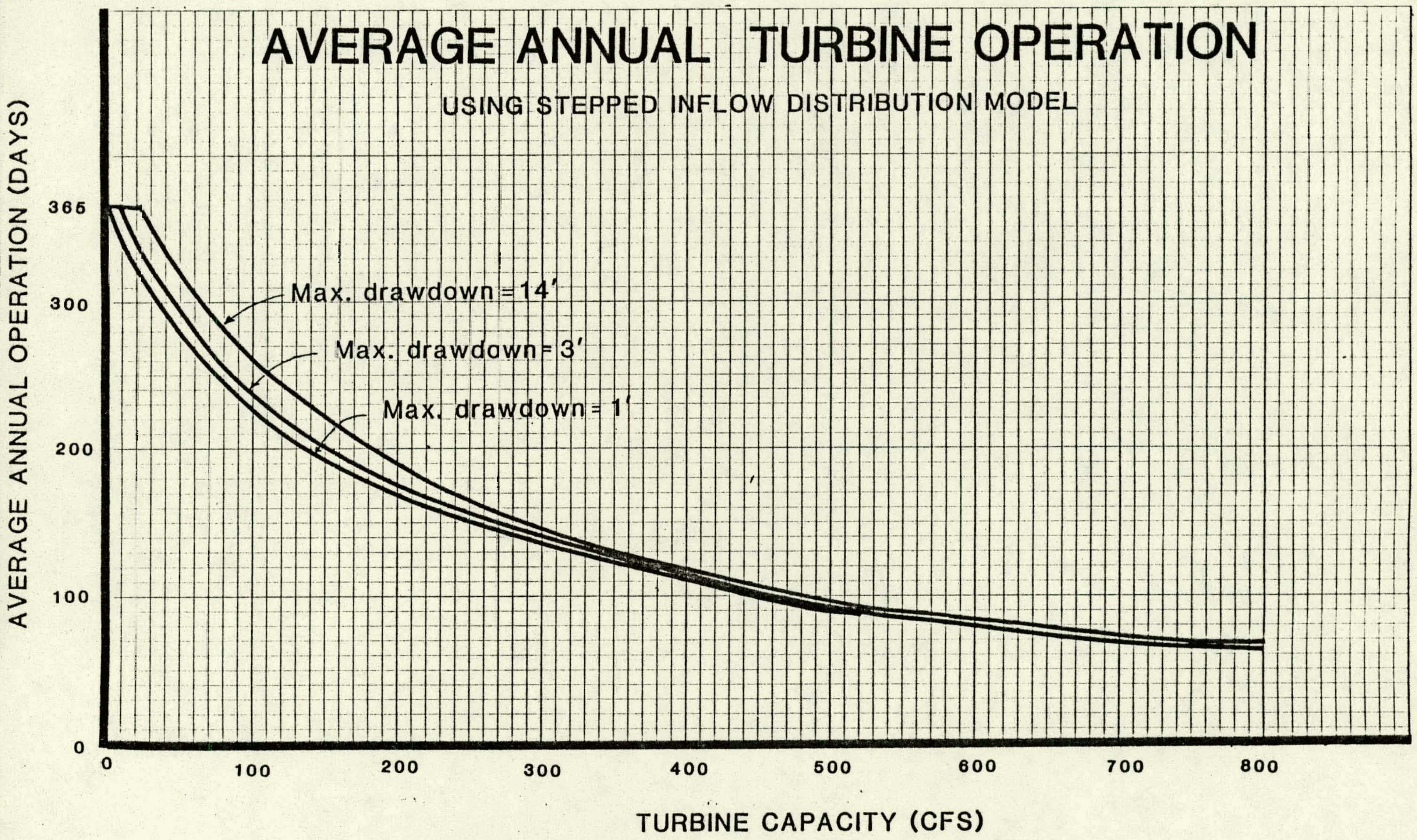


NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

ANNUAL TURBINE OPERATION

OPERATING TIME VS TURBINE CAPY.



NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

ANNUAL TURBINE OPERATION

OPERATING TIME VS TURBINE CAPY.

TYPICAL
RESERVOIR SIMULATION OUTPUT

GIVEN :

- 3ft. ALLOWABLE DRAFT
- 6 M.G.D. WATER SUPPLY YIELD
- TURBINE OPERATION AT 50,100,200,300,400 500,600,800 C.F.S.

WATERVLIET RESERVOIR HYDRO-ELECTRIC STUDY BASED ON STREAMFLOW SYNTHESIS
MONTHLY SUMMARY OF TURBINE OPERATION AT 50 CFS
ASSUMING: OPERATION CEASES AT 3 FEET BELOW FLASHBOARDS
DOMESTIC WATER SUPPLY MAINTAINED AT 6 MGD

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOTAL	DEFICIT (MG MIN.	MAX.
1	13.6	30.0	25.6	13.9	17.7	31.0	30.0	31.0	30.0	20.9	4.2	8.9	256.7	0	350
2	5.8	.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	29.2	31.0	4.9	283.2	0	393
3	3.9	30.0	31.0	31.0	28.3	31.0	30.0	23.9	.0	.0	21.8	7.9	238.7	0	385
4	21.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	5.4	31.0	30.0	329.6	0	350
5	31.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	31.0	28.3	30.0	362.5	0	350
6	31.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	13.4	16.3	12.9	30.0	315.8	0	350
7	31.0	22.1	31.0	25.0	28.3	31.0	30.0	31.0	30.0	31.0	26.7	3.0	320.0	0	350
8	8.7	3.5	31.0	31.0	28.3	31.0	30.0	31.0	30.0	31.0	2.6	4.8	262.9	0	350
9	14.5	13.2	31.0	30.0	27.7	31.0	30.0	31.0	30.0	31.0	31.0	30.0	330.4	0	350
10	21.9	.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	31.0	31.0	30.0	326.1	0	379
11	31.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	14.2	6.1	28.4	322.0	0	350
12	12.3	19.4	31.0	31.0	28.3	31.0	30.0	31.0	30.0	21.0	6.6	4.6	276.1	0	350
13	19.5	30.0	31.0	31.0	28.3	31.0	30.0	31.0	14.1	4.0	31.0	30.0	311.0	0	350
14	31.0	30.0	31.0	31.0	7.8	31.0	30.0	31.0	30.0	31.0	31.0	30.0	344.8	0	350
15	31.0	26.1	25.7	25.2	28.3	31.0	30.0	31.0	28.5	25.7	15.3	.0	297.7	0	350
16	.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	19.3	23.7	8.8	.0	264.0	0	527
17	.0	22.5	31.0	31.0	28.3	31.0	30.0	31.0	30.0	16.2	4.7	17.3	273.0	0	598
18	15.5	30.0	31.0	31.0	28.3	31.0	30.0	31.0	14.4	6.8	.0	.0	249.0	0	430
19	.0	28.8	31.0	31.0	28.3	31.0	30.0	31.0	11.9	10.2	3.9	30.0	267.1	0	628
20	31.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	10.2	8.5	30.0	322.0	0	350
21	31.0	30.0	31.0	31.0	28.1	31.0	30.0	31.0	30.0	31.0	15.1	3.8	322.9	0	350
22	.9	30.0	31.0	28.2	28.3	31.0	30.0	31.0	30.0	28.7	.9	12.2	282.2	0	350
23	16.5	30.0	31.0	17.3	28.3	31.0	30.0	25.8	7.3	13.7	10.1	10.3	251.2	0	350
24	16.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	23.5	13.3	4.4	2.6	272.1	0	350
25	.7	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	29.2	31.0	7.2	310.3	0	350
26	19.5	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	6.9	18.1	.0	286.7	0	350
27	1.7	11.1	31.0	31.0	27.6	31.0	30.0	31.0	30.0	18.7	2.7	6.1	251.9	0	409
28	29.1	30.0	31.0	14.2	18.3	31.0	30.0	31.0	30.0	31.0	30.7	27.5	333.8	0	350
29	6.6	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	31.0	23.8	30.0	333.6	0	350
30	25.5	30.0	31.0	28.2	28.3	31.0	30.0	31.0	11.3	11.5	25.6	7.2	290.5	0	350
31	9.0	30.0	31.0	29.5	10.0	31.0	30.0	31.0	29.2	31.0	4.0	.0	265.8	0	443
32	.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	15.4	12.1	31.0	11.1	281.9	0	537
33	3.1	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	31.0	23.5	30.0	329.9	0	350
34	31.0	29.1	31.0	31.0	28.3	31.0	30.0	31.0	28.2	28.1	1.9	.0	300.6	0	350
35	.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	9.4	12.1	31.0	2.1	266.9	0	463
36	.0	20.5	31.0	31.0	28.3	31.0	30.0	31.0	29.5	12.2	2.7	13.2	260.3	0	374
37	31.0	25.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	31.0	29.9	30.0	359.2	0	350
38	31.0	28.4	31.0	31.0	28.3	31.0	30.0	31.0	30.0	11.0	8.0	3.3	293.9	0	350
39	12.8	30.0	31.0	24.7	28.3	31.0	30.0	23.1	.0	.4	1.1	14.2	226.5	0	386
40	31.0	30.0	31.0	29.9	18.7	31.0	30.0	31.0	14.4	18.5	6.5	.0	272.0	0	350
41	.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	7.1	.0	.9	250.2	0	464
42	11.3	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	31.0	15.9	3.6	304.0	0	350
43	.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	15.3	23.5	31.0	24.4	306.5	0	363
44	31.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	31.0	24.5	30.0	358.7	0	350
45	31.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	21.2	15.4	31.0	30.0	340.8	0	350
46	31.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	29.8	6.9	3.4	.6	283.9	0	350
47	2.5	30.0	31.0	25.6	28.3	31.0	30.0	31.0	30.0	29.9	8.1	10.5	287.9	0	350
48	20.8	30.0	31.0	31.0	28.3	31.0	30.0	31.0	16.7	14.1	31.0	30.0	324.9	0	350
49	28.2	21.6	31.0	31.0	28.3	31.0	30.0	31.0	30.0	22.6	14.5	27.6	326.9	0	350
50	11.7	30.0	31.0	31.0	21.2	31.0	30.0	31.0	30.0	31.0	26.6	10.5	314.9	0	350
AVG.	16.4	26.4	30.8	29.4	26.7	31.0	30.0	30.6	24.5	20.1	16.5	14.6	296.9	0	628

WATERVLIET RESERVOIR HYDRO-ELECTRIC STUDY BASED ON STREAMFLOW SYNTHESIS
MONTHLY SUMMARY OF TURBINE OPERATION AT 100 CFS
ASSUMING: OPERATION CEASES AT 3 FEET BELOW FLASHBOARDS
DOMESTIC WATER SUPPLY MAINTAINED AT 6 MGD

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOTAL	DEFICIT (MG) MIN.	MAX.
1	6.8	30.0	11.9	6.9	8.8	31.0	30.0	31.0	18.5	9.3	2.1	4.4	190.8	0	350
2	2.9	.0	31.0	27.1	28.3	31.0	30.0	31.0	30.0	17.7	16.7	2.2	247.8	0	393
3	2.0	30.0	31.0	27.3	28.3	31.0	30.0	11.9	.0	.0	10.9	3.9	206.3	0	385
4	10.5	21.8	31.0	31.0	28.3	31.0	30.0	15.8	15.8	1.6	19.3	24.2	260.2	0	350
5	31.0	22.7	31.0	31.0	28.3	31.0	30.0	31.0	20.6	20.4	12.5	21.5	311.0	0	350
6	31.0	25.3	31.0	31.0	14.9	31.0	30.0	17.7	4.5	8.1	6.4	18.6	249.7	0	351
7	20.3	9.4	18.1	9.9	21.1	31.0	30.0	31.0	30.0	29.1	10.5	1.5	241.9	0	350
8	4.4	1.7	31.0	26.5	16.5	31.0	30.0	31.0	15.2	17.9	.0	2.4	207.7	0	350
9	7.2	6.6	23.7	9.6	13.9	31.0	30.0	31.0	30.0	21.7	16.3	17.1	238.1	0	350
10	10.6	.0	31.0	27.4	24.6	31.0	30.0	31.0	30.0	26.8	20.0	30.0	292.4	0	379
11	31.0	30.0	31.0	18.4	27.6	31.0	28.1	15.8	17.9	4.1	3.0	14.3	252.2	0	350
12	6.1	9.7	30.6	11.7	13.9	31.0	30.0	31.0	23.9	5.1	3.3	2.3	198.6	0	350
13	9.8	15.6	31.0	27.0	28.3	31.0	30.0	31.0	5.3	2.0	21.2	18.5	250.7	0	350
14	31.0	30.0	31.0	18.2	2.4	31.0	30.0	31.0	30.0	27.4	22.6	19.9	304.4	0	350
15	20.8	10.8	12.8	12.6	26.1	31.0	30.0	27.9	8.8	12.9	7.7	.0	201.5	0	350
16	.0	30.0	31.0	21.7	28.3	31.0	30.0	31.0	8.8	11.8	4.4	.0	228.0	0	527
17	.0	11.2	31.0	25.9	28.3	31.0	30.0	31.0	24.0	2.7	2.3	8.7	226.1	0	598
18	7.8	30.0	31.0	25.3	28.3	31.0	30.0	31.0	7.2	3.4	.0	.0	225.0	0	430
19	.0	14.4	19.1	12.8	28.3	31.0	30.0	22.5	.6	5.1	1.9	22.7	188.4	0	628
20	31.0	30.0	31.0	31.0	28.3	31.0	30.0	16.9	15.1	3.6	4.3	17.7	269.8	0	350
21	26.6	30.0	31.0	31.0	14.0	31.0	30.0	31.0	13.8	21.6	4.6	1.9	266.5	0	350
22	.4	27.2	28.0	8.7	25.3	31.0	30.0	31.0	22.5	11.9	.5	6.1	222.6	0	350
23	8.2	30.0	21.0	3.2	28.3	31.0	30.0	12.9	3.6	6.9	5.0	5.1	185.3	0	350
24	8.0	30.0	31.0	31.0	28.3	31.0	30.0	31.0	11.8	6.7	2.2	1.3	242.2	0	350
25	.3	30.0	31.0	24.5	28.3	31.0	30.0	31.0	26.8	12.4	16.6	3.3	265.1	0	350
26	9.7	26.4	23.2	14.1	28.3	31.0	30.0	31.0	16.7	1.6	9.0	.0	220.9	0	350
27	.9	5.5	22.9	30.1	8.4	31.0	30.0	31.0	19.3	7.9	1.3	3.1	191.4	0	409
28	14.7	30.0	22.8	1.7	9.1	31.0	30.0	31.0	23.4	31.0	18.4	13.7	256.9	0	350
29	3.3	25.8	31.0	23.5	17.3	31.0	30.0	31.0	30.0	29.2	6.9	17.3	276.3	0	350
30	12.3	30.0	31.0	14.1	28.3	31.0	30.0	31.0	4.6	5.7	12.8	3.6	234.4	0	350
31	4.5	30.0	31.0	14.8	5.0	31.0	30.0	31.0	14.7	20.6	.0	.0	212.6	0	467
32	.0	30.0	31.0	19.5	20.3	31.0	30.0	26.9	2.3	6.1	19.1	4.3	220.5	0	561
33	1.6	15.8	27.8	31.0	28.3	31.0	30.0	31.0	19.8	26.3	6.6	22.5	271.6	0	350
34	24.6	9.2	31.0	17.0	21.0	31.0	30.0	29.2	8.7	14.1	.9	.0	216.6	0	350
35	.0	27.0	31.0	29.9	28.3	31.0	30.0	31.0	2.2	5.5	18.0	.2	234.0	0	463
36	.0	10.3	31.0	27.8	28.3	31.0	30.0	31.0	15.0	6.1	1.4	6.6	218.3	0	374
37	20.1	11.0	31.0	26.5	27.6	31.0	30.0	26.5	10.4	25.7	14.6	23.9	278.3	0	350
38	23.9	8.9	31.0	28.3	28.3	31.0	30.0	31.0	22.7	.8	4.0	1.7	241.4	0	350
39	6.4	30.0	31.0	10.8	28.3	31.0	30.0	11.6	.0	.2	.6	7.1	186.9	0	386
40	31.0	30.0	28.6	9.5	9.3	31.0	30.0	18.8	4.0	9.3	3.2	.0	204.7	0	350
41	.0	30.0	18.9	26.7	13.0	31.0	30.0	31.0	18.0	2.6	.0	.5	201.7	0	464
42	5.7	30.0	31.0	31.0	28.3	31.0	30.0	31.0	26.5	21.4	5.1	1.8	272.8	0	350
43	.0	23.6	31.0	31.0	28.3	31.0	30.0	31.0	7.5	11.8	22.2	9.3	256.6	0	363
44	30.1	30.0	31.0	31.0	28.3	31.0	30.0	31.0	30.0	31.0	8.2	30.0	341.6	0	350
45	27.5	30.0	31.0	22.9	28.3	31.0	30.0	21.3	5.2	7.7	16.2	28.1	279.1	0	350
46	31.0	22.2	31.0	31.0	28.3	31.0	30.0	31.0	15.5	3.4	1.7	.3	256.3	0	350
47	1.3	24.9	31.0	12.8	28.3	31.0	30.0	31.0	12.9	14.6	4.0	5.3	226.9	0	350
48	10.4	30.0	31.0	23.7	28.3	31.0	30.0	19.0	4.8	7.0	16.1	18.5	249.8	0	350
49	13.5	10.8	31.0	28.4	28.3	31.0	30.0	31.0	29.9	5.9	7.3	13.8	260.9	0	350
50	5.8	30.0	31.0	21.4	7.8	31.0	30.0	31.0	30.0	23.1	10.4	5.2	256.8	0	350
AVG.	11.7	21.8	28.5	21.8	22.8	31.0	30.0	27.6	15.8	12.2	8.4	9.3	240.8	0	628

WATERVLIET RESERVOIR HYDRO-ELECTRIC STUDY BASED ON STREAMFLOW SYNTHESIS
MONTHLY SUMMARY OF TURBINE OPERATION AT 200 CFS
ASSUMING: OPERATION CEASES AT 3 FEET BELOW FLASHBOARDS
DOMESTIC WATER SUPPLY MAINTAINED AT 6 MGD

														DEFICIT (MG	
YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOTAL	MIN.	MAX.
1	3.4	20.2	3.7	3.5	4.4	31.0	30.0	26.6	6.5	4.7	1.0	2.2	137.3	0	350
2	1.5	.0	25.3	15.1	22.6	31.0	30.0	31.0	30.0	8.9	8.4	1.1	204.8	0	393
3	1.0	30.0	25.3	15.4	28.3	31.0	30.0	5.3	.0	.0	5.4	2.0	173.6	0	385
4	5.2	10.9	31.0	31.0	28.3	31.0	30.0	7.9	7.9	.8	9.6	15.1	208.7	0	350
5	22.0	10.6	31.0	23.1	28.3	30.8	30.0	23.5	8.3	10.2	6.3	12.5	236.6	0	350
6	20.2	13.8	31.0	19.1	6.9	31.0	23.5	6.2	2.2	4.1	3.2	9.3	170.6	0	350
7	10.6	4.7	9.0	5.0	10.6	31.0	30.0	26.9	19.3	17.6	5.3	.8	170.7	0	350
8	2.2	.9	18.6	14.3	8.3	31.0	30.0	18.4	6.7	9.0	.0	1.2	140.5	0	350
9	3.6	3.3	11.9	4.8	6.9	31.0	30.0	28.0	30.0	14.0	8.1	8.5	180.2	0	350
10	5.3	.0	17.2	15.5	12.3	31.0	30.0	31.0	19.2	16.5	10.0	29.3	217.3	0	379
11	31.0	19.1	15.1	8.5	13.8	31.0	12.9	7.9	8.9	2.0	1.5	7.2	159.0	0	350
12	3.1	4.8	15.3	5.9	7.0	31.0	30.0	21.5	12.5	2.6	1.6	1.1	136.4	0	350
13	4.9	7.8	18.4	15.0	26.3	31.0	30.0	20.4	.8	1.0	11.2	9.2	176.1	0	350
14	27.0	30.0	26.0	6.4	1.2	31.0	30.0	21.0	20.2	16.8	12.9	10.5	233.1	0	350
15	11.3	5.4	6.4	6.3	13.1	31.0	30.0	14.0	4.4	6.4	3.8	.0	132.1	0	350
16	.0	26.9	22.4	8.4	14.5	31.0	30.0	20.9	2.1	5.9	2.2	.0	164.4	0	527
17	.0	5.6	16.8	13.6	23.9	31.0	21.9	25.0	12.6	1.3	1.2	4.3	157.4	0	598
18	3.9	30.0	31.0	13.6	25.5	31.0	21.7	26.2	.9	1.7	.0	.0	185.5	0	430
19	.0	7.2	9.6	6.4	23.2	31.0	30.0	11.3	.3	2.6	1.0	14.0	136.4	0	628
20	24.4	30.0	18.4	25.2	28.3	31.0	30.0	8.4	7.6	1.8	2.1	8.8	216.0	0	350
21	16.4	19.8	15.2	29.3	4.3	31.0	30.0	16.1	6.9	11.0	2.3	.9	183.3	0	350
22	.2	16.2	14.0	4.3	12.6	31.0	30.0	26.4	10.8	5.9	.2	3.1	154.8	0	350
23	4.1	30.0	10.5	1.6	14.4	31.0	25.9	3.8	1.8	3.4	2.5	2.6	131.7	0	350
24	4.0	19.9	16.9	22.9	21.0	31.0	30.0	22.8	3.2	3.3	1.1	.7	176.7	0	350
25	.2	25.5	16.5	11.8	28.3	22.7	30.0	31.0	16.4	6.2	8.3	1.7	198.4	0	350
26	4.9	15.2	11.6	7.1	16.9	31.0	30.0	18.1	7.5	.8	4.5	.0	147.4	0	350
27	.4	2.8	11.5	18.2	4.2	31.0	30.0	24.4	6.9	4.0	.7	1.5	135.5	0	409
28	7.4	29.7	8.7	.8	4.6	31.0	30.0	31.0	14.6	21.1	7.8	6.9	193.5	0	350
29	1.6	14.4	22.7	10.6	8.6	31.0	30.0	31.0	26.6	17.7	3.5	8.7	206.4	0	350
30	6.2	20.9	22.1	4.3	19.3	31.0	27.1	18.9	.1	2.9	6.4	1.8	161.0	0	350
31	2.3	20.2	22.8	4.7	2.5	31.0	30.0	23.9	4.6	10.3	.0	.0	152.2	0	467
32	.0	19.0	18.3	7.8	10.2	31.0	30.0	13.5	1.2	3.0	9.5	2.2	145.6	0	361
33	.8	7.9	13.9	22.0	19.7	31.0	30.0	22.2	7.4	16.3	3.3	13.8	188.1	0	350
34	15.4	4.6	24.4	5.8	10.5	31.0	30.0	14.6	4.4	7.0	.5	.0	148.2	0	350
35	.0	15.7	31.0	18.0	15.3	31.0	30.0	18.9	.0	2.7	9.0	.1	171.8	0	463
36	.0	5.1	30.1	16.0	21.1	31.0	30.0	22.4	4.8	3.0	.7	3.3	167.6	0	374
37	10.4	5.5	25.0	14.4	13.8	31.0	30.0	13.2	5.2	16.0	7.3	15.0	186.8	0	350
38	15.1	4.4	22.8	16.6	22.7	31.0	30.0	20.7	11.0	.4	2.0	.8	177.5	0	350
39	3.2	20.0	18.3	3.5	26.1	31.0	30.0	5.8	.0	.1	.3	3.6	141.8	0	386
40	22.5	23.3	11.6	4.8	4.7	31.0	30.0	9.4	2.0	4.6	1.6	.0	145.4	0	350
41	.0	28.7	6.7	14.6	6.5	29.2	30.0	28.0	6.3	1.3	.0	.2	151.6	0	464
42	2.8	24.6	31.0	25.4	20.9	31.0	30.0	31.0	16.3	10.9	2.6	.9	227.3	0	350
43	.0	11.8	16.5	19.1	22.9	31.0	30.0	21.2	1.1	5.9	12.5	4.6	176.7	0	363
44	18.2	23.0	30.0	25.4	20.4	31.0	30.0	31.0	18.5	18.8	3.9	21.4	271.6	0	350
45	16.8	30.0	24.6	9.9	16.3	31.0	30.0	10.7	2.6	3.8	8.1	17.1	200.9	0	350
46	19.9	9.9	31.0	31.0	28.3	31.0	30.0	21.9	5.0	1.7	.8	.1	210.6	0	350
47	.6	13.3	21.6	3.7	16.3	31.0	30.0	18.1	5.6	7.3	2.0	2.6	152.2	0	350
48	5.2	30.0	23.4	10.9	15.5	31.0	30.0	9.5	2.4	3.5	8.0	9.2	178.7	0	350
49	6.8	5.4	16.1	16.8	21.3	31.0	30.0	27.5	17.9	2.9	3.6	6.9	186.3	0	350
50	2.9	30.0	21.6	8.0	3.9	31.0	30.0	31.0	24.6	13.0	5.2	2.6	203.8	0	350
AVG.	7.4	15.8	19.5	12.9	15.7	30.8	29.1	20.0	8.7	6.7	4.3	5.4	176.2	0	628

WATERVLIET RESERVOIR HYDRO-ELECTRIC STUDY BASED ON STREAMFLOW SYNTHESIS
MONTHLY SUMMARY OF TURBINE OPERATION AT 300 CFS
ASSUMING: OPERATION CEASES AT 3 FEET BELOW FLASHBOARDS
DOMESTIC WATER SUPPLY MAINTAINED AT 6 MGD

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOTAL	DEFICIT (MG MIN.	MAX.
1	2.3	15.5	2.5	2.3	2.9	31.0	26.2	19.8	4.4	3.1	.7	1.5	112.2	0	350
2	1.0	.0	18.9	10.1	17.0	31.0	30.0	31.0	30.0	5.9	5.6	.7	181.2	0	393
3	.7	24.6	18.9	10.3	23.9	31.0	21.5	2.2	.0	.0	3.6	1.3	138.0	0	385
4	3.5	7.3	26.1	23.8	28.3	31.0	30.0	5.3	5.3	.5	6.4	10.6	178.0	0	350
5	16.8	7.0	24.7	17.5	28.3	20.4	30.0	17.3	5.6	6.8	4.2	8.3	186.8	24	350
6	15.5	9.2	23.4	14.2	4.6	31.0	15.7	4.1	1.5	2.7	2.1	6.2	130.3	0	350
7	7.1	3.1	6.0	3.3	7.0	22.3	29.4	20.0	14.9	13.6	3.5	.5	130.8	350	350
8	1.5	.6	12.4	9.5	5.5	31.0	30.0	12.2	4.5	6.0	.0	.8	114.0	0	350
9	2.4	2.2	7.9	3.2	4.6	28.1	26.4	20.8	25.2	7.5	5.4	5.7	139.4	350	350
10	3.5	.0	11.5	10.3	8.2	31.0	30.0	26.8	14.8	11.7	6.7	21.5	176.0	0	379
11	25.9	14.7	10.1	5.7	9.2	21.7	7.6	5.3	6.0	1.4	1.0	4.8	113.3	350	350
12	2.0	3.2	10.2	3.9	4.6	31.0	21.0	13.8	8.3	1.7	1.1	.8	101.7	226	350
13	3.3	5.2	12.3	10.0	19.4	22.4	21.3	12.0	.6	.7	7.5	6.2	120.8	350	350
14	20.1	30.0	19.4	4.3	.8	31.0	25.6	13.0	15.5	12.2	8.6	7.0	187.4	0	350
15	7.5	3.6	4.3	4.2	8.7	31.0	25.9	7.5	2.9	4.3	2.6	.0	102.5	257	350
16	.0	19.9	15.4	5.6	9.7	31.0	30.0	14.5	1.4	3.9	1.5	.0	132.9	0	527
17	.0	3.7	11.2	9.1	17.8	23.1	12.8	18.7	8.4	.9	.8	2.9	109.5	350	598
18	2.6	23.1	23.2	8.6	18.9	27.4	12.7	19.5	.6	1.1	.0	.0	137.8	350	430
19	.0	4.8	6.4	4.3	17.4	31.0	27.0	5.7	.2	1.7	.6	9.3	108.4	0	628
20	18.4	26.3	10.5	18.8	23.1	31.0	24.5	3.8	5.0	1.2	1.4	5.9	169.9	0	350
21	12.3	15.2	10.2	21.6	2.9	31.0	26.4	8.9	4.6	7.4	1.5	.6	142.6	266	350
22	.1	10.8	9.3	2.9	8.4	31.0	30.0	19.7	7.2	4.0	.2	2.0	125.6	0	350
23	2.7	30.0	7.0	1.1	9.6	29.3	15.5	2.5	1.2	2.3	1.7	1.7	104.7	0	350
24	2.7	15.3	11.3	17.3	15.0	30.0	30.0	17.2	2.1	2.2	.7	.4	144.3	0	350
25	.1	19.0	11.0	7.9	20.9	14.9	30.0	24.7	10.7	4.1	5.5	1.1	150.0	0	350
26	3.2	10.1	7.7	4.7	11.2	28.4	26.5	10.3	5.0	.5	3.0	.0	110.8	350	350
27	.3	1.8	7.6	12.6	2.8	31.0	30.0	18.4	4.6	2.6	.4	1.0	113.3	0	409
28	4.9	21.8	5.8	.6	3.0	31.0	29.2	25.4	7.9	16.1	5.2	4.6	155.5	56	350
29	1.1	9.6	15.9	7.1	5.8	31.0	28.0	25.3	19.7	13.7	2.3	5.8	165.2	0	350
30	4.1	16.0	14.8	2.9	12.9	31.0	16.7	12.6	.1	1.9	4.3	1.2	118.4	259	350
31	1.5	15.5	15.9	3.1	1.7	26.0	20.2	17.7	3.1	6.9	.0	.0	111.6	350	467
32	.0	13.8	12.2	5.2	6.8	30.8	28.0	7.2	.8	2.0	6.4	1.4	114.5	350	561
33	.5	5.3	9.3	16.7	13.1	31.0	28.1	14.8	4.9	11.3	2.2	9.2	146.5	148	350
34	10.7	3.1	18.4	3.9	7.0	29.7	24.8	7.9	2.9	4.7	.3	.0	113.2	350	350
35	.0	10.5	24.6	12.4	10.2	22.6	22.4	10.8	.0	1.8	6.0	.1	121.3	350	463
36	.0	3.4	22.2	10.7	15.2	30.4	30.0	17.0	3.2	2.0	.5	2.2	136.7	0	374
37	6.9	3.7	18.8	9.6	9.2	31.0	30.0	8.8	3.5	10.8	4.9	10.3	147.5	0	350
38	10.1	3.0	15.9	11.1	17.0	31.0	30.0	14.3	7.4	.3	1.3	.6	141.8	0	350
39	2.1	15.4	12.2	2.3	19.3	31.0	23.3	2.1	.0	.1	.2	2.4	110.2	135	386
40	17.0	17.5	7.7	3.2	3.1	31.0	30.0	4.4	1.3	3.1	1.1	.0	119.5	0	350
41	.0	21.1	4.5	9.7	4.3	19.4	30.0	20.8	4.2	.9	.0	.2	115.1	0	464
42	1.9	18.4	24.0	19.0	14.9	31.0	21.7	28.5	10.5	7.2	1.7	.6	179.5	0	350
43	.0	7.9	11.0	14.1	17.2	31.0	30.0	15.1	.8	3.9	8.3	3.1	142.3	0	363
44	14.2	17.3	22.1	19.0	14.0	23.6	30.0	25.1	14.2	14.6	2.6	16.3	213.1	0	350
45	13.1	30.0	18.5	6.6	10.9	31.0	23.0	5.3	1.7	2.6	5.4	13.4	161.3	0	350
46	15.3	6.6	23.7	31.0	28.3	28.3	27.5	14.3	3.3	1.1	.6	.1	180.1	0	350
47	.4	8.9	14.4	2.5	10.9	31.0	30.0	10.8	3.7	4.9	1.3	1.8	120.6	0	350
48	3.5	30.0	17.6	7.3	10.3	31.0	25.6	4.5	1.6	2.3	5.4	6.2	145.3	0	350
49	4.5	3.6	10.8	11.2	15.4	30.8	30.0	20.4	13.3	2.0	2.4	4.6	149.1	0	350
50	1.9	24.0	13.9	5.4	2.6	23.6	27.8	23.3	18.4	8.7	3.5	1.7	154.7	350	350
AVG.	5.4	12.2	13.9	9.2	11.7	28.6	25.6	14.2	6.3	4.7	2.8	3.7	138.5	0	628

WATERVLIET RESERVOIR HYDRO-ELECTRIC STUDY BASED ON STREAMFLOW SYNTHESIS
MONTHLY SUMMARY OF TURBINE OPERATION AT 400 CFS
ASSUMING: OPERATION CEASES AT 3 FEET BELOW FLASHBOARDS
DOMESTIC WATER SUPPLY MAINTAINED AT 6 MGD

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOTAL	DEFICIT (MG) MIN.	DEFICIT (MG) MAX.
1	1.7	12.6	1.9	1.7	2.2	31.0	21.2	16.4	3.3	2.3	.5	1.1	95.9	0	350
2	.7	.0	14.9	7.6	13.3	25.0	28.8	25.1	30.0	4.5	4.2	.5	154.5	0	393
3	.5	19.9	15.1	7.7	19.3	28.6	14.8	1.6	.0	.0	2.7	1.0	111.3	350	385
4	2.6	5.4	21.1	19.4	25.2	27.4	26.7	2.6	3.9	.4	4.8	7.9	147.7	350	350
5	14.1	5.3	20.1	14.7	23.9	14.0	24.1	12.8	4.2	5.1	3.1	6.3	147.6	350	350
6	13.2	6.9	19.1	10.6	3.5	28.3	10.4	3.1	1.1	2.0	1.6	4.7	104.5	350	350
7	5.3	2.3	4.5	2.5	5.3	16.7	23.6	16.5	11.7	10.2	2.6	.4	101.7	350	350
8	1.1	.4	9.3	7.2	4.1	27.6	30.0	9.2	3.4	4.5	.0	.6	97.4	0	350
9	1.8	1.6	5.9	2.4	3.5	21.1	20.5	17.1	20.4	5.6	4.1	4.3	108.3	350	350
10	2.7	.0	8.6	7.7	6.2	26.3	25.2	21.7	11.5	8.8	5.0	17.7	141.3	350	379
11	21.0	11.2	7.6	4.3	6.9	16.3	5.7	3.9	4.5	1.0	.8	3.6	86.6	350	350
12	1.5	2.4	7.6	2.9	3.5	25.3	15.3	10.4	6.2	1.3	.8	.6	77.8	350	350
13	2.4	3.9	9.2	7.5	16.0	16.8	16.0	9.0	.4	.5	5.6	4.6	92.0	350	350
14	16.6	28.8	16.0	3.2	.6	25.3	19.0	9.7	12.9	9.2	6.5	5.2	152.8	350	350
15	5.7	2.7	3.2	3.1	6.5	25.2	19.6	5.6	2.2	3.2	1.9	.0	79.0	350	350
16	.0	16.4	11.5	4.2	7.3	25.9	27.3	9.5	1.1	3.0	1.1	.0	107.2	350	527
17	.0	2.8	8.4	6.8	14.8	17.3	9.6	14.7	6.3	.7	.6	2.2	84.2	350	598
18	1.9	18.9	19.0	6.5	15.6	20.6	9.5	16.2	.4	.8	.0	.0	109.3	350	430
19	.0	3.6	4.8	3.2	14.1	28.5	21.6	4.3	.1	1.3	.5	7.0	89.0	350	628
20	15.3	21.2	7.8	15.7	18.8	29.1	17.0	2.9	3.8	.9	1.1	4.4	138.0	350	350
21	9.3	12.1	7.6	17.7	2.2	25.1	20.6	6.7	3.5	5.5	1.1	.5	111.8	350	350
22	.1	8.1	7.0	2.2	6.3	28.6	25.7	16.3	5.4	3.0	.1	1.5	104.4	350	350
23	2.1	30.0	5.3	.8	7.2	22.0	11.6	1.9	.9	1.7	1.3	1.3	86.0	0	350
24	2.0	12.2	8.5	14.5	11.3	22.9	28.3	11.9	1.6	1.7	.6	.3	115.7	350	350
25	.1	15.7	8.2	5.9	17.1	11.2	29.4	20.1	8.1	3.1	4.1	.8	123.8	350	350
26	2.4	7.6	5.8	3.5	8.4	21.3	20.8	7.7	3.8	.4	2.3	.0	83.9	350	350
27	.2	1.4	5.7	9.5	2.1	26.8	24.2	14.0	3.5	2.0	.3	.8	90.4	350	409
28	3.7	17.8	4.3	.4	2.3	25.9	23.4	20.6	6.0	13.6	3.9	3.4	125.4	350	350
29	.8	7.2	11.9	5.3	4.3	26.4	22.5	20.6	16.3	10.3	1.7	4.3	131.6	350	350
30	3.1	13.5	11.1	2.2	9.6	25.1	12.2	9.4	.1	1.4	3.2	.9	91.8	350	350
31	1.1	12.6	11.9	2.3	1.2	19.5	15.2	13.2	2.3	5.2	.0	.0	84.7	350	467
32	.0	10.4	9.1	3.9	5.1	24.5	22.5	5.4	.6	1.5	4.8	1.1	88.7	350	561
33	.4	3.9	7.0	14.1	9.8	25.6	22.6	11.1	3.7	8.5	1.6	6.9	115.3	350	350
34	8.0	2.3	14.0	2.9	5.2	22.3	18.6	5.9	2.2	3.5	.2	.0	85.3	350	350
35	.0	7.9	20.0	9.3	7.7	16.9	16.8	8.1	.0	1.3	4.5	.1	92.5	350	463
36	.0	2.6	18.2	8.0	11.4	23.8	30.0	11.6	2.4	1.5	.3	1.7	111.4	317	374
37	5.2	2.7	14.8	7.2	6.9	25.0	29.0	5.3	2.6	8.1	3.6	7.8	118.2	350	350
38	7.6	2.2	11.9	8.3	13.3	26.4	30.0	10.7	5.5	.2	1.0	.4	117.6	0	350
39	1.6	12.4	9.2	1.7	15.9	25.6	16.7	1.5	.0	.0	.1	1.8	86.5	350	386
40	14.3	14.6	5.8	2.4	2.3	28.0	24.0	3.3	1.0	2.3	.8	.0	98.9	350	350
41	.0	17.4	3.4	7.3	3.3	14.6	30.0	17.1	3.2	.6	.0	.1	96.9	262	464
42	1.4	15.3	19.5	15.8	11.2	31.0	16.3	23.0	7.9	5.4	1.3	.4	148.5	0	350
43	.0	5.9	8.3	10.6	13.7	26.3	25.6	10.0	.6	2.9	6.2	2.3	112.3	350	363
44	11.5	14.5	18.1	15.8	10.5	17.7	30.0	20.4	10.7	11.7	1.9	13.7	176.5	0	350
45	9.8	30.0	15.4	4.9	8.1	28.1	15.9	4.0	1.3	1.9	4.0	10.4	133.9	0	350
46	13.0	4.9	19.3	24.9	27.2	19.9	22.2	10.8	2.5	.9	.4	.1	146.0	350	350
47	.3	6.6	10.8	1.8	8.2	27.7	24.4	7.7	2.8	3.6	1.0	1.3	96.4	350	350
48	2.6	30.0	14.0	5.5	7.7	26.1	19.1	3.4	1.2	1.8	4.0	4.6	120.0	0	350
49	3.4	2.7	8.1	8.4	11.6	24.6	26.1	16.9	10.0	1.5	1.8	3.5	118.4	350	350
50	1.5	19.5	10.4	4.0	1.9	17.7	22.4	19.0	15.3	6.5	2.6	1.3	122.1	350	350
AVG.	4.3	10.2	10.8	7.2	9.3	23.7	21.2	11.0	5.0	3.5	2.1	2.9	111.2	0	628

WATERVLIET RESERVOIR HYDRO-ELECTRIC STUDY BASED ON STREAMFLOW SYNTHESIS
MONTHLY SUMMARY OF TURBINE OPERATION AT 500 CFS
ASSUMING: OPERATION CEASES AT 3 FEET BELOW FLASHBOARDS
DOMESTIC WATER SUPPLY MAINTAINED AT 6 MGD

														DEFICIT (MG)	
YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOTAL	MIN.	MAX.
1	1.4	10.1	1.5	1.4	1.8	27.8	16.2	13.4	2.6	1.9	.4	.9	79.2	350	350
2	.6	.0	11.9	6.0	10.6	20.3	24.2	21.3	30.0	3.6	3.3	.4	132.4	0	393
3	.4	17.1	12.1	6.2	16.6	24.1	11.8	1.3	.0	.0	2.2	.8	92.6	350	385
4	2.1	4.4	18.2	16.8	21.3	23.2	22.6	2.1	3.2	.3	3.9	6.3	124.2	350	350
5	12.5	4.2	17.3	12.5	20.2	11.2	20.5	10.3	3.3	4.1	2.5	5.0	123.7	350	350
6	11.2	5.5	16.5	8.5	2.8	23.8	8.3	2.5	.9	1.6	1.3	3.7	86.7	350	350
7	4.2	1.9	3.6	2.0	4.2	13.4	20.1	13.6	9.3	8.2	2.1	.3	83.0	350	350
8	.9	.3	7.4	5.7	3.3	23.3	30.0	7.3	2.7	3.6	.0	.5	85.1	0	350
9	1.4	1.3	4.7	1.9	2.8	16.9	16.4	14.8	17.5	4.5	3.3	3.4	89.0	350	350
10	2.1	.0	6.9	6.2	4.9	22.3	21.4	18.6	9.2	7.0	4.0	15.3	117.9	350	379
11	18.0	8.9	6.1	3.4	5.5	13.0	4.5	3.2	3.6	.8	.6	2.9	70.6	350	350
12	1.2	1.9	6.1	2.3	2.8	20.9	12.2	8.3	5.0	1.0	.7	.5	62.9	350	350
13	2.0	3.1	7.4	6.0	13.9	13.5	12.8	7.2	.3	.4	4.5	3.7	74.7	350	350
14	14.5	24.2	12.8	2.6	.5	20.9	15.2	7.8	10.3	7.3	5.2	4.2	125.4	350	350
15	4.5	2.2	2.6	2.5	5.2	20.6	15.7	4.5	1.8	2.6	1.5	.0	63.7	350	350
16	.0	14.4	9.2	3.4	5.8	21.9	23.0	7.6	.8	2.4	.9	.0	89.4	350	527
17	.0	2.2	6.7	5.4	11.9	13.9	7.7	11.8	5.1	.5	.5	1.7	67.4	350	598
18	1.6	16.3	16.4	5.2	13.5	16.4	7.6	13.0	.4	.7	.0	.0	90.9	350	430
19	.0	2.9	3.8	2.6	11.2	24.1	17.3	3.4	.1	1.0	.4	5.6	72.4	350	628
20	13.5	18.2	6.3	13.8	16.1	24.5	13.6	2.3	3.0	.7	.9	3.5	116.4	350	350
21	7.4	9.7	6.1	15.4	1.7	20.5	16.5	5.3	2.8	4.4	.9	.4	91.2	350	350
22	.1	6.5	5.6	1.7	5.1	24.1	21.8	13.2	4.3	2.4	.1	1.2	86.0	350	350
23	1.6	30.0	4.2	.6	5.8	17.6	9.3	1.5	.7	1.4	1.0	1.0	74.8	0	350
24	1.6	9.8	6.8	12.3	9.0	18.3	23.8	9.5	1.3	1.3	.4	.3	94.4	350	350
25	.1	13.8	6.6	4.7	14.8	9.0	24.7	17.3	6.4	2.5	3.3	.7	103.8	350	350
26	1.9	6.1	4.6	2.8	6.7	17.1	16.6	6.2	3.0	.3	1.8	.0	67.2	350	350
27	.2	1.1	4.6	7.6	1.7	22.7	20.6	11.2	2.8	1.6	.3	.6	74.8	350	409
28	2.9	15.5	3.5	.3	1.8	22.0	19.9	17.7	4.8	11.6	3.1	2.7	106.0	350	350
29	.7	5.7	9.5	4.2	3.5	22.4	18.8	17.7	14.2	8.2	1.4	3.5	109.8	350	350
30	2.5	10.8	8.9	1.7	7.7	20.6	9.7	7.5	.0	1.1	2.6	.7	74.0	350	350
31	.9	10.1	9.5	1.9	1.0	15.6	12.1	10.6	1.9	4.1	.0	.0	67.7	350	467
32	.0	8.3	7.3	3.1	4.1	19.6	18.8	4.3	.5	1.2	3.8	.9	71.8	350	561
33	.3	3.2	5.6	11.4	7.9	21.5	19.0	8.9	3.0	6.8	1.3	5.5	94.3	350	350
34	6.4	1.8	11.2	2.3	4.2	17.9	14.9	4.8	1.7	2.8	.2	.0	68.2	350	350
35	.0	6.3	17.2	7.4	6.1	13.5	13.4	6.5	.0	1.1	3.6	.0	75.3	350	463
36	.0	2.1	15.8	6.4	9.1	19.1	25.3	9.2	1.9	1.2	.3	1.3	91.6	350	374
37	4.2	2.2	11.8	5.7	5.5	20.3	24.4	4.2	2.1	6.5	2.9	6.2	96.0	350	350
38	6.1	1.8	9.5	6.6	10.7	22.4	30.0	8.6	4.4	.2	.8	.3	101.3	0	350
39	1.3	9.9	7.3	1.4	13.8	21.6	13.3	1.2	.0	.0	.1	1.4	71.4	350	386
40	12.7	12.9	4.6	1.9	1.9	23.7	20.4	2.7	.8	1.9	.6	.0	84.0	350	350
41	.0	15.1	2.7	5.8	2.6	11.7	25.5	14.8	2.5	.5	.0	.1	81.3	350	464
42	1.1	13.4	16.9	13.9	8.9	29.6	12.0	19.6	6.3	4.3	1.0	.4	127.4	350	350
43	.0	4.7	6.6	8.5	10.9	22.3	21.7	8.0	.5	2.4	5.0	1.9	92.3	350	363
44	9.2	12.8	15.7	13.9	8.4	14.2	27.0	17.6	8.5	9.4	1.6	12.2	150.3	350	350
45	7.8	30.0	12.5	3.9	6.5	23.7	12.7	3.2	1.0	1.5	3.2	8.3	114.5	0	350
46	10.9	3.9	16.7	21.2	22.9	15.9	18.1	8.6	2.0	.7	.3	.1	121.3	350	350
47	.3	5.3	8.6	1.5	6.5	23.4	20.8	6.2	2.2	2.9	.8	1.1	79.5	350	350
48	2.1	30.0	11.2	4.4	6.2	22.1	15.3	2.7	1.0	1.4	3.2	3.7	103.3	0	350
49	2.7	2.2	6.5	6.7	9.3	19.7	22.1	14.3	8.0	1.2	1.5	2.8	96.7	350	350
50	1.2	16.8	8.3	3.2	1.6	14.2	18.5	16.4	13.4	5.2	2.1	1.0	102.0	350	350
AVG.	3.6	8.8	8.9	5.9	7.6	19.6	17.8	9.1	4.2	2.8	1.7	2.3	92.4	0	628

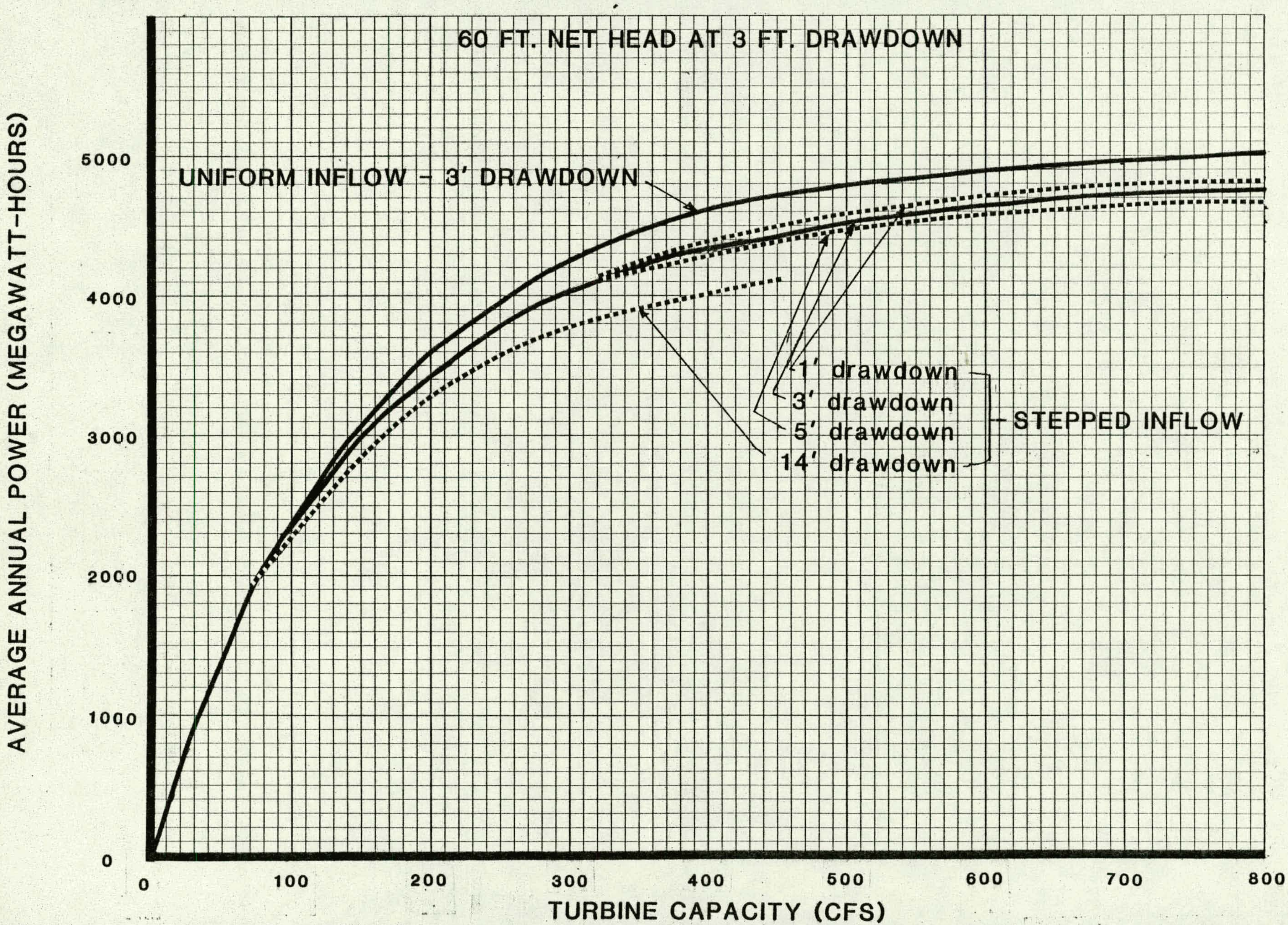
WATERVLIET RESERVOIR HYDRO ELECTRIC STUDY BASED ON STREAMFLOW SYNTHESIS
MONTHLY SUMMARY OF TURBINE OPERATION AT 600 CFS
ASSUMING: OPERATION CEASES AT 3 FEET BELOW FLASHBOARDS
DOMESTIC WATER SUPPLY MAINTAINED AT 6 MGD

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOTAL	DEFICIT (MG) MIN.	MAX.
1	1.1	8.4	1.2	1.2	1.5	24.2	13.5	11.1	2.2	1.6	.3	.7	67.0	350	350
2	.5	.0	9.9	5.0	8.9	16.9	21.2	18.8	30.0	3.0	2.8	.4	117.3	0	393
3	.3	15.3	10.1	5.1	14.8	21.1	9.9	1.1	.0	.0	1.8	.7	80.1	350	385
4	1.7	3.6	16.2	15.0	18.7	20.4	19.8	1.7	2.6	.3	3.2	5.3	108.6	350	350
5	10.9	3.5	15.4	10.4	17.8	9.4	18.1	8.6	2.8	3.4	2.1	4.2	106.5	350	350
6	9.3	4.6	14.8	7.1	2.3	20.9	6.9	2.1	.7	1.4	1.1	3.1	74.3	350	350
7	3.5	1.6	3.0	1.7	3.5	11.1	17.5	11.4	7.8	6.8	1.8	.3	69.9	350	350
8	.7	.3	6.2	4.8	2.8	20.5	26.9	5.2	2.2	3.0	.0	.4	73.0	350	350
9	1.2	1.1	4.0	1.6	2.3	14.1	13.7	12.3	15.6	3.8	2.7	2.8	75.1	350	350
10	1.8	.0	5.7	5.2	4.1	19.1	18.8	16.5	7.7	5.9	3.3	13.8	101.8	350	379
11	16.1	7.4	5.0	2.8	4.6	10.9	3.8	2.6	3.0	.7	.5	2.4	59.8	350	350
12	1.0	1.6	5.1	2.0	2.3	17.4	10.2	6.9	4.2	.9	.5	.4	52.4	350	350
13	1.6	2.6	6.1	5.0	11.9	11.2	10.7	6.0	.3	.3	3.7	3.1	62.6	350	350
14	13.1	21.2	10.6	2.1	.4	17.4	12.6	6.5	8.6	6.1	4.3	3.5	106.5	350	350
15	3.8	1.8	2.1	2.1	4.4	17.2	13.1	3.7	1.5	2.1	1.3	.0	53.0	350	350
16	.0	13.0	7.7	2.8	4.8	18.4	20.2	6.4	.7	2.0	.7	.0	76.6	350	527
17	.0	1.9	5.6	4.5	9.9	11.6	6.4	9.8	4.2	.4	.4	1.4	56.2	350	598
18	1.3	14.6	14.7	4.3	11.2	13.7	6.3	10.8	.3	.6	.0	.0	77.8	350	430
19	.0	2.4	3.2	2.1	9.4	21.1	14.4	2.9	.1	.9	.3	4.7	61.4	350	628
20	12.3	16.1	5.2	12.1	14.4	21.5	11.3	1.9	2.5	.6	.7	2.9	101.7	350	350
21	6.2	8.1	5.1	13.9	1.4	17.1	13.7	4.5	2.3	3.7	.8	.3	77.0	350	350
22	.1	5.4	4.7	1.4	4.2	21.1	19.1	11.0	3.6	2.0	.1	1.0	73.7	350	350
23	1.4	30.0	3.5	.5	4.8	14.7	7.7	1.3	.6	1.1	.8	.9	67.3	0	350
24	1.3	8.1	5.6	10.2	7.5	15.3	20.8	7.9	1.1	1.1	.4	.2	79.7	350	350
25	.1	12.5	5.5	3.9	13.3	7.5	21.6	15.5	5.4	2.1	2.8	.6	90.5	350	350
26	1.6	5.1	3.9	2.4	5.6	14.2	13.8	5.1	2.5	.3	1.5	.0	56.0	350	350
27	.1	.9	3.8	6.3	1.4	19.9	18.2	9.3	2.3	1.3	.2	.5	64.4	350	409
28	2.5	13.9	2.9	.3	1.5	18.5	17.2	15.8	4.0	9.7	2.6	2.3	91.1	350	350
29	.5	4.8	7.9	3.5	2.9	19.3	15.7	15.8	12.9	6.9	1.2	2.9	94.2	350	350
30	2.1	9.0	7.4	1.4	6.4	17.2	8.1	6.3	.0	1.0	2.1	.6	61.6	350	350
31	.8	8.4	8.0	1.6	.8	13.0	10.1	8.8	1.5	3.4	.0	.0	56.5	350	467
32	.0	6.9	6.1	2.6	3.4	16.3	15.6	3.6	.4	1.0	3.2	.7	59.8	350	561
33	.3	2.6	4.6	9.5	6.6	17.9	15.9	7.4	2.5	5.7	1.1	4.6	78.6	350	350
34	5.4	1.5	9.3	1.9	3.5	14.9	12.4	4.0	1.5	2.3	.2	.0	56.8	350	350
35	.0	5.2	15.4	6.2	5.1	11.3	11.2	5.4	.0	.9	3.0	.0	63.7	350	463
36	.0	1.7	14.1	5.3	7.6	15.9	22.1	7.6	1.6	1.0	.2	1.1	78.2	350	374
37	3.5	1.8	9.8	4.8	4.6	16.9	21.3	3.5	1.7	5.4	2.4	5.2	81.0	350	350
38	5.1	1.5	8.0	5.5	8.9	19.3	27.4	6.2	3.7	.1	.7	.3	86.6	350	350
39	1.1	8.3	6.1	1.2	11.7	18.0	11.1	1.0	.0	.0	.1	1.2	59.7	350	386
40	11.2	10.9	3.9	1.6	1.6	20.7	18.0	2.2	.7	1.5	.5	.0	72.9	350	350
41	.0	13.6	2.2	4.9	2.2	9.7	22.2	12.3	2.1	.4	.0	.1	69.7	350	464
42	.9	12.0	15.1	12.3	7.4	25.7	10.0	17.4	5.3	3.6	.9	.3	110.9	350	350
43	.0	3.9	5.5	7.1	9.1	19.1	19.1	6.6	.4	2.0	4.2	1.5	78.5	350	363
44	7.6	10.7	14.0	12.3	7.0	11.8	23.5	15.7	7.1	7.8	1.3	10.6	129.4	350	350
45	6.5	28.8	9.5	3.3	5.4	20.8	10.6	2.7	.9	1.3	2.7	6.9	99.4	350	350
46	9.1	3.3	14.9	18.7	20.0	13.2	15.1	7.2	1.7	.6	.3	.0	104.1	350	350
47	.2	4.4	7.2	1.2	5.4	20.5	18.3	5.1	1.9	2.4	.7	.9	68.3	350	350
48	1.7	30.0	9.3	3.6	5.2	18.8	12.7	2.3	.8	1.2	2.7	3.1	91.4	0	350
49	2.3	1.8	5.4	5.6	7.7	16.4	19.4	11.9	6.7	1.0	1.2	2.3	81.6	350	350
50	1.0	15.0	7.0	2.7	1.3	11.8	15.4	14.7	12.2	4.3	1.7	.9	88.0	350	350
AVG.	3.1	7.8	7.6	5.1	6.5	16.7	15.3	7.7	3.7	2.4	1.4	2.0	79.0	0	628

[illegible] RESERVOIR HYDRO-ELECTRIC STUDY BASED ON SIEBE-BELOW SYNTHESIS
MONTHLY SUMMARY OF TURBINE OPERATION AT 800 CFS
ASSUMING: OPERATION CEASES AT 3 FEET BELOW FLASHBOARDS
DOMESTIC WATER SUPPLY MAINTAINED AT 6 MGD

														DEFICIT (MG)	
YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	TOTAL	MIN.	MAX.
1	.8	6.3	.9	.9	1.1	19.7	10.1	8.4	1.6	1.2	.3	.6	51.8	350	350
2	.4	.0	7.4	3.8	6.6	12.7	17.4	15.6	26.4	1.6	2.1	.3	94.3	350	393
3	.2	13.0	7.5	3.9	12.5	17.2	7.4	.8	.0	.0	1.4	.5	64.3	350	385
4	1.3	2.7	13.7	12.8	15.4	15.7	16.4	1.3	2.0	.2	2.4	4.0	87.9	350	350
5	8.2	2.6	12.9	7.8	14.8	7.0	13.8	6.4	2.1	2.6	1.6	3.1	82.9	350	350
6	7.0	3.5	11.8	5.3	1.7	16.8	5.2	1.5	.6	1.0	.8	2.3	57.5	350	350
7	2.7	1.2	2.3	1.2	2.6	8.4	13.1	8.5	5.8	5.1	1.3	.2	52.4	350	350
8	.5	.2	4.6	3.6	2.1	16.0	21.7	3.9	1.7	2.2	.0	.3	56.8	350	350
9	.9	.8	3.0	1.2	1.7	10.6	10.3	9.2	13.2	2.8	2.0	2.1	57.8	350	350
10	1.3	.0	4.3	3.9	3.1	14.3	15.2	13.9	5.8	4.4	2.5	11.8	80.5	350	379
11	13.6	5.6	3.8	2.1	3.5	8.2	2.8	2.0	2.2	.5	.4	1.8	46.4	350	350
12	.8	1.2	3.8	1.5	1.7	13.0	7.6	5.2	3.1	.6	.4	.3	39.3	350	350
13	1.2	2.0	4.6	3.8	8.9	8.4	8.0	4.5	.2	.3	2.8	2.3	46.9	350	350
14	11.2	17.4	8.0	1.6	.3	13.1	9.5	4.9	6.4	4.6	3.2	2.6	82.8	350	350
15	2.8	1.4	1.6	1.6	3.3	12.9	9.8	2.8	1.1	1.6	1.0	.0	39.8	350	350
16	.0	10.1	5.8	2.1	3.6	13.8	16.6	4.8	.5	1.5	.5	.0	59.4	350	527
17	.0	1.4	4.2	3.4	7.5	8.7	4.8	7.3	3.2	.3	.3	1.1	42.2	350	598
18	1.0	12.4	11.6	3.2	8.4	10.3	4.8	8.1	.2	.4	.0	.0	60.4	350	430
19	.0	1.8	2.4	1.6	7.0	17.1	10.8	2.1	.1	.6	.2	3.5	47.3	350	628
20	9.6	13.6	3.9	9.1	12.2	17.7	8.5	1.4	1.9	.4	.5	2.2	81.2	350	350
21	4.6	6.0	3.8	11.7	1.1	12.8	10.3	3.3	1.7	2.8	.6	.2	59.0	350	350
22	.1	4.1	3.5	1.1	3.2	17.2	15.8	8.2	2.7	1.5	.1	.8	58.1	350	350
23	1.0	26.9	2.0	.4	3.6	11.0	5.8	.9	.5	.9	.6	.6	54.2	350	350
24	1.0	6.1	4.2	7.7	5.6	11.5	17.1	5.9	.8	.8	.3	.2	61.3	350	350
25	.0	9.6	4.1	3.0	10.3	5.6	17.7	12.9	4.0	1.6	2.1	.4	71.3	350	350
26	1.2	3.8	2.9	1.8	4.2	10.7	10.4	3.9	1.9	.2	1.1	.0	42.0	350	350
27	.1	.7	2.9	4.7	1.0	15.0	13.9	7.0	1.7	1.0	.2	.4	48.6	350	409
28	1.8	11.9	2.2	.2	1.1	13.9	12.9	13.4	3.0	7.3	1.9	1.7	71.4	350	350
29	.4	3.6	5.9	2.6	2.2	14.5	11.8	13.4	10.4	5.1	.9	2.2	72.9	350	350
30	1.5	6.8	5.6	1.1	4.8	12.9	6.1	4.7	.0	.7	1.6	.5	46.2	350	350
31	.6	6.3	6.0	1.2	.6	9.7	7.6	6.6	1.2	2.6	.0	.0	42.3	350	467
32	.0	5.2	4.6	2.0	2.5	12.2	11.7	2.7	.3	.8	2.4	.5	44.9	350	561
33	.2	2.0	3.5	7.1	4.9	13.4	11.9	5.6	1.8	4.2	.8	3.4	58.9	350	350
34	4.0	1.1	7.0	1.5	2.6	11.2	9.3	3.0	1.1	1.8	.1	.0	42.6	350	350
35	.0	3.9	12.8	4.6	3.8	8.5	8.4	4.1	.0	.7	2.2	.0	49.1	350	463
36	.0	1.3	10.6	4.0	5.7	11.9	18.1	5.7	1.2	.8	.2	.8	60.2	350	374
37	2.6	1.4	7.4	3.6	3.4	12.7	17.5	2.6	1.3	4.1	1.8	3.9	62.3	350	350
38	3.8	1.1	6.0	4.1	6.7	14.5	22.1	4.7	2.8	.1	.5	.2	66.5	350	350
39	.8	6.2	4.6	.9	8.8	13.5	8.3	.8	.0	.0	.1	.9	44.8	350	386
40	8.4	8.2	2.9	1.2	1.2	16.5	13.6	1.7	.5	1.2	.4	.0	55.7	350	350
41	.0	11.5	1.7	3.6	1.6	7.3	18.2	9.2	1.6	.3	.0	.1	55.1	350	464
42	.7	9.0	12.3	9.2	5.6	20.8	7.5	14.6	3.9	2.7	.6	.2	87.2	350	350
43	.0	2.9	4.1	5.3	6.8	14.3	15.6	5.0	.3	1.5	3.1	1.2	60.2	350	363
44	5.7	8.0	10.5	9.3	5.3	8.8	19.1	13.3	5.3	5.8	1.0	7.9	100.1	350	350
45	4.9	23.1	7.1	2.5	4.1	16.6	7.9	2.0	.6	1.0	2.0	5.2	77.0	350	350
46	6.8	2.5	12.0	15.6	16.4	9.9	11.3	5.4	1.3	.4	.2	.0	81.8	350	350
47	.2	3.3	5.4	.9	4.1	16.1	14.2	3.8	1.4	1.8	.5	.7	52.4	350	350
48	1.3	30.0	7.0	2.7	3.9	14.1	9.5	1.7	.6	.9	2.0	2.3	76.0	0	350
49	1.7	1.3	4.0	4.2	5.8	12.3	16.1	8.9	5.0	.7	.9	1.7	62.7	350	350
50	.7	12.6	5.2	2.0	1.0	8.8	11.6	11.6	9.1	3.3	1.3	.7	68.1	350	350
AVG.	2.4	6.4	5.8	3.9	5.0	12.8	11.9	6.0	2.9	1.8	1.1	1.5	61.3	0	628

AVERAGE ANNUAL POTENTIAL POWER PRODUCTION



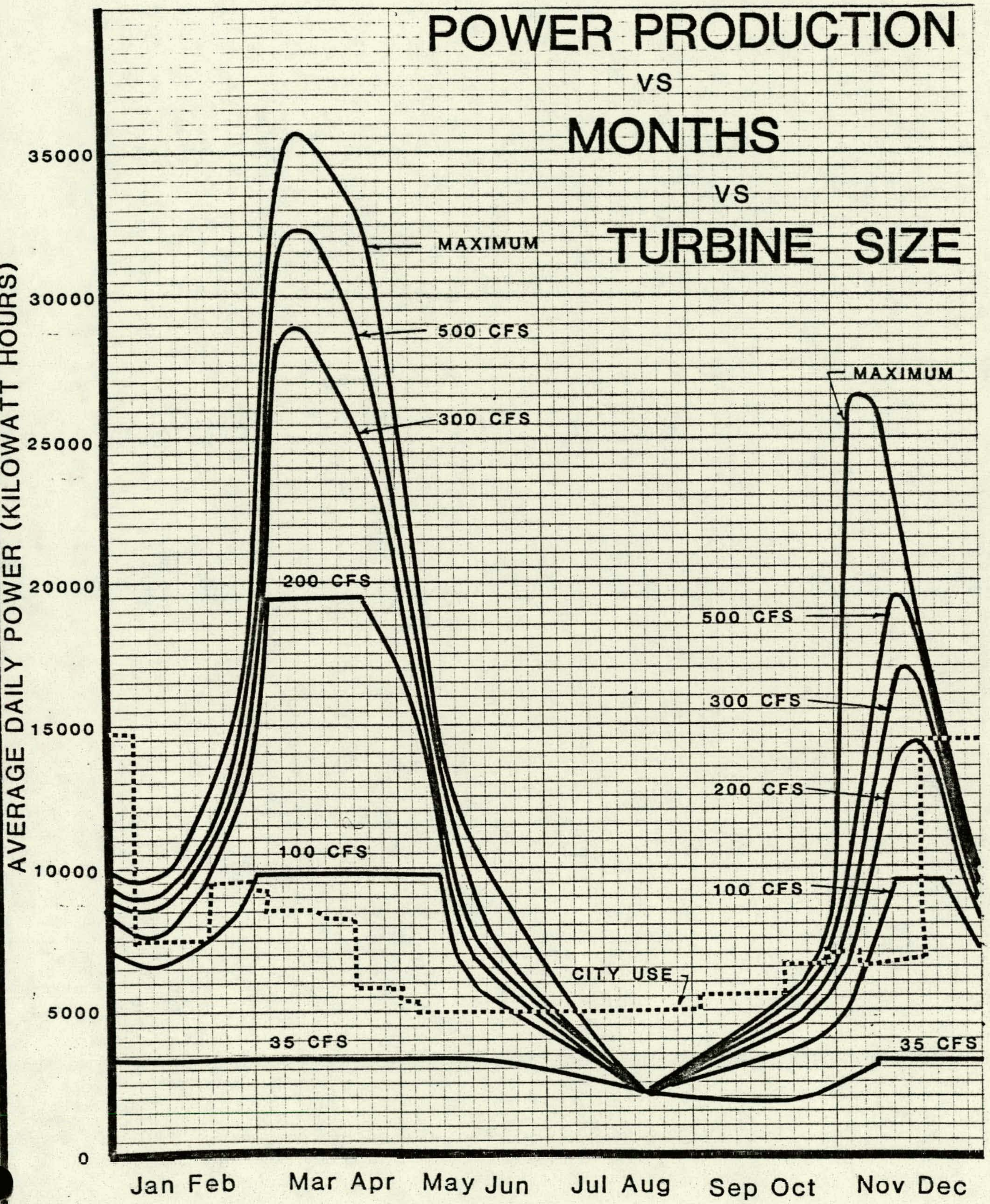
NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

POWER PRODUCTION

POWER VS TURBINE CAPACITY

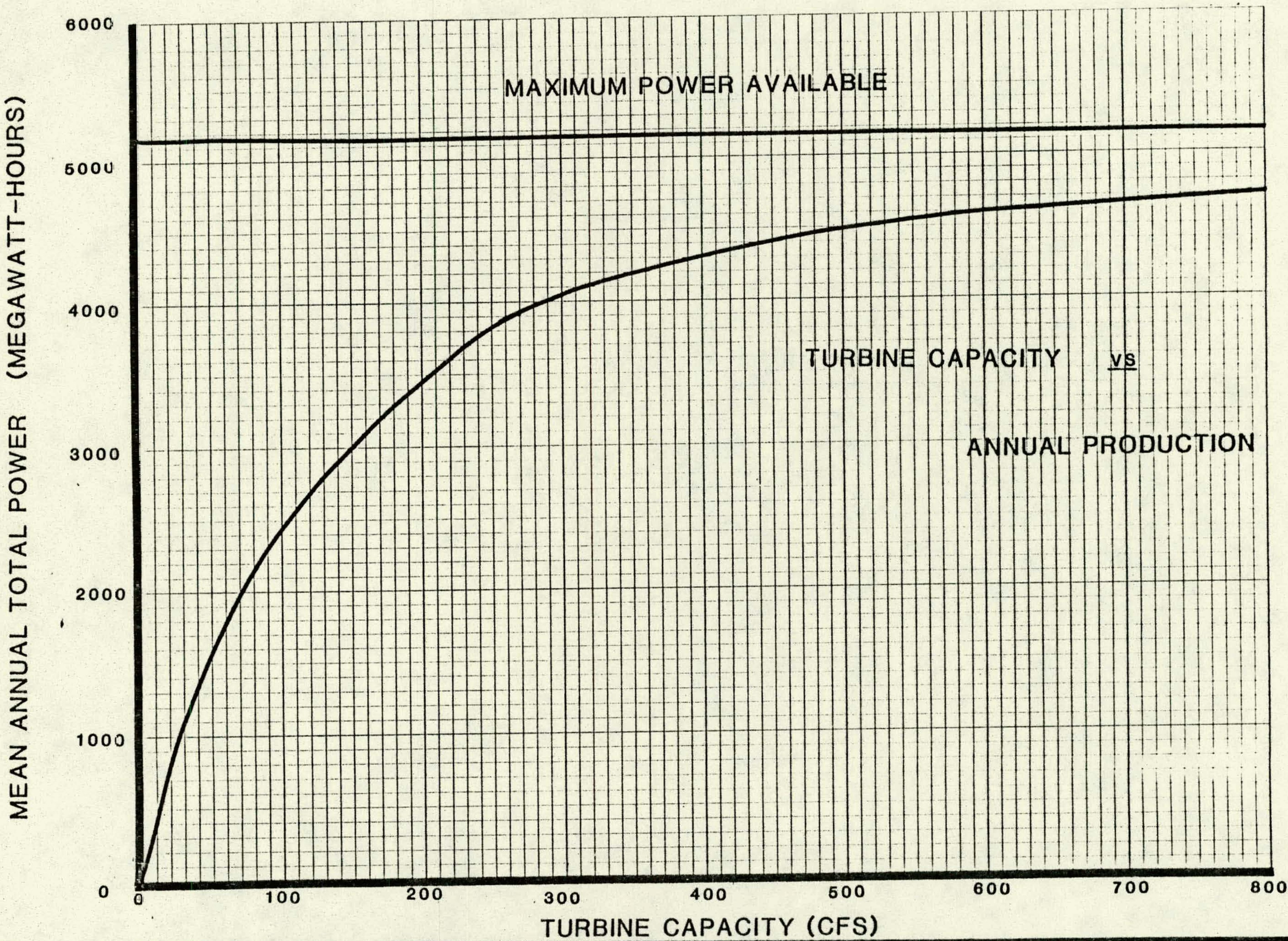
PRODUCTION VS. MONTHS



GIVEN: 60 FT. NET HEAD @ .80 eff.

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

POWER vs. CAPACITY

MARKETING

Electric Power Market

The primary consideration of the marketing analysis has been the determination of suitable placement of any surplus power generated at any proposed hydroelectric facility at French's Mills. It was assumed at the outset that the highest benefit for the first incremental power generated would be for municipal use at the site to replace the mechanical hydropower presently utilized for water supply pumping with electrical power. Placement of the power generated in excess of this requirement was considerably more involved.

It was first necessary to determine what legal restrictions would be placed upon disposal of the surplus power. Discussions were held with the New York State Public Service Commission. It was determined that under terms of current PSC tariffs and regulations, sale of surplus power by the City of Watervliet to any existing consumer within the Niagara Mohawk Power Corporation franchised area would be considered "pirating" and would be illegal, unless the City, as producer, could prove this would be in the public interest. New consumers are excepted from this rule and a consumer, requesting a new service, may possibly be served by the developer of the Normanskill Hydroelectric facility. Since firm power generated at the site would be minimal, and it would serve at best only to supply the City's municipal pumping station, it was obvious that sale of power to new consumers as their sole source of power would be unacceptable. For this reason, discussions with existing or potential new retail consumers such as clients of the Guilderland Industrial Development Agency, were not pursued.

It was determined, that the PSC pirating regulations did not apply to the possible sale of power either to the Power Authority of the State of New York (PASNY) or to Federal facilities such as the U.S. Government Arsenal at Watervliet. In this light, discussions were held with the Watervliet Arsenal to determine the interest on their part to using municipally generated power. Due to the large amount of power consumed by the Arsenal in their manufacturing facilities in relation to what the City could supply, this alternative was judged to be unfeasible.

The Power Authority of the State of New York (PASNY) is a state-chartered authority whose purpose is to develop electrical generation and transmission facilities within the state. A request has been made of PASNY to ascertain their interests in purchasing the surplus dump power available from the Normanskill Hydroelectric facility. As of this date, a formal reply from this organization has not been received.

Discussions were held with the Niagara Mohawk Power Corporation (N.M.P.C.) to explore several areas of interest. The first area explored with the utility was the possibility that N.M.P.C. purchase all surplus power from this facility. Discussions with the local N.M.P.C. management yielded an offer from Niagara Mohawk Power Corporation of 3 to 5 mils per kilowatt hour for this surplus power.

Pursuing the determination of suitable purchase price, an examination was made of contracts on file with the New York State Public Service Commission between the Niagara Mohawk Power Corporation and various municipal and private producers of electrical energy. Detailed examination was made of these contracts, both for prevailing rate and also of their interface requirements. Two of the five existing contracts most comparable to our case, established the value of power at 4.5 mils per kilowatt hour, the other three at 9 mils per kilowatt hour. Terms in three of the contracts were left indefinite and the remaining two expire in 1983. All the most current contracts executed between February and June of 1978 set a price for this power at 9 mils per kilowatt hour. In certain cases, these contracts provide for reciprocity on the part of Niagara Mohawk for supply of power to the municipality in the event that their generation facilities were off-line at the rate of 1.2 cents per kilowatt hour. A final determination was made based upon our discussions and examinations of current contracts and on evaluation of current energy prices on national and state level that the 9 mil per kilowatt hour rate would be used for calculating benefits accruable to the city for sale of surplus power to Niagara Mohawk.

The second area of discussion with the utility (N.M.P.C.) involved determination of charges imposed by the utility for "wheeling" power. "Wheeling" involves transmission of power generated at the Normanskill Hydroelectric site over existing Niagara Mohawk Power Corporation facilities. Power would then be extracted within the City of Watervliet at municipal facilities. The charge for "transmission" of municipally generated power would take into account transmission losses and expenses the utility would incur in operating and maintaining that portion of their transmission system allocable to this use. It should be noted here that transmission system is used in a generic sense since transmission of the quantity of power expected to be developed with the Normans Kill site could be easily handled by the utility's distribution system. The utility, through its local management, showed a very cool initial reception to even discussing wheeling. Subsequent discussions with the Syracuse office yielded a tentative offer of 2 to 4 mils per kilowatt hour for wheeling. Presently, the Power Authority of the State of New York (PASNY) is charged 2 to 2-1/2 mils per kilowatt hour for wheeling across N.M.P.C. lines on an aggregate state-wide basis. It is expected that this rate will be increased shortly at the insistence of the Public Service Commission. It has also been determined that the Federal Energy Regulatory Commission could be addressed to compel Niagara Mohawk to wheel power to the City if an agreement on wheeling could not be reached with Niagara Mohawk Power Corporation. A similar situation arose in the Town of Massena, New York.

Final discussions were held with the Niagara Mohawk Power Corporation on the possibility of purchase or lease of the site by Niagara Mohawk for construction of generation facilities by the utility. Niagara Mohawk had initially expressed some interest in possible lease of the site but subsequently has stated informally that they might rather purchase the site outright. No further discussions have been held with Niagara Mohawk regarding this matter.

Having determined the external costs and benefits to the city for generation and sale of power from the proposed site, determination of the intrinsic value of power remained.

Municipal Power Consumption

The detailed account of power purchased by municipal facilities was undertaken to determine what possible benefits would accrue to the city for use of surplus power available at the site using the assumption that the power would be wheeled across Niagara Mohawk Power Corporation facilities. An audit was performed to determine the amount of energy consumed, it's total cost and periods of consumption. All city accounts with the Niagara Mohawk Power Corporation were compiled for a three year span (1976-1978) for 13 municipal facilities listed as follows:.

1. Municipal Swimming Pool
2. Water Filtration Plant
3. City Hall
4. Water Distribution Pumping Station
5. City Garage
6. Municipal Ice Skating Facility
7. Raw Water Pumping Station
8. Senior Citizen Center
9. Fire Station
10. Street Light Service
11 Traffic Light Service
12. Civic Center
13. Hudson Shores Park

Data was compiled on the electrical consumption of these facilities by taking monthly or bimonthly utility bills and disaggregating the total consumption over the billing period. In certain cases, as in the case of the municipal ice skating facility, adjustments were made for known peak operating loads from facility operating records. In the case of the Senior Citizen Center, now under construction, engineer's estimates of power requirements at the facility were utilized in determining total power consumption for a typical year.

A significant factor in the City of Watervliet's annual cost for power is the operation of the City's street lighting system. The street lighting system is comprised of approximately 598 luminaires both separately mounted and mounted on utility company poles. Under the present system, the City pays an annual charge for each fixture as defined by the New York State Public Service Commission Tariff Classifications. (P.S.C. No. 213)

The total annual charges for the street lighting facilities is then divided by the calculated load based upon manufacturer's catalogue power requirements for the individual lamps. A factor of 4,170 hours per year is used for the anticipated on-time of luminaires activated by photocells. The monthly charge billed, therefore, is approximately 1/12th of the annual charge, but varies according to the time of the year representing the normal variations of the nocturnal cycles. On a straight calculated kilowatt-per-year basis, the cost for this service is approximately 7-1/2 cents per kilowatt hour. It is understood, however, that this cost represents not only cost of power to the equipment, but also operating maintenance costs and an amount sufficient to amortize the facilities over their expected life. Under terms of the present contract between the City and Niagara Mohawk Power Corporation, under PSC Tariff No. 213, the city may at any time elect to terminate service by paying the depreciated book value of the facilities less the salvage value. With this in mind, an attempt was made to determine this residual value as a means of calculating the true benefit for either power consumption alone or full operation of the facilities by the city. Repeated requests to Niagara Mohawk Power Corporation for this information have been futile. The only figure offered by N.M.P.C. verbally was an approximate replacement value of "about $100,000." It was also inferred that this replacement value included only materials. Upon further investigation, several apparent discrepancies have been found in the current contract between the City and Niagara Mohawk Power Corporation. Prior to July 1977, the majority of lighting fixtures listed on N.M.P.C contract schedule SL, as installed within the City of Watervliet, were of conventional incandescent type. Billing costs, prior to this date, were calculated on the filed tariff charges for this type of luminaire. However, the new Schedule SL furnished the City by N.M.P.C. after July 1977 indicates that all of the approximately 525 luminaires were either mercury vapor or high pressure sodium type. Subsequent billing for street lighting facilities has been on this basis. Inquiries to the Niagara Mohawk Power Corporation as to when and if the entire city street lighting system was converted to the newer type of luminaire have been to no avail. A cursory examination of several street lighting fixtures indicates that they are in fact the old style incandescent luminaire. Having been impeded in our attempts to obtain sufficient information from the Niagara Mohawk Power Corporation to determine the benefits and costs for city ownership and operation of the street lighting facilities, the costs and benefits were developed independently. As a basis of capital cost for take-over of the facilities, the $100,000 quoted by Niagara Mohawk (thought to be excessively high) was used. An estimate from a local reputable contractor with considerable experience in installation, operation and maintenance of municipal street lighting facilities was obtained for the installation portion of this capital expense. In addition, an estimate for contract operation and maintenance (relamping, etc.) was also obtained. Using these figures and amortizing the capital portion of the outlay over 20 years at the current city bonding rate, it was determined that the annual charges including operation and maintenance for the existing street lighting facilities was approximately $25,000 per annum. The difference then between this figure and the $50,000 per year current charges to the city from Niagara Mohawk Power Corporation was used therefore as representing the electrical power consumption cost of the street lighting facilities.

A summary of electrical power consumption in the facilities investigated is shown on Figure 30.

Benefit Value Program

Each of the various alternative hydroelectric generating configurations which were considered would produce electric power as its primary benefit. The value of the power which it is capable of producing depends not only on the total amount of power, but also on whether the power that is being produced will be simultaneously consumed by the water pumping station at the site, whether the remaining excess, if any, will simultaneously be used remotely by municipally owned facilities in the City of Watervliet, or whether the remaining excess, if any, will be "dumped" into the Niagara Mohawk system.

A model was developed which compared the time and rate distribution of the power which could be produced against the power consumption requirements of the owner both at the site and within the City. The electrical energy consumption pattern for a recent year was input to the model. It summarized the annual use by representing each month by two periods, each with relatively uniform use. For each of those 24 usage periods, the power capable of being produced by each alternative configuration for the 50 corresponding months from the reservoir streamflow simulation was determined and the average amount of power falling into each of the three benefit categories was compiled. The simulation thus progressed through the 24 calendar periods and was summarized as annual totals to which the appropriate benefit rates are applied in order to derive the total annual value of the power generated for each alternative and in each benefit category.

When the generating equipment may be idle due to lack of available water, the generating equipment could have a fourth potential marketable benefit to the Niagara Mohawk Power Corporation if operated in a mode by which it could provide power factor correction in the local Niagara Mohawk service area. The value of such potential benefit would be proportional to the peak generating capacity of the machine and might accrue whenever it is not generating electricity. A nominally low benefit rate was chosen to reflect the remoteness of this aspect as a factor for selection.

The credit summary was further refined to reflect the fact that any of the Type 3 turbines (Kaplan,see Figure 44) would be capable of operating at load factors or flow rates reduced to approximately 10% of the peak capacity. A correction was further applied to the benefits determined for these turbines to reflect the advantageous fact that they could operate a substantially greater percentage of time compared to that calculated under the assumption that the turbine could run only at full flow capacity. Total power output for the generating equipment would not be increased, but a greater relative amount of the power which it could produce would be capable of being used simultaneously by the pumping station at the site accruing power credit at a higher rate and avoiding the necessity to put this power into the Niagara Mohawk Power Corp. system incurring a transportation or "wheeling" charge for the energy. The correction for increased operating time is based upon the relationship shown in Figure 25. Credits for power factor correction were correspondingly reduced for all of the Type 3 turbines in proportion to decreased idle time.

Figure 30A displays an annual summary for each alternative showing the total city power consumption as well as the cost at the assumed rate per kilowatt hour and the corresponding average of credits over the 50-year simulation period for power produced in each of the benefit categories and the resulting net cost of power after applying those credits.

The total credits thus derived are the basis for several later computations pertaining to machine selection and overall economic feasibility.

Utility Interface

Certain technical requirements for interfacing with Niagara Mohawk Power system were determined through discussions with Niagara Mohawk facility engineers. The transmission voltage for input into the Niagara Mohawk system at the French's Mills location would be 13,200 volts. It was assumed that although present Niagara Mohawk facilities at the site are of inadequate construction for transmission of this power, current planning requirements already include extension of 13,200 volt facilities to the site in the near future.

Requirements for protection and relaying used are those stated in IEEE-357-1973 "IEEE Guide for Protective Relaying of Utility Consumer Interconnections". Niagara Mohawk Power Corporation has also been approached to determine the feasibility of using power factor correction during off-line generator periods. Since there is as a conservative estimate, over 600 horsepower of connected inductive load within a one mile radius of the proposed generation facilities, the benefits of power factor correction would seem substantial. While mild interest has been expressed by Niagara Mohawk concerning this power factor correction, no value for this benefit has been determined. For this reason, a nominal token value has been shown in the calculations purely to represent the possibility of this end use.

A final interface requirement discussed has been that of concurrency of power generation and consumption. The accounting methods which would be used to calculate the payment amounts accruable either to Niagara Mohawk or to the City for power either generated, sold, purchased or wheeled will involve metering at some 14 locations. Since the proposed facility most probably will be a run-of-river facility with normal fluctuations in generating pattern, some conditions must be established between the utility and the municipality as to the concurrency of generating and consumption periods. While the most obvious accounting methods would be the one presently in use, that is, simple monthly readings of pertinent meters with the subsequent charges or credits for power either sold, used or wheeled, this method may not be entirely fair to the utility. Should the hydroelectric facility for instance, generate at a maximum rate for the first week of the month and fall to a low or zero rate for the remaining period in the month, the City could conceivably have credit for the power generated averaged over the month. Preliminary discussions with the utility have indicated that they would be amenable to any equitable accounting stance which would take these concurrency problems into consideration. Consideration of this concurrency problem has lead to consideration of a fairly sophisticated operating system for a facility of this size in order to provide the optimum operating mode within the accounting periods to maximize City benefits.

Incurred Municipal Benefits and Costs

Additional economic factors relating to city development of the project were determined under this chapter. Factors which must be considered are changes in property tax assessments, insurance requirements, labor requirements and municipal bonding rates if municipality is to assume financial responsibility for the facility.

Currently, the city pays approximately $31,000 in school, county, town, highway, and fire district taxes to the Town of Guilderland and the appropriate school and fire districts for property owned at the Town of Guilderland site. The present equalization rate for construction of the type considered by this project is 10%. Based upon a current tax rate of $255 per $1,000 of assessed valuation, $1,000,000 of construction would increase the city's present tax burden by approximately $26,000 per year. A figure somewhat less than this was used in the Economic Analysis of the project with the assumption that assessment would not be at full value of construction since substantial portions of the construction involve modification or rehabilitation of existing facilities.

Presently, the municipal pumping station located at the proposed site is manned 24 hours a day, 7 days per week. It is assumed that generation of hydroelectric power at the site would additionally entail modification of the present pumping station to serve as the control facility. This facility would, for safe and adequate control, be highly automated. A reduction in workforce to only one or two individuals from the present staff of six would be possible. These individuals would be responsible for monitoring the operation and maintaining the combined hydroelectric/pumping facility. At current levels, the cost to the city is approximately

$19,000 per year per man in wages and fringe benefits. Substantial savings would accrue to the city with the reduction in the labor force if the proposed hydroelectric facility is pursued.

Presently, the city carries sufficient Workmen's Compensation, Property and Public Liability insurance at the site to meet Municipal Law requirements. It has been assumed that any additional insurance requirement due to the construction of a hydroelectric facility at the site would be self-insured. Further discussion of the amount assumed for payment into a sinking fund for this use is discussed in the Economic Analysis section.

Since at least a portion of the proposed facility would be financed through municipal borrowing, a determination of expected bonding rates was made. The actual rate for municipal bonding by the City of Watervliet, based upon geometric mean of the past five years' issuance of bonds, is 6.31%. Further discussion of the ramifications of municipal bonding will be given in the Implementation section.

MUNICIPAL ELECTRIC CONSUMPTION

MUNICIPAL ELECTRICAL CONSUMPTION
FOR TYPICAL CALENDER YEAR BY FACILITY
EXPRESSED AS KWH PER DAY

ANNUAL SUMMARY SHOWN
FOLLOWING DECEMBER

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR JANUARY

DAY#	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2434	247	14757
2	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2434	247	14757
3	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2434	247	14757
4	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2434	247	14757
5	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2434	247	14757
6	8607	440	91	0	43	143	31	2	39	2350	0	250	81	2434	247	14760
7	8607	440	91	0	43	143	31	2	39	2350	1	250	81	2434	247	14760
8	8607	440	91	0	43	143	31	2	39	2350	1	250	81	2434	247	14760
9	8607	440	91	0	43	0	31	2	39	2350	1	270	81	2434	247	14636
10	1428	440	91	0	13	0	34	2	39	2350	1	270	80	2434	352	7533
11	1428	440	112	0	13	0	34	2	39	2350	1	270	80	2434	352	7554
12	1428	440	112	0	13	0	34	2	39	2350	1	270	80	2434	352	7554
13	1428	440	112	0	13	0	34	2	39	2350	1	270	80	2434	352	7554
14	1428	440	112	0	13	0	34	2	39	2350	1	270	80	2434	352	7554
15	1428	440	112	0	13	0	34	2	39	2350	1	270	80	2434	352	7554
16	1428	440	112	0	13	0	34	2	39	2350	1	270	80	2434	352	7554
17	1428	440	112	0	13	0	34	2	39	2350	1	270	80	2434	352	7554
18	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
19	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
20	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
21	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
22	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
23	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
24	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
25	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
26	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
27	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
28	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
29	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
30	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2434	352	7575
31	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2443	352	7584
TOT.	108872	13640	3257	0	668	1146	1024	60	1512	72850	15	8212	2495	75451	9963	299166
AVG.	3512	440	105	0	22	37	33	2	49	2350	0	265	80	2434	321	9651

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR FEBRUARY

DAY#	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2443	352	7584
2	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2443	352	7584
3	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2443	352	7584
4	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2443	352	7584
5	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2443	352	7584
6	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2443	352	7584
7	1428	440	112	0	13	0	34	2	60	2350	1	270	80	2443	352	7584
8	3516	440	112	0	12	0	30	2	60	2350	1	270	86	2443	348	9669
9	3516	440	99	0	12	0	30	2	60	2350	1	270	86	2443	348	9656
10	3516	440	99	0	12	0	30	2	60	2350	1	270	86	2443	348	9656
11	3516	440	99	0	12	0	30	2	60	2350	1	270	86	2443	348	9656
12	3516	440	99	0	12	0	30	2	60	2350	1	270	86	2443	348	9656
13	3516	440	99	0	12	0	30	2	60	2350	1	270	86	2443	348	9656
14	3516	440	99	0	12	0	30	2	60	2350	1	270	86	2443	348	9656
15	3516	440	99	0	12	0	30	2	60	2350	1	270	86	2443	348	9656
16	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
17	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
18	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
19	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
20	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
21	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
22	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
23	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
24	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
25	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
26	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
27	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
28	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
TOT.	83829	12315	2870	0	343	0	876	56	1876	65800	14	7560	2359	68408	9770	256076
AVG.	2994	440	102	0	12	0	31	2	67	2350	1	270	84	2443	349	9146

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR MARCH

DAY#	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2443	348	9671
2	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2153	348	9381
3	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2153	348	9381
4	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2153	348	9381
5	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2153	348	9381
6	3516	440	99	0	12	0	30	2	75	2350	1	270	86	2153	348	9381
7	3516	441	99	0	12	0	30	2	75	2350	1	270	86	2153	348	9383
8	3516	441	99	0	10	0	30	2	75	2350	1	270	86	2153	348	9381
9	3516	441	99	0	10	0	30	2	75	2350	1	270	86	2153	348	9381
10	2453	441	99	0	10	67	21	2	75	2350	1	305	80	2153	326	8383
11	2453	441	91	0	10	67	21	2	75	2350	1	305	80	2153	326	8375
12	2453	441	91	0	10	67	21	2	75	2350	1	305	80	2153	326	8375
13	2453	441	91	0	10	67	21	2	75	2350	1	305	80	2153	326	8375
14	2453	441	91	0	10	67	21	2	75	2350	1	305	80	2153	326	8375
15	2453	441	91	0	10	67	21	2	75	2350	1	305	80	2153	326	8375
16	2453	441	91	0	10	67	21	2	75	2350	1	305	80	2153	326	8375
17	2453	441	91	0	10	67	21	2	75	2350	1	305	80	2153	326	8375
18	2453	441	91	0	10	67	21	2	75	2350	1	305	80	2153	326	8375
19	2453	441	91	0	10	67	21	2	75	2350	1	305	80	2153	326	8375
20	2453	441	91	0	10	67	21	2	71	2350	1	305	80	2153	326	8371
21	2453	441	91	0	10	67	21	2	71	2350	1	305	80	2153	326	8371
22	2453	441	91	0	10	67	21	2	71	2350	1	305	80	2153	326	8371
23	2453	441	91	0	10	67	21	2	71	2350	1	305	80	2153	326	8371
24	2453	441	91	0	10	67	21	2	71	2350	1	305	80	2153	326	8371
25	2453	441	91	0	10	67	21	2	71	2350	1	305	80	2153	326	8371
26	2453	441	91	0	10	67	21	2	71	2350	1	305	80	2153	326	8371
27	2453	441	91	0	10	67	21	2	71	2350	1	305	80	2153	326	8371
28	2453	441	91	0	10	67	21	2	71	2350	1	305	80	2153	326	8371
29	2453	441	91	0	10	67	21	2	71	2350	1	305	80	2153	326	8371
30	2453	441	91	0	10	67	21	2	71	2350	1	305	80	2153	326	8371
31	2453	441	91	0	10	67	21	2	71	2350	1	305	80	1992	326	8209
TOT.	85599	13668	2901	0	323	1465	741	62	2271	72850	16	9144	2536	66885	10310	268769
AVG.	2761	441	94	0	10	47	24	2	73	2350	1	295	82	2158	333	8670

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR APRIL

DAY#	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	2453	441	91	0	10	67	21	2	71	2350	1	305	80	1992	326	8209
2	2453	441	91	0	10	67	21	2	71	2350	1	305	80	1992	326	8209
3	2453	441	91	0	10	67	21	2	71	2350	1	305	80	1992	326	8209
4	2453	441	91	0	10	67	21	2	71	2350	1	305	80	1992	326	8209
5	2453	441	91	0	10	67	21	2	71	2350	1	305	80	1992	326	8209
6	2453	442	91	0	10	67	21	2	71	2350	1	305	80	1992	326	8210
7	2453	442	91	0	10	67	21	2	71	2350	1	305	80	1992	326	8210
8	2453	442	91	0	10	67	21	2	71	2350	1	305	80	1992	326	8210
9	2453	442	91	0	10	67	21	2	71	2350	1	305	80	1992	326	8210
10	2453	442	91	0	10	67	21	2	71	2350	1	305	80	1992	326	8210
11	0	442	91	0	98	67	12	2	71	2350	1	305	67	1992	240	5738
12	0	442	103	0	98	67	12	2	71	2350	1	305	67	1992	240	5750
13	0	442	103	0	98	67	12	2	71	2350	1	305	67	1992	240	5750
14	0	442	103	0	98	67	12	2	71	2350	1	305	67	1992	240	5750
15	0	442	103	0	98	67	12	2	71	2350	1	305	67	1992	240	5750
16	0	442	103	0	98	67	12	2	71	2350	1	305	67	1992	240	5750
17	0	442	103	0	98	67	12	2	71	2350	1	305	67	1992	240	5750
18	0	442	103	0	98	67	12	2	71	2350	1	305	67	1992	240	5750
19	0	442	103	0	98	67	12	2	47	2350	1	305	67	1992	240	5726
20	0	442	103	0	98	67	12	2	47	2350	1	305	67	1992	240	5726
21	0	442	103	0	98	67	12	2	47	2350	1	305	67	1992	240	5726
22	0	442	103	0	98	67	12	2	47	2350	1	305	67	1992	240	5726
23	0	442	103	0	98	67	12	2	47	2350	1	305	67	1992	240	5726
24	0	442	103	0	98	67	12	2	47	2350	1	305	67	1992	240	5726
25	0	442	103	0	98	67	12	2	47	2350	1	305	67	1992	240	5726
26	0	442	103	0	98	67	12	2	47	2350	1	305	67	1992	240	5726
27	0	442	103	0	98	67	12	2	47	2350	1	305	67	1992	240	5726
28	0	442	103	0	98	67	12	2	47	2350	1	305	67	1992	240	5726
29	0	442	103	0	98	67	12	2	47	2350	1	305	67	1992	240	5726
30	0	442	103	0	98	67	12	2	47	2350	1	305	67	1624	240	5358
TOT.	24525	13254	2968	0	2069	1998	448	60	1833	70500	15	9155	2151	59390	8063	196428
AVG.	818	442	99	0	69	67	15	2	61	2350	1	305	72	1980	269	6548

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR MAY

DAY#	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	0	442	103	0	98	67	12	2	47	2350	1	305	67	1624	240	5358
2	0	442	103	0	98	67	12	2	47	2350	1	305	67	1624	240	5358
3	0	442	103	0	98	67	12	2	47	2350	1	305	67	1624	240	5358
4	0	442	103	0	98	67	12	2	47	2350	1	305	67	1624	240	5358
5	0	441	103	0	98	67	12	2	47	2350	1	305	67	1624	240	5357
6	0	441	103	0	98	67	12	2	47	2350	0	305	67	1624	240	5357
7	0	441	103	0	98	67	12	2	47	2350	0	305	67	1624	240	5357
8	0	441	103	0	98	67	12	2	47	2350	0	305	67	1624	240	5357
9	0	441	103	0	98	38	12	2	47	2350	0	235	67	1624	240	5258
10	48	441	103	13	9	38	9	2	47	2350	0	235	53	1624	152	5125
11	48	441	91	13	9	38	9	2	47	2350	0	235	53	1624	152	5112
12	48	441	91	13	9	38	9	2	47	2350	0	235	53	1624	152	5112
13	48	441	91	13	9	38	9	2	47	2350	0	235	53	1624	152	5112
14	48	441	91	13	9	38	9	2	47	2350	0	235	53	1624	152	5112
15	48	441	91	13	9	38	9	2	47	2350	0	235	53	1624	152	5112
16	48	441	91	13	9	38	9	2	47	2350	0	235	53	1624	152	5112
17	48	441	91	13	9	38	9	2	47	2350	0	235	53	1624	152	5112
18	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
19	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
20	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
21	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
22	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
23	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
24	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
25	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
26	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
27	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
28	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
29	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
30	48	441	91	13	9	38	9	2	33	2350	0	235	53	1624	152	5098
31	48	441	91	13	9	38	9	2	33	2350	0	235	53	1444	152	4918
TOT.	1056	13674	2941	282	1086	1403	307	62	1248	72850	15	7848	1777	50169	5504	160221
AVG.	34	441	95	9	35	45	10	2	40	2350	0	253	57	1618	178	5168

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR JUNE

DAY#	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	48	441	91	13	9	38	9	2	33	2350	0	235	53	1444	152	4918
2	48	441	91	13	9	38	9	2	33	2350	0	235	53	1444	152	4918
3	48	441	91	13	9	38	9	2	33	2350	0	235	53	1444	152	4918
4	48	441	91	13	9	38	9	2	33	2350	0	235	53	1444	152	4918
5	48	441	91	13	9	38	9	2	33	2350	0	235	53	1444	152	4918
6	48	442	91	13	9	38	9	2	33	2350	0	235	53	1444	152	4919
7	48	442	91	13	9	38	9	2	33	2350	0	235	53	1444	152	4919
8	48	442	91	13	9	38	9	2	33	2350	0	235	53	1444	152	4919
9	78	442	91	181	5	38	9	2	33	2350	0	235	38	1444	150	5095
10	78	442	110	181	5	38	9	2	33	2350	0	235	38	1444	150	5114
11	78	442	110	181	5	38	9	2	33	2350	0	235	38	1444	150	5114
12	78	442	110	181	5	38	9	2	33	2350	0	235	38	1444	150	5114
13	78	442	110	181	5	38	9	2	33	2350	0	235	38	1444	150	5114
14	78	442	110	181	5	38	9	2	33	2350	0	235	38	1444	150	5114
15	78	442	110	181	5	38	9	2	33	2350	0	235	38	1444	150	5114
16	78	442	110	181	5	38	9	2	33	2350	0	235	38	1444	150	5114
17	78	442	110	181	5	38	9	2	33	2350	0	235	38	1444	150	5114
18	78	442	110	181	5	38	9	2	33	2350	0	235	38	1444	150	5114
19	78	442	110	181	5	38	9	2	44	2350	0	235	38	1444	150	5125
20	78	442	110	181	5	38	9	2	44	2350	0	235	38	1444	150	5125
21	78	442	110	181	5	38	9	2	44	2350	0	235	38	1444	150	5125
22	78	442	110	181	5	38	9	2	44	2350	0	235	38	1444	150	5125
23	78	442	110	181	5	38	9	2	44	2350	0	235	38	1444	150	5125
24	78	442	110	181	5	38	9	2	44	2350	0	235	38	1444	150	5125
25	78	442	110	181	5	38	9	2	44	2350	0	235	38	1444	150	5125
26	78	442	110	181	5	38	9	2	44	2350	0	235	38	1444	150	5125
27	78	442	110	181	5	38	9	2	44	2350	0	235	38	1444	150	5125
28	78	442	110	181	5	38	9	2	44	2350	0	235	38	1444	150	5125
29	78	442	110	181	5	38	9	2	44	2350	0	235	38	1444	150	5125
30	78	442	110	181	5	38	9	2	44	2350	0	235	38	1250	150	4931
TOT.	2106	13256	3124	4079	174	1135	264	60	1113	70500	14	7052	1251	43131	4516	151775
AVG.	70	442	104	136	6	38	9	2	37	2350	0	235	42	1438	151	5059

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR JULY

DAY#	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	78	442	110	181	5	38	9	2	44	2350	0	235	38	1250	150	4931
2	78	442	110	181	5	38	9	2	44	2350	0	235	38	1250	150	4931
3	78	442	110	181	5	38	9	2	44	2350	0	235	38	1250	150	4931
4	78	442	110	181	5	38	9	2	44	2350	0	235	38	1250	150	4931
5	78	442	110	181	5	38	9	2	44	2350	0	235	38	1250	150	4931
6	78	443	110	181	5	38	9	2	44	2350	0	235	38	1250	150	4932
7	78	443	110	181	5	38	9	2	44	2350	0	235	38	1250	150	4932
8	78	443	110	181	5	38	9	2	44	2350	0	235	38	1250	150	4932
9	78	443	110	181	5	40	9	2	44	2350	0	212	38	1250	150	4911
10	78	443	110	181	5	40	9	2	44	2350	0	212	38	1250	150	4911
11	112	443	110	191	52	40	9	2	44	2350	0	212	44	1250	182	5041
12	112	443	173	191	52	40	9	2	44	2350	0	212	44	1250	182	5104
13	112	443	173	191	52	40	9	2	44	2350	0	212	44	1250	182	5104
14	112	443	173	191	52	40	9	2	44	2350	0	212	44	1250	182	5104
15	112	443	173	191	52	40	9	2	44	2350	0	212	44	1250	182	5104
16	112	443	173	191	52	40	9	2	44	2350	0	212	44	1250	182	5104
17	112	443	173	191	52	40	9	2	44	2350	0	212	44	1250	182	5104
18	112	443	173	191	52	40	9	2	44	2350	0	212	44	1250	182	5104
19	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
20	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
21	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
22	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
23	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
24	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
25	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
26	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
27	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
28	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
29	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
30	112	443	173	191	52	40	9	2	40	2350	0	212	44	1250	182	5100
31	112	443	173	191	52	40	9	2	40	2350	0	212	44	1342	182	5192
TOT.	3129	13737	4668	5813	1129	1231	279	62	1313	72850	15	6746	1296	38847	5323	156439
AVG.	101	443	151	188	36	40	9	2	42	2350	0	218	42	1253	172	5046

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR AUGUST

DAY#	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	112	443	173	191	52	40	9	2	40	2350	0	212	44	1342	182	5192
2	112	443	173	191	52	40	9	2	40	2350	0	212	44	1342	182	5192
3	112	443	173	191	52	40	9	2	40	2350	0	212	44	1342	182	5192
4	112	443	173	191	52	40	9	2	40	2350	0	212	44	1342	182	5192
5	112	443	173	191	52	40	9	2	40	2350	0	212	44	1342	182	5192
6	112	443	173	191	52	40	9	2	40	2350	0	212	44	1342	182	5192
7	112	443	173	191	52	40	9	2	40	2350	0	212	44	1342	182	5192
8	112	443	173	191	52	40	9	2	40	2350	0	212	44	1342	182	5192
9	99	443	173	91	70	40	10	2	40	2350	0	212	34	1342	204	5111
10	99	443	157	91	70	40	10	2	40	2350	0	212	34	1342	204	5095
11	99	443	157	91	70	40	10	2	40	2350	0	212	34	1342	204	5095
12	99	443	157	91	70	40	10	2	40	2350	0	212	34	1342	204	5095
13	99	443	157	91	70	40	10	2	40	2350	0	212	34	1342	204	5095
14	99	443	157	91	70	40	10	2	40	2350	0	212	34	1342	204	5095
15	99	443	157	91	70	40	10	2	40	2350	0	212	34	1342	204	5095
16	99	443	157	91	70	40	10	2	40	2350	0	212	34	1342	204	5095
17	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
18	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
19	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
20	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
21	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
22	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
23	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
24	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
25	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
26	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
27	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
28	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
29	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5090
30	99	443	157	91	70	40	10	2	35	2350	0	212	34	1342	204	5070
31	99	443	157	91	70	40	10	2	35	2350	0	212	34	1501	204	5329
TOT.	3164	13735	5015	3623	2029	1252	303	62	1177	72850	15	6557	1133	41831	6148	158894
AVG.	102	443	162	117	65	40	10	2	38	2350	0	212	37	1349	198	5126

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR SEPTEMBER

DAY#	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	99	443	157	91	70	40	10	2	35	2350	0	212	34	1581	204	5329
2	99	443	157	91	70	40	10	2	35	2350	0	212	34	1581	204	5329
3	99	443	157	91	70	40	10	2	35	2350	0	212	34	1581	204	5329
4	99	443	157	91	70	40	10	2	35	2350	0	212	34	1581	204	5329
5	99	443	157	91	70	40	10	2	35	2350	0	212	34	1581	204	5329
6	99	443	157	91	70	40	10	2	35	2350	0	212	34	1581	204	5329
7	99	443	157	91	70	40	10	2	35	2350	0	212	34	1581	204	5329
8	99	443	157	0	67	40	15	2	35	2350	0	212	67	1581	154	5223
9	99	443	100	0	67	40	15	2	35	2350	0	212	67	1581	154	5166
10	99	443	100	0	67	29	15	2	35	2350	0	518	67	1581	154	5461
11	99	443	100	0	67	29	15	2	35	2350	0	518	67	1581	154	5461
12	99	443	100	0	67	29	15	2	35	2350	0	518	67	1581	154	5461
13	99	443	100	0	67	29	15	2	35	2350	0	518	67	1581	154	5461
14	99	443	100	0	67	29	15	2	35	2350	0	518	67	1581	154	5461
15	99	443	100	0	67	29	15	2	35	2350	0	518	67	1581	154	5461
16	99	443	100	0	67	29	15	2	35	2350	0	518	67	1581	154	5461
17	99	443	100	0	67	29	15	2	35	2350	0	518	67	1581	154	5461
18	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
19	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
20	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
21	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
22	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
23	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
24	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
25	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
26	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
27	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
28	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
29	99	443	100	0	67	29	15	2	37	2350	0	518	67	1581	154	5462
30	99	443	100	0	67	29	15	2	37	2350	0	518	67	1697	154	5579
TOT.	2961	13300	3455	648	2026	979	420	60	1078	70500	15	12785	1783	47537	4964	162511
AVG.	99	443	115	22	68	33	14	2	36	2350	0	426	59	1585	165	5417

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR OCTOBER

DAY#	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	99	443	100	0	67	29	15	2	37	2350	0	518	67	1697	154	5579
2	99	443	100	0	67	29	15	2	37	2350	0	518	67	1697	154	5579
3	99	443	100	0	67	29	15	2	37	2350	0	518	67	1697	154	5579
4	97	443	100	0	67	29	15	2	37	2350	0	518	67	1697	154	5578
5	99	443	100	0	67	29	15	2	37	2350	0	518	67	1697	154	5578
6	99	443	100	0	67	29	15	2	37	2350	0	518	67	1697	154	5578
7	99	443	100	0	67	29	15	2	37	2350	0	518	74	1697	154	5585
8	99	443	100	0	51	29	15	2	37	2350	0	518	80	1697	154	5575
9	99	443	100	0	51	29	17	2	37	2350	0	518	80	1697	154	5577
10	1372	443	94	0	51	29	17	2	37	2350	0	518	80	1697	113	6804
11	1372	443	94	0	51	29	17	2	37	2350	0	518	80	1697	113	6804
12	1372	443	94	0	51	29	17	2	37	2350	0	518	80	1697	113	6804
13	1372	443	94	0	51	29	17	2	37	2350	0	518	80	1697	113	6804
14	1372	443	94	0	51	29	17	2	37	2350	0	518	80	1697	113	6804
15	1372	443	94	0	51	29	17	2	37	2350	0	518	80	1697	113	6804
16	1372	443	94	0	51	29	17	2	37	2350	0	518	80	1697	113	6804
17	1372	443	94	0	51	29	17	2	37	2350	0	518	80	1697	113	6804
18	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
19	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
20	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
21	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
22	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
23	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
24	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
25	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
26	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
27	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
28	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
29	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
30	1372	443	94	0	51	29	17	2	33	2350	0	518	80	1697	113	6801
31	1372	443	94	0	51	29	17	2	33	2350	0	518	80	2064	113	7167
TOT.	31081	13724	2969	3	1694	909	513	62	1084	72850	15	16063	2403	52986	3866	200221
AVG.	1003	443	96	0	55	29	17	2	35	2350	0	518	78	1709	125	6459

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR NOVEMBER

DAY#	ICE RINK	SENIOR CIT.A&D	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	1372	443	94	0	51	29	17	2	33	2350	0	518	80	2064	113	7167
2	1372	442	94	0	51	29	17	2	33	2350	0	518	80	2064	113	7166
3	1372	441	94	0	51	29	17	2	33	2350	0	518	80	2064	113	7166
4	1372	441	94	0	51	29	17	2	33	2350	0	518	80	2064	113	7166
5	1372	441	94	0	51	29	17	2	33	2350	0	518	80	2064	113	7166
6	1372	441	94	0	51	29	17	2	33	2350	0	518	80	2064	113	7166
7	1372	441	94	0	30	86	17	2	33	2350	0	384	80	2064	113	7068
8	1032	441	94	0	10	86	24	2	33	2350	0	384	81	2064	166	6768
9	1032	441	94	0	10	86	31	2	33	2350	0	384	81	2064	166	6775
10	1032	441	94	0	10	143	31	2	33	2350	0	250	81	2064	166	6698
11	1032	441	94	0	10	143	31	2	33	2350	0	250	81	2064	166	6698
12	1032	441	94	0	10	143	31	2	33	2350	0	250	81	2064	166	6698
13	1032	441	94	0	10	143	31	2	33	2350	0	250	81	2064	166	6698
14	1032	441	94	0	10	143	31	2	33	2350	0	250	81	2064	166	6698
15	1032	441	94	0	10	143	31	2	33	2350	0	250	81	2064	166	6698
16	1032	441	94	0	10	143	31	2	33	2350	0	250	81	2064	166	6698
17	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	166	6705
18	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
19	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
20	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
21	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
22	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
23	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
24	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
25	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
26	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
27	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
28	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
29	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2064	192	6730
30	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2160	192	6827
TOT.	33343	13233	2824	0	560	3444	816	59	1089	70500	14	9516	2431	62012	4944	204785
AVG.	1111	441	94	0	19	115	27	2	36	2350	0	317	81	2067	165	6826

CITY OF WATERVLIET
TYPICAL POWER CONSUMPTION FOR DECEMBER

DAY#	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
1	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2160	192	6827
2	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2160	192	6827
3	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2160	192	6827
4	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2160	192	6827
5	1032	441	94	0	10	143	31	2	40	2350	0	250	81	2160	192	6827
6	1032	438	94	0	10	143	31	2	40	2350	0	250	81	2160	192	6824
7	1032	438	94	0	10	143	31	2	40	2350	0	250	81	2160	192	6824
8	8607	438	94	0	43	143	31	2	40	2350	0	250	81	2160	205	14446
9	8607	438	94	0	43	143	31	2	40	2350	0	250	81	2160	205	14446
10	8607	438	91	0	43	143	31	2	40	2350	0	250	81	2160	205	14443
11	8607	438	91	0	43	143	31	2	40	2350	0	250	81	2160	205	14443
12	8607	438	91	0	43	143	31	2	40	2350	0	250	81	2160	205	14443
13	8607	438	91	0	43	143	31	2	40	2350	0	250	81	2160	205	14443
14	8607	438	91	0	43	143	31	2	40	2350	0	250	81	2160	205	14443
15	8607	438	91	0	43	143	31	2	40	2350	0	250	81	2160	205	14443
16	8607	438	91	0	43	143	31	2	40	2350	0	250	81	2160	205	14443
17	8607	438	91	0	43	143	31	2	40	2350	0	250	81	2160	205	14443
18	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
19	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
20	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
21	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
22	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
23	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
24	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
25	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
26	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
27	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
28	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
29	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
30	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2160	247	14484
31	8607	438	91	0	43	143	31	2	39	2350	0	250	81	2434	247	14757
TOT.	213798	13593	2852	0	1106	4442	951	59	1232	72850	15	7757	2514	67248	6855	395271
AVG.	6897	438	92	0	36	143	31	2	40	2350	0	250	81	2169	221	12751

TWELVE MONTH SUMMARY

	ICE RINK	SENIOR CIT.A&B	CITY HALL	POOL-A	POOL-B	HUDSON SHORES	CITY GARAGE	GROTTO COURT	WISWALL AVENUE	PUMPING STATION	HURST ROAD	FILTER PLANT	CIVIC CENTER	STREET LIGHTS	FIRE HOUSE	TOTAL
TOT.	593464	161126	39843	14447	13207	19403	6943	724	16824	857750	178	108394	24130	673896	80226	2610556
AVG.	1626	441	109	40	36	53	19	2	46	2350	0	297	66	1846	220	7152

MUNICIPAL ELECTRICAL ENERGY COST & CREDIT SUMMARY

ALTERNATES 1.01 - 8.13

KWH	KILOWATT-HOURS
KWHY	KILOWATT-HOURS PER YEAR
KVACH	KILOVOLT-AMP CORRECTIVE-HOUR(P.F.)

WATERVLIET HYDRO-ELECTRIC FEASIBILITY STUDY

ANNUAL POWER COST & CREDIT SUMMARY FOR VARIOUS ALTERNATIVE PROJECTS
BASED ON 50 YEAR INFLOW SIMULATION WITH 6 MGD WATER SUPPLY

	CURRENT COSTS		CREDITS FOR ALTERNATIVE POWER GENERATION SCHEMES					
ALTERNATIVE #	CITY POWER USE (KWHY)	PWR COST @ 5.3¢ /KWH	SITE USE @ 5.3¢ /KWH	CITY USE @ 4.9¢ /KWH	EXCESS @ .9¢ /KWH	P.F.CORR.@ .01¢/KVACH	TOTAL CREDITS	NET COST
ALT.NO. 1.01	2611080	138387.24	39680.39	14160.93	.00	15.12	53856.44	84530.80
ALT.NO. 1.02	2611080	138387.24	29990.00	57615.79	1759.68	99.93	89465.40	48921.84
ALT.NO. 1.03	2611080	138387.24	29990.00	57615.79	1759.68	99.93	89465.40	48921.84
ALT.NO. 2.01	2611080	138387.24	29990.00	63793.30	3278.16	115.14	97176.60	41210.64
ALT.NO. 2.02	2611080	138387.24	29990.00	65971.99	4187.32	122.65	100271.96	38115.28
ALT.NO. 2.03	2611080	138387.24	29990.00	66548.08	4494.98	125.02	101158.08	37229.16
ALT.NO. 2.04	2611080	138387.24	29990.00	66783.06	4624.10	126.00	101523.16	36864.08
ALT.NO. 2.05	2611080	138387.24	29990.00	66876.22	4675.91	126.40	101668.53	36718.71
ALT.NO. 2.06	2611080	138387.24	21945.44	72865.50	11630.93	342.19	106784.06	31603.18
ALT.NO. 2.07	2611080	138387.24	21945.44	75347.83	13825.61	373.75	111492.63	26894.61
ALT.NO. 2.08	2611080	138387.24	21945.44	76497.46	15069.70	391.07	113903.67	24483.57
ALT.NO. 2.09	2611080	138387.24	17250.41	75452.03	15232.94	581.83	108517.21	29870.03
ALT.NO. 2.10	2611080	138387.24	17250.41	77462.36	17208.08	624.43	112545.28	25841.96
ALT.NO. 2.11	2611080	138387.24	17250.41	78328.37	18135.44	644.17	114358.39	24028.85
ALT.NO. 2.12	2611080	138387.24	11508.08	81873.36	20082.53	1215.36	114679.33	23707.91
ALT.NO. 4.01	2611080	138387.24	43832.24	25524.77	139.84	7.40	69504.25	68882.99
ALT.NO. 4.02	2611080	138387.24	43832.24	26489.69	177.27	7.53	70506.73	67880.51
ALT.NO. 4.03	2611080	138387.24	43832.24	27092.12	209.72	7.62	71141.70	67245.54
ALT.NO. 4.04	2611080	138387.24	41933.45	38676.40	3507.28	31.66	84148.79	54238.45
ALT.NO. 4.05	2611080	138387.24	41933.45	39480.98	3780.43	32.41	85227.27	53159.97
ALT.NO. 4.06	2611080	138387.24	41933.45	39776.83	3883.94	32.70	85626.92	52760.32
ALT.NO. 4.07	2611080	138387.24	41933.45	39973.19	3953.11	32.88	85892.63	52494.61
ALT.NO. 4.08	2611080	138387.24	40087.35	40769.79	6549.80	72.14	87479.08	50908.16
ALT.NO. 4.09	2611080	138387.24	40087.35	41562.11	6900.59	73.86	88623.91	49763.33
ALT.NO. 4.10	2611080	138387.24	40087.35	41952.15	7077.11	74.72	89191.33	49195.91
ALT.NO. 4.11	2611080	138387.24	36603.53	44983.03	9049.45	201.19	90837.20	47550.04
ALT.NO. 5.01	2611080	138387.24	29990.00	30613.41	.35	61.42	60665.18	77722.06
ALT.NO. 5.02	2611080	138387.24	29990.00	35195.19	54.66	66.56	65306.41	73080.83
ALT.NO. 5.03	2611080	138387.24	29990.00	36509.83	88.84	68.14	66656.81	71730.43
ALT.NO. 5.04	2611080	138387.24	29990.00	37162.97	106.70	68.93	67328.60	71058.64
ALT.NO. 5.05	2611080	138387.24	29990.00	37326.20	111.18	69.12	67496.50	70890.74
ALT.NO. 5.06	2611080	138387.24	21945.44	52180.13	1984.02	101.92	76211.51	62175.73
ALT.NO. 5.07	2611080	138387.24	21945.44	55618.82	3000.86	201.72	80766.84	57620.40
ALT.NO. 5.08	2611080	138387.24	21945.44	56735.75	3367.41	208.53	82257.13	56130.11
ALT.NO. 5.09	2611080	138387.24	21945.44	57539.26	3635.61	213.48	83333.79	55053.45
ALT.NO. 5.10	2611080	138387.24	17250.41	55008.50	3835.18	306.50	76400.59	61986.65
ALT.NO. 5.11	2611080	138387.24	17250.41	57930.80	4899.47	335.59	80416.27	57970.97
ALT.NO. 5.12	2611080	138387.24	17250.41	59207.84	5408.25	349.10	82215.60	56171.64
ALT.NO. 5.13	2611080	138387.24	11508.08	61791.65	5955.08	631.33	79886.14	58501.10

WATERVLIET HYDRO-ELECTRIC FEASIBILITY STUDY

ANNUAL POWER COST & CREDIT SUMMARY FOR VARIOUS ALTERNATIVE PROJECTS
BASED ON 50 YEAR INFLOW SIMULATION WITH 6 MGD WATER SUPPLY

	CURRENT COSTS		CREDITS FOR ALTERNATIVE POWER GENERATION SCHEMES					
ALTERNATIVE #	CITY POWER USE (KWHY)	PWR COST @ 5.3¢ /KWH	SITE USE @ 5.3¢ /KWH	CITY USE @ 4.9¢ /KWH	EXCESS @ .9¢ /KWH	P.F.CORR.@ .01¢/KVACH	TOTAL CREDITS	NET COST
ALT.NO. 6.01	2611080	138387.24	29990.00	59867.63	2138.57	104.48	92100.68	46286.56
ALT.NO. 6.02	2611080	138387.24	29990.00	65325.47	3858.14	120.08	99293.69	39093.55
ALT.NO. 6.03	2611080	138387.24	29990.00	66548.08	4494.98	125.02	101158.08	37229.16
ALT.NO. 6.04	2611080	138387.24	29990.00	67015.95	4753.61	126.99	101886.55	36500.69
ALT.NO. 6.05	2611080	138387.24	29990.00	67201.04	4857.44	127.78	102176.26	36210.98
ALT.NO. 6.06	2611080	138387.24	21945.44	69099.47	8996.39	302.59	100343.89	38043.35
ALT.NO. 6.07	2611080	138387.24	21945.44	74225.88	12784.34	358.90	109314.56	29072.68
ALT.NO. 6.08	2611080	138387.24	21945.44	75897.14	14400.36	381.79	112624.73	25762.51
ALT.NO. 6.09	2611080	138387.24	21945.44	76536.73	15114.45	391.69	113988.31	24398.93
ALT.NO. 6.10	2611080	138387.24	17250.41	72076.15	12422.21	519.49	102268.26	36118.98
ALT.NO. 6.11	2611080	138387.24	17250.41	76261.03	15999.23	598.46	110109.13	28278.11
ALT.NO. 6.12	2611080	138387.24	17250.41	77882.16	17645.59	633.78	113411.94	24975.30
ALT.NO. 6.13	2611080	138387.24	11508.08	79376.88	17404.46	1112.54	109401.96	28985.28
ALT.NO. 7.01	2611080	138387.24	29990.00	52279.87	1085.85	90.45	83446.17	54941.07
ALT.NO. 7.02	2611080	138387.24	29990.00	56236.62	1565.06	97.37	87889.05	50498.19
ALT.NO. 7.03	2611080	138387.24	29990.00	57405.11	1729.46	99.54	89224.11	49163.13
ALT.NO. 7.04	2611080	138387.24	29990.00	57826.29	1789.93	100.33	89706.55	48680.69
ALT.NO. 7.05	2611080	138387.24	29990.00	58036.77	1820.18	100.72	89947.67	48439.57
ALT.NO. 7.06	2611080	138387.24	21945.44	65725.52	7017.46	271.65	94960.07	43427.17
ALT.NO. 7.07	2611080	138387.24	21945.44	68524.27	8634.29	297.02	99401.02	38986.22
ALT.NO. 7.08	2611080	138387.24	21945.44	69541.49	9279.02	306.92	101072.87	37314.37
ALT.NO. 7.09	2611080	138387.24	21945.44	69977.55	9562.73	311.25	101796.97	36590.27
ALT.NO. 7.10	2611080	138387.24	17250.41	68228.87	9812.41	459.23	95750.92	42636.32
ALT.NO. 7.11	2611080	138387.24	17250.41	70606.88	11376.93	495.60	99729.82	38657.42
ALT.NO. 7.12	2611080	138387.24	17250.41	71634.30	12103.10	512.22	101500.03	36887.21
ALT.NO. 7.13	2611080	138387.24	11508.08	74569.78	13206.09	945.97	100229.92	38157.32
ALT.NO. 8.01	2611080	138387.24	43832.24	52393.22	3791.13	12.58	100029.17	38358.07
ALT.NO. 8.02	2611080	138387.24	43832.24	54301.64	4800.11	13.40	102947.39	35439.85
ALT.NO. 8.03	2611080	138387.24	43832.24	54874.32	5124.23	13.66	103844.45	34542.79
ALT.NO. 8.04	2611080	138387.24	43832.24	55109.13	5259.99	13.77	104215.13	34172.11
ALT.NO. 8.05	2611080	138387.24	43832.24	55202.45	5314.40	13.81	104362.90	34024.34
ALT.NO. 8.06	2611080	138387.24	41933.45	55355.74	12440.37	53.09	109782.65	28604.59
ALT.NO. 8.07	2611080	138387.24	41933.45	57398.89	14380.24	57.22	113769.80	24617.44
ALT.NO. 8.08	2611080	138387.24	41933.45	58086.84	15148.37	58.82	115227.48	23159.76
ALT.NO. 8.09	2611080	138387.24	41933.45	58355.80	15467.28	59.48	115816.01	22571.23
ALT.NO. 8.10	2611080	138387.24	40087.35	57147.73	18058.94	122.39	115416.41	22970.83
ALT.NO. 8.11	2611080	138387.24	40087.35	58810.95	20048.93	130.33	119077.56	19309.68
ALT.NO. 8.12	2611080	138387.24	40087.35	59460.29	20928.83	133.77	120610.24	17777.00
ALT.NO. 8.13	2611080	138387.24	36603.53	61445.42	23515.10	350.76	121914.81	16472.43

CONFIGURATION

Existing Facilities

The Watervliet Reservoir impoundment is located on the Normans Kill at French's Mills, approximately 3.5 miles south of Schenectady in Albany County. The dam is approximately 40 feet high impounding a usable storage volume of 1.6 billion gallons. The dam is owned and operated by the City of Watervliet, New York. The reservoir serves as a water supply reservoir for the City of Watervliet and the Town of Guilderland, New York. The dam is classified in the high hazard potential category under the National Dam Inspection Act, Public Law 92-367 due to a pump station and several homes downstream that would be affected by a breach of the dam. The dam was designed by Solomon, Norcross & Keis, Engineers of Atlanta, Georgia in 1915 and built in approximately 1916. The dam is of a hollow Amburssen type structure comprised of slab and buttress construction. The length is 380 feet. The upstream face is sloped at 1.0 on 1.0 and the downstream face 1.7 (vertical) on 1.0 (horizontal). The total length of spillway weir is approximately 324 feet. Crest elevation (concrete) is 256 local datum with the temporary flashboard elevation at 259 local datum. A 5 foot diameter conduit through the dam near its southern end is controlled by a 4 foot sluice gate. Invert of this conduit (mud valve) at its upstream end is elevation 222.6 local datum. A 50 inch steel penstock passes through the dam near its northern end and is controlled by a 48 inch single gate valve. The centerline of the penstock in the upstream face of the dam is elevation 240 local datum. Extensive memoranda are available detailing the initial design stages and discussions held with the New York State Water Resources Commission (previously New York State Conservation Commission) from the years 1900 to 1916.

The contract drawings of the dam are available as are additional drawings and specificatlons issued by the original dam designer, Solomon, Norcross, & Keis, Consulting Engineers, V. G. Lamb, City Engineer of Watervliet, and this office. Modifications and rehabilitation of the dam have been limited to construction of a training wall at the north abutment shortly after 1916 due to erosion in that area due to heavy spillway flows. This training wall was again raised 2-3 feet in 1955, again due to erosion of the adjacent streambank due to heavy spillway flows. A new concrete apron was added just downstream of the original structure in 1936 and in 1965 the spillway and concrete apron were resurfaced with gunite. The 30-36 inch high flashboards are replaced every 2-3 years, the last replacement in the spring of 1978.

The dam has been the focus of a Phase I Inspection Report as part of the National Dam Safety Program. This report was submitted to the U. S. District Corps of Engineers by Tippets-Abbett-McCarthy-Stratton on July 5, 1978. The Corps of Engineers report revealed several hazardous conditions at the dam which were immediately corrected by the City of Watervliet. The main deficiency that has been corrected is replacement of a 4 foot long section of penstock inside the dam adjacent to the intake valve. This section was heavily corroded and was replaced with new 3/8 inch thick welded steel penstock on June 23, 1978. Also noted in the dam safety report was the possible spalled condition of the concrete apron on the dam and spalling of the spillway surface. At the time of the National Dam Safety Report, access to the dam was hindered by high flows. Subsequent to the issuance of the report, the New York State Department of Environmental Conservation Dam Inspection Bureau has made a detailed inspection of the face and given the apron and spillway surface a clean bill of health.

The penstock connecting the dam with the existing pumping station was originally constructed in 1916 of 1/4 inch thick riveted steel pipe. The initial section of penstock from station 00 to station 4 + 72 is of original construction. Documents available indicate that this buried section was re-excavated from 1950 to 1952, scraped, cleaned and recoated with bituminastic material. The elevated section from station 4 + 72 to 6 + 25 was substantially rebuilt and replaced in 1960 following severe undermining and deterioration of concrete pier supports during a heavy flood. The steel surge pipe connected to the penstock at elevation 6 + 25 was also replaced in 1960 and is comprised of 1/4 inch welded steel pipe, 4 foot diameter, carried up to elevation 270 local datum. The surge pipe is securely anchored in the rock ledge at this location. The section of penstock from elevation 6 + 25 to approximately 9 + 00 is again of original riveted steel construction. This section of penstock passes beneath the Town highway and is known to be in poor condition. The remainder of the penstock from station 9 + 00 to termination at the manifold at station 14 + 28 is of new construction, replaced in approximately 1955, is elevated and of 1/4 welded steel construction.

Ultrasonic testing of the older sections of the penstock (those buried sections of riveted steel construction) was performed on June 23, 1978. It was found that the original 1/4 steel plate was corroded in areas, leaving a resulting thickness of 0.100 inches minimum. Due to this severe deteriorated condition, any considerations for reuse and adaption of the existing faciilities has included replacement of the original riveted steel penstock sections with new 1/4 inch thickness steel penstock of welded construction.

Running parallel to the 48 inch penstock is a 10 inch cast iron water main, supplying spring water from a spring at the reservoir periphery to the pumping station. It has been determined that this 10 inch cast iron main is severely tuberculated, is of inadequate hydraulic capacity to supply water for pumping purposes alone and thus is no consequence in any adaptation or rehabilitation effort.

The existing water pumping station was constructed in 1915 under the original water supply contract. The original construction entailed acquisiton of two horizontal Francis turbines directly connected to two-stage centrifugal pumps to supply water to the City via a transmission main extending across the Towns of Guilderland and Colonie, New York to the City of Watervliet. Little is known of the original turbines. No provisions were made in the original construction for electrical pumping, however from records of the

N.Y.S Water Resources Commission, it is assumed that electric pumping capabilities were added several years later following the drought of 1917. At that time the Watervliet reservoir was completely emptied by February of 1918 due to unregulated use by the City of water for pumping purposes. The existing machinery located at the pumping station is comprised of two S. Morgan Smith horizontal Francis turbines connected through gear boxes to single stage DeLaval centrifugal pumps. The original turbines were apparently replaced as part of a WPA project in 1933. It is uncertain what necessitated the replacement of the original units. From correspondence dating to that time, however, it is known that some difficulties were encountered in the installation and initial operation of the replacement units due to problems in cooling and lubricating the gear increasers. The turbines are designed to operate under 62 feet of head at 900 RPM. The single runners are each 12-3/4 inches in diameter and are horizontal type, with steel cases. Hydraulic curves and original test data for the turbines is available. Auxiliary pumping is provided at the station by three identical DeLaval centrifugal pumps powered by 100 kva Westinghouse induction motors. The existing hydraulic turbines, although continuing to operate satisfactory 24 hours a day are approximately 45 years old and nearing the end of their useful economic life. Recommendations following for utilizing the existing facilities require rebuilding of the units to original specifications to provide for adequate reliability.

Additional features of the additional pumping station include transformer bank supplying standby power to electric pumps. This transformer bank and associated electric switch gear is approximately 50 years old and is of open front construction. Due to safety, space, and reliability considerations, all the alternatives developed that include the existing facilities must also include replacement of this electric switch gear. Internal piping at the pumping station is of cast iron construction. It is in generally fair condition although all flange connections should be rehabilitated as a prerequisite for any rehabilitation of the facility.

The pumping station structure is of reinforced concrete foundation with a 12 inch triple course brick wall superstructure. The roof is framed with steel angle trusses approxlmately 9'7" on center, supporting channel purlins, with 2 inches of subroofing and slate roofing. The building is of substantial construction although rehabilitation of windows, doors, roofing, and heating and ventilating systems will be required to extend the life of the structure for 20 plus years.

All elevations pertinent to this project have been field verified and the correspondence between the local (Keis) datum and the USGS datum has been determined. A listing of all pertinent elevations and tail water and head water assumptions follows.

DESIGN ELEVATIONS
U.S.G.S Datum
(Keis datum equals USGS minus 3.0 feet)

Point	Elevation
Top of flashboards (36")	262.4
Top concrete dam	259.4
Invert mud valve conduit	325.3
Streambed at base of dam	225
Design tail water at base of dam	227
Streambed at first falls	224.5
Streambed below first falls	209.0
Design tail water below first falls	211.0
Streambed at second falls	204.0
Streambed below second falls	196.0
Design tail water below second falls	198.0
Floor at existing pump station	202.3
Bottom streambed at existing tail race	192.+
Design tail at existing pumping station	197.+
Centerline existing horizontal turbines	202.83

Site Options

As a prelude to determination of the optimum hydroelectric alternative for this site, a wide range of alternatives was developed. The only limitation at the initial stage for these alternatives was a maximum head limitation of 20 meters, (66 feet). Little penalty was extracted with this limitation since the stream gradient below the existing pump station is less than 0.0013. Due to the congested area just downstream from the dam, several unusual configurations were developed. These congestions are due to two steel trestles of late Nineteenth Century vintage carrying mainline ConRail tracks across the Normans Kill, a county highway bridge and a relatively narrow streambed and gorge. A third additional consideration design parameter was the relatively high (38,600 cfs) Standard Project Flood [Ref. 102] for the site resulting from the 120 square mile watershed. The eight alternates initially chosen represent a broad range of possibilities not only for civil works but also for various machine configurations. A description of each option follows. Each option has also been schematically shown on an aerial photograph of the site (Figures 41A-41H).

Option One - This alternative would utilize the existing 48 inch steel penstock. Deteriorated sections of the penstock would be replaced with new 48 inch penstock of welded steel construction. The existing surge pipe would be retained. The existing intake would be improved with a new trash rack, a motorized valve operator and a new intake transition penstock. Location of the machines under Alternate One would be at the existing pump house. The three different machine types selected for analysis under this option are the existing horizontal Francis machine, a new larger horizontal Francis machine and a vertical axial flow propeller machine. Rationale behind selection of machines for this and other alternates are discussed further in the next section.

Option Two - Comprised of a siphon intake adjacent to the dam, this siphon intake would be a wholly separate structure from the dam and would be comprised of driven steel sheeting and reinforced concrete. The siphon intake would connect with a steel penstock located at the north end of the dam. The siphon penstock would extend along the side of the gorge, crossing the county highway, and terminating at a powerhouse at the north end of the second falls on the Normans Kill some 900 feet distant from the siphon intake. Due to the high side slopes at the site of the powerhouse, a vertical machine was judged to be most appropriate in this case. A Francis machine was selected for analysis.

Option Three - Utilizing the existing mud valve and wasteway at the dam, this alternative was considered possible with the use of a bulb type or a horizontal axial flow tubular type turbine, utilizing the existing conduit and inlet valve. This option was eliminated after it was determined that the design of the existing conduit and mud valve were not adequate for pressurized and/or water hammer conditions that would occur under a hydroelectric generating scheme.

Option Four - Option Four would consist of a new gravity intake located in bay #7 of the dam. The intake would be of reinforced concrete construction, approximately bay width (18 feet). The intake would consist of a stop log rack, motor operated sluice gate (head gate), manually cleaned bar rack and intake transition section. The powerhouse under Option Four would be within the dam with discharge from the turbine directly at the downstream face of the dam. The machine selected for inclusion under this alternate is a horizontal, axial flow, variable pitch propeller machine. Due to limited spillway capacity, it was felt that further reduction in the spillway capacity caused by construction of a conventional downstream face powerhouse suitable for vertical machines would not be appropriate.

Option Five - A siphon intake similar to that discussed under Option Two with the siphon penstock terminating at a powerhouse at the foot of the dam is included under Option Five This alternative was examined since it eliminated the necessity of crossing the ConRail right-of-way and the county highway although the approximate 35 feet of gross head was significantly less than site potential.

Option Six - A siphon intake similar to that discussed ln Alternative Two would be constructed with a siphon penstock extending 1,750 feet to the site of the existing powerhouse. This extremely long penstock would be buried over the initial section and then run elevated for the final 1,000 plus feet. The powerhouse would consist of a new structure located adjacent to the existing pump station, housing either a horizontal or vertical Francis machine or a horizontal axial flow propeller machine.

Option Seven - This option includes a siphon intake connected to a siphon penstock terminating at the base of the first Normans Kill falls, at a powerhouse similar to that discussed under Option Two. This alternate was investigated due to the shorter length of penstock required as compared to Options Two and Six.

Option Eight - Option Eight is comprised of a new gravity intake as discussed under Option Four at bay 5 of the dam. The intake would terminate in a new steel penstock exiting at the base of the dam and extending for 900 feet down the center of the Normans Kill. This penstock would be constructed beneath the streambed by blasting the predominately rock streambed, installing the penstock, backfilling with concrete and replacing the rock streambed to its original condition. The penstock would terminate in an underground powerhouse located just upstream from the second falls. The powerhouse would house a horizontal axial flow, variable pitch propeller turbine with a discharge emanating at the base of the second falls. This alternate was deemed particularly feasible and attractive due to the short (900 foot length) penstock and a relatively high (65 feet) gross head. It is also felt that the buried nature of the penstock and powerhouse would have positive environmental and aesthetic considerations.

Since the hydrologic phase determined that a wide range of flow considerations were available at the site, each alternate was thus then investigated for several different flows ranglng from 55 to 500 cfs in order to optimize penstock sizing in relation to hydraulic losses and cost. Each flow subalternate was again divided into various penstock size configurations. In all, 78 different combinations of site alternate, penstock size, design flow, and machine type were investigated.

Machine Options

Numerous turbine/generator manufacturers were contacted to ascertain availability of suitable equipment. The following suppliers were contacted with responses as indicated. Parentheses indicate number of different configurations upon which suppliers furnished cost data:

Supplier	Response as of 04/23/79
Escher Wyss Ltd.	not interested
James Leffel Company	quoted (see General Electric)
Mitsubishi Industries Ltd.	no reply
Nohab Hydropower Division	no reply
Alsthom Atlantic Inc.	no reply
Sulzer Brothers Ltd.	see Escher Wyss
General Electric Company	quoted (2)
Allis-Chalmers Corp.	quoted (10)
Ossberger (Stapenhorst Inc.)	quoted (2)
Oy Tampella AB	quoted (1)

The following machine types were examined for inclusion into the optimum configuration analysis:

a. Bulb
b. Rim Generator
c. Horizontal Axis Francis
d. Vertical Axis Francis
e. Horizontal Propeller (fixed and adjustable)
f. Vertical Propeller (fixed and adjustable)
g. Crossflow

Preliminary analysis yielded the following:

The bulb type machine initially thought to be feasible for several of the siphon alternates was rejected for several reasons. Following inquiries to several manufacturers, it was determined that the size of the project and of the penstock passageways were inadequate for proper bulb design. In addition, the flow variability inherent in this "run of river" design and the relatively high (65 degree F) summer water temperature posed cooling problems.

The rim type generator was rejected due to the small size of the project and and thus the hydraulic passageways and by the lack of interest of any manufacturer in supplying such a machine. In addition, the highly variable water quality with springtime turbidities (particulate) exceeding 500 ntu would cause severe problems with the sealing surfaces at the periphery of the machine. problems with the bulb type machine.

The cross-flow type hydraulic turbine was investigated and initially looked to be promising, however reliability considerations were the predominant reasons for rejecting the cross-flow apparatus from further consideration.

Multiple runner Francis machines were determined to be too complex for this size project. The remaining machines, horizontal Francis type, vertical Francis type, horizontal axial tube type, and vertical Kaplan type machines were considered. However, difficulties were encountered in obtaining any quotations for vertical Kaplan machines. A tabulation of the machine selection follows:

Machine Type Selection

Alternative	BULB	RIM GEN	HORZ. FRANCIS	VERT. FRANCIS	HORZ. PROP.	VERT. PROP.	CROSSFLOW
1.01			X				
1.02				X			
1.03			X				
2.				X			
3.							
4.					X		
5.				X			
6.			X	X	X		
7.				X			
8.					X		

Comments: (1) Bulb turbines eliminated due to size limitations and potential cooling difficulties due to flow variability.

(2) Rim generator types eliminated due to size and abnormally high turbidity.

(3) Cross-flow type eliminated due to reliability considerations.

(4) Multiple runner Francis type eliminated due to complexity.

Costs

Capital costs for the civil structures, machinery, mechanical works and equipment are estimated 1979 costs derived from manufacturers, suppliers, contractors, cost estimating manuals such as Dodge Construction Cost manual, and the firms bid award records. Costs included are for materials, labor, overhead and profit. For each of the 78 alternatives, costs were determined.

A specific typical cost breakdown for a given Alternate (8.07) is included at the end of this section. A description of the cost estimating methods used follows:

1. Penstock - In Alternative No. 1, part of the existing penstock will be reused so the cost presented reflects replacement of only part of the penstock with new fabricated steel pipe and rehabilitation of the remaining existing penstock. In all other options, the existing penstock would be abandoned and a new penstock constructed. Initially three penstock materials were considered; fabricated steel, reinforced concrete and concrete-lined rock tunnel. Unit cost for each is illustrated on Figure 42. Since the cost of lined rock channel and concrete pipe is substantially greater than steel, the penstock material considered in each of the alternatives is fabricated steel. The penstock cost in each alternative is the proposed penstock length times the unit cost of steel pipe constructed under the appropriate specific conditions, that is underground in soil, underground in rock, etc.

2. Intake - The existing penstock intake, though adequate for its present use, is lacking in several important features. First, there are no practical means of routinely inspecting and cleaning the intake and bar rack. Second, there is no way of dewatering the section of penstock between intake and the gate valve for penstock or

valve repairs. In addition, increasing the penstock size would dictate completely rebuilding the existing intake at a cost not much lower than a new intake.

Initially it was thought that penetrating the dam for a new intake would entail construction difficulty. Therein was born the idea of a siphon intake located behind the dam with a penstock laid in the rock around the north abutment, as shown on Figures Nos. 41D thru 41G for Alternatives Nos. 2, 5, 6 and 7, respectively. A siphon is necessary since the ground at the abutment is rock and is substantially higher than the dam crest. Gravity flow around the dam would require a deep excavation in the rock abutment which could lead to potential seepage problems.

Upon closer examination, it was determined that construction of a gravity intake integral with the dam would be feasible and would probably be more economical than constructing a siphon intake. A reassessment of the dam's structural stability and conversations with contractors experienced in this type of work now lead us to believe that construction of a dam integral intake would be feasible. The cost of both intake structures have been estimated using Lang factor methodology as follows:

The cost of the dam integral intake (Options 4 and 8) is for the most part fixed. The intake will be constructed between two existing dam buttresses so its external physical size, quantities of concrete and form work are constant. However, the sluice gate and bar rack sizes will vary with flow. Intake costs for various flows (Q) were derived from the following equation:

(1) Intake cost (Dam Integral) = $K\ (1243Q^{0.475} + 60.3Q + \$205,545)$

K is a constant between 1.15 and 1.25 relating overhead and profits to capital costs. The first term of the expression within the brackets relates cost of the sluice gate to flow. The second term relates the cost of the bar rack to flow. The third term is a constant which includes the costs of all labor and other materials.

For the siphon intake, the same assumptions regarding the bar rack and sluice gate were made. In addition, the width of the structure will vary with the siphon diameter, so concrete costs can also be related to Q. The following equation gives costs for the siphon intake:

$$(2)\ \text{Intake cost (Siphon)} = K\,(1243Q^{0.475} + 60.3Q + 1720\,(Q^{0.5}) + \$292{,}480)$$

The third term of the expression within the parenthesis relates cost of concrete to flow, that is, Q. The constant term in this expression is substantially larger than in equation No. 1 due to the sheeting cost involved in this intake.

Rehabilitation of the existing intake to accommodate Option No. 1 is estimated to cost about $33,000. This includes a new bar rack, a motorized valve operator along with the replacement of the short piece of penstock between the valve and the intake.

3. Powerhouse - Powerhouse size for a Francis-type turbine (Options 1, 2, 5, 6, 7) is related directly to the physical size of the machine, that is, the turbine. An indicator of machine size is runner diameter. Powerhouse costs for several machine sizes were determined through ordinary estimating methods and these costs were related to runner diameter using Lang factors.

$$(3)\ \text{Powerhouse cost}_1 = \text{powerhouse cost}_2 \times (\text{Diameter}_1/\text{Diameter}_2)^{1.35}$$

The powerhouse for Alternate No. 4 will be inside the dam. Since it is a tube-type installation, the cost is not expected to vary with machine size. It is estimated to be a constant $325,000. This cost includes the construction of a superstructure exterior to the dam to allow for access to the powerhouse.

The powerhouse for Option No. 8 will be constructed in rock beneath the streambed with an access tunnel also beneath the streambed leading to the north bank of the stream. The entire structure would, in essence, be a concrete-lined rock tunnel. Form work and exterior finishing will be minimal. The cost for this structure is estimated at $170,500.

The cost of modifying the existing pump station to serve as a powerhouse for Option 1.01 would include the cost of removing the two existing hydraulic pumps, modifying the existing piping, installing an adequate heating, ventillating and air-conditioning systems and constructing stands for the two new generators. Approximate cost for this work will be $45,000.

In Option 1.02, the existing hydraulic pumps and turbines would be removed and replaced with a new vertical Francis turbine and generator. The cost of modifying the structure for this purpose is $96,000.

Option 1.03 replaces the existing turbines and pumps with a horizontal Francis turbine and generator. This will require a new draft tube and modification of the tail race at an estimated cost of $96,000.

4. Switch Gear - Switch gear includes all those electrical devices necessary to transport power from the point of generation to the point of use. Included are such items as circuit breakers, relays, transformers, switchboards, etc. These costs were separated into two categories, constant costs and variable costs. Constant costs include costs for certain relays, switches and transformers, metering, utility tie, and a station battery.

Variable switch gear costs such as the cost for certain transformers and switchboards were related to power production by Lang factors by the following equation:

(4) $\text{Cost}_1 = \text{cost}_2\ (\text{power}_1/\text{power}_2)^X$

where X varies between 0.24 and 0.8 depending upon the type of equipment being estimated.

The cost of the transmission line from the powerhouse to the existing pump station and utility tie is given by the following equation:

(5) Cost = 50 (1500 - penstock length)

The total switch gear cost is the sum of all variable costs as given by the above-mentioned equations plus a constant cost. The general equation for arriving at total switch gear cost is:

(6) $\text{Switchgear cost}_1 =$

$$\text{Transformer Cost}_2\ (\text{Power}_1/\text{Power}_2)^{0.7997} +$$
$$\text{Switchboard Costs}_2(\text{Power}_1/\text{Power}_2)^{0.2427} +$$
$$50\ (1500 - \text{penstock length}) + \text{Constant}$$

5. Machines - Machine costs in this report refers to costs for both generators and turbines, including any miscellaneous equipment such as speed increasers, exciters, etc. The cost for variable pitch axial flow turbines (Options 4 and 8) were derived from cost estimates of various size machines provided by the Allis-Chalmers hydroturbine division. However, these quotes included certain switch gear costs which had to be disaggregated in order to determine bare machine cost. From the eight costs quoted on eight different size machines, the following exponential equation relating power to machine cost (for machines of this type).

(7) $\text{Machine cost}_1 = \text{Machine cost}_2\ (\text{power}_1/\text{Power}_2)^{0.495}$

This equation includes certain switch gear costs, both constant and variable, which must be subtracted in order to arrive at a bare machine cost.

(8) $\text{Bare machine cost}_1 =$

$$\text{Machine cost}_2\ (\text{Power}_1/\text{Power}_2)^{0.495} -$$
$$\text{Transformer costs}_2\ (\text{Power}_1/\text{Power}_2) -$$
$$\text{Switchboard costs}_2\ (\text{Power}_1/\text{Power}_2)^{0.2427} -$$
$$50\ (1500 - \text{penstock length}) - \text{Constant}$$

Machine costs for Francis-type turbines (Options 1, 2, 5, 6 and 7) were derived from costs provided by the General Electric Company. In this case as in the case of the axial flow turbines, an equation was derived to relate cost of machine to the power produced.

(9) $\text{Machine cost}_1 = \text{Machine cost}_2(\text{Power}_1/\text{Power}_2)^{0.495}$

However, the quote did not include a cost for a inlet valve ahead of the turbine. Costs for several sizes of hydraulically operated butterfly valves were obtained and an equation exponentially relating penstock diameter to valve cost was derived. The total Francis machine cost (inlet valve cost) is given by Equation No. 9A.

(9A) $\text{Francis machine cost}_1 =$

$$\text{Francis machine cost}_2\ (\text{Power}_1/\text{Power}_2) +$$
$$\text{valve cost}_2\ (\text{penstock dia.}_1/\text{penstock dia.}_2)^{1.25}$$

6. Ancillary Equipment - Certain ancillary equipment, not directly related to the production of power, is necessary for the operation of the hydroelectric facility. This equipment includes safety and firefighting apparatus, hoists, telemetry, tools, small power generators, etc. The cost for such equipment is estimated to be a constant $74,000 for all alternatives.

7. Mobilization and Temporary Services - The cost of contractor mobilization is estimated to be approximately 5% of the estimated capital cost of the preceding Items, 1 thru 6. Also included in this item is the cost for Temporary Services such as a water supply line and temporary pumping power when required.

8. Administration, Legal and Technical - Also included in the total project capital cost is a cost for design administration, legal services and engineering investigation. These costs were divided into three categories: 1. Design. 2. Legal and administrative. 3. Engineering investigation. Design costs are based on a percentage of capital costs as recommended by ASCE Manual No. 45. The cost of engineering investigations such as field surveys, licensing report, geotechnical surveys, etc. are neither site specific nor dependent upon the quantity of power produced and will be included as a constant lump sum for all alternatives. Legal and administrative fees were estimated to be approximately 1% of the sum of the capital, design and investigation costs. The total cost for this item can be expressed as a function of capital costs plus a constant by the following equation:

(10) Administration, legal and technical cost =

$$0.747\ (\text{capital cost})^{0.838} +$$

$$.01\ (\text{capital cost}) + \text{Constant}$$

The following cost tabulations for a typical alternative (in this case 8.07) are furnished as examples.

TYPICAL INTAKE COST BREAKDOWN
(Alternative 8.07)

Item	Quantity	Unit Price	Cost
Sheeting, bracing & dewatering	70 tons	$ 1,520	$106,400
Concrete	300 C.Y.	$ 250	$ 75,000
Bar rack	L.S.	$13,400	$ 13,400
Miscellaneous metals	8 tons	$ 3,000	$ 24,000
Electrical facilities	L.S.	$ 8,000	$ 10,000
Miscellaneous	L.S.	$15,000	$ 15,000
Sluice gate, 8' x 8', incl. motor operator	L.S.	$21,000	$ 21,000
SubTotal			$264,800
Plus 10% contingencies			26,480
Total Cost			$291,280

Typical Switch Gear Cost Breakdown
(Alternative 8.07)

Item	Quantity	Unit Price	Cost
15 KV horn gap switch	3	$ 1,500	$ 4,500
125 AMP 15 KV circuit breaker	1	17,000	17,000
2,000 KVA transformer	1	30,000	30,000
600 AMP 5 KV air circuit breaker	2	12,000	24,000
10 AMP 5 KV air circuit breaker	2	12,000	24,000
30 KVA dry transformer	1	2,400	2,400
40 AMP 5 KV air circuit breaker	2	12,000	24,000
100 AMP 5 KV air circuit breaker	2	12,000	24,000
Current transformers	21	375	7,875
Power transformers	12	450	5,400
Protective relays:			
type 25	1	750	750
Type 27	1	570	470
type 50	2	500	1,000
type 51	3	500	1,500
type 51G	2	500	1,000
type 51M	1	500	500
type 81	1	525	525
type 87	1	875	875
Metering	L.S.	6,000	6,000
Utility tie	L.S.	7,500	7,500
Station battery	L.S.	12,000	12,000
Overhead line	900	50	45,000
2400 volt switchboard	1	35,000	35,000

Miscellaneous	39,000
Subtotal	314,295
Plus 10% contengencies	31,429
Total Amount	$345,724

Typical Powerhouse Cost Breakdown
(Alternative 8.07)

Item	Quantity	Unit Price	Cost
Excavation	483 Cubic Yds.	$ 50	$ 24,150
Constructural concrete	247 Cubic Yds.	200	$ 49,400
Miscellaneous metals	7 tons	3,000	$ 21,000
Interior electric and auxiliary generator	L.S.	36,000	$ 36,000
Piping	L.S.	5,000	$ 5,000
HVAC	L.S.	18,000	$ 19,500
Subtotal			$155,050
Plus 10% contengencies			$ 15,505
Total Amount			$170,555

Optimization Methodology

The evaluation of the 78 alternative configurations initially suggested itself as a linear programming problem. However, after completing the marketing phase, the uniqueness of the value function became apparent, i.e., it was observed that the value of power generated depends upon whether the power is sold to the local utility, wheeled to the City, wheeled to other customers, or whether the machine was used simply for synchronous power factor correction. This uniqueness of the power value function causes abrupt discontinuities in the total project cost function, making the application of linear programming solutions difficult. Consideration was given to continuing along the linear programming methodology line using the constrained linear system threshold concept developed by Todini and Wallis. However, this approach was also abandoned. Instead, it was decided to develop an optimization matrix for a comparative value analysis.

Eight powerhouse site options were selected. Each of these options include six independent variables (design flow, penstock diameter, net head, intake type, machine type and machine efficiency) which results in a total of 78 alternate options. The 78 alternatives form the horizontal elements of the optimization matrix while 36 variables comprise the vertical elements (Figure 44). The vertical elements are as follows:

Line 1. Alternative number - The first number designates one of the eight powerhouse site options. The remaining decimal indicates the alternative number within that option.

Line 2. Design Flow (Q) - The specific flows used were 100, 200, 300 and 500 cubic feet per second except for Alternative No. 1.01 which was defined as utilizing the existing machines with a flow of 35 cubic feet per second.

Line 3. Gross Head (H) - defined as the relative difference in elevations between the top of flashboards and design tail water as previously listed under "Design Elevations."

Line 4. Penstock Diameter - The sizes considered were 48, 60, 72, 84 and 96 inch penstock. Velocity limitation was 12 feet per second.

Line 5. Intake Area - Intake area was based upon a maximum velocity of 2.5 feet per second at the bar rack and 6 feet per second at the sluice gate. The magnitude of the intake area was a determinant in the intake cost, although not a large one.

Line 6. Net Head - Net head is the gross head minus all friction and minor losses such as at the entrance, valves and bends. The friction coefficient used in all cases was C = 100.

Lines 8, 9, and 10. Runner Diameter, Setting, Specific Speed These three parameters were used as determinants for the size of the structure and type of machine. These variables were calculated using the standard turbine homologous equations [Ref. 4]

Line 11. Unit Efficiency - total machine efficiency including turbine, gear box and generator for the various types based upon manufacturers' data. Unit efficiencies are comprised of machine efficiency at full load, gear box efficiency of .98 (if gear box is used) and a generator efficiency of .95. Unit efficiency as defined here includes all losses, including entrance and exit losses, at the turbine.

Line 12. Composite Efficiency - It is apparent from manufacturers' published data that machines, i.e., turbines and generators, operate at various efficiencies depending upon the given flow and the load. The composite efficiency is a weighed average efficiency based upon simulated flow patterns.

Line 13. Net Power - Net power is the net generating capacity at the bus bar for a given flow, net head and composite efficiency. This net power was also used in the benefit value program to determine the total benefits to be accrued from selling power.

Line 14. Penstock Length - Scaled from 1" = 200' New York State Department of Transportation photogrammetric maps..

Line 15 thru 25. These elements are the items of capital cost and have been explained previously in the Costs section.

Line 26. First Annual O & M Cost - This is the total annual cost in the first year for operating and maintaining the facility excluding labor cost.

Line No. 27. O & M Compound Cost Gradient - This variable is used to escalate the annual O & M cost by a fixed annual rate over the period of the analysis. Further explanation of this rate will be given in the Economic Analysis chapter following.

Line No. 28. Present Worth of 50-Year O & M Cost - This is the the present value of the total amount to be disbursed for O & M over the 50-year period discounted with the stated discount rate.

Line No. 29. Present Worth of Costs - The sum of Lines 25 and 28.

Line No. 30. Annual Value of Energy Generated - This number represents the value of the power used by the City in place of power currently purchased from Niagara Mohawk Power Corporation plus additional revenue from the sale of excess power to Niagara Mohawk. This number has been previously calculated in the benefit value program (see Marketing chapter).

Line 31. Energy Compound Value Gradient - This compound amount factor reflects the projected annual increase in electrical energy cost.

Line 32. Present Worth of 50 Years of Energy - The total value of all energy produced by the facility in the 50-year service life, reduced to a present value using the assumed discount rate.

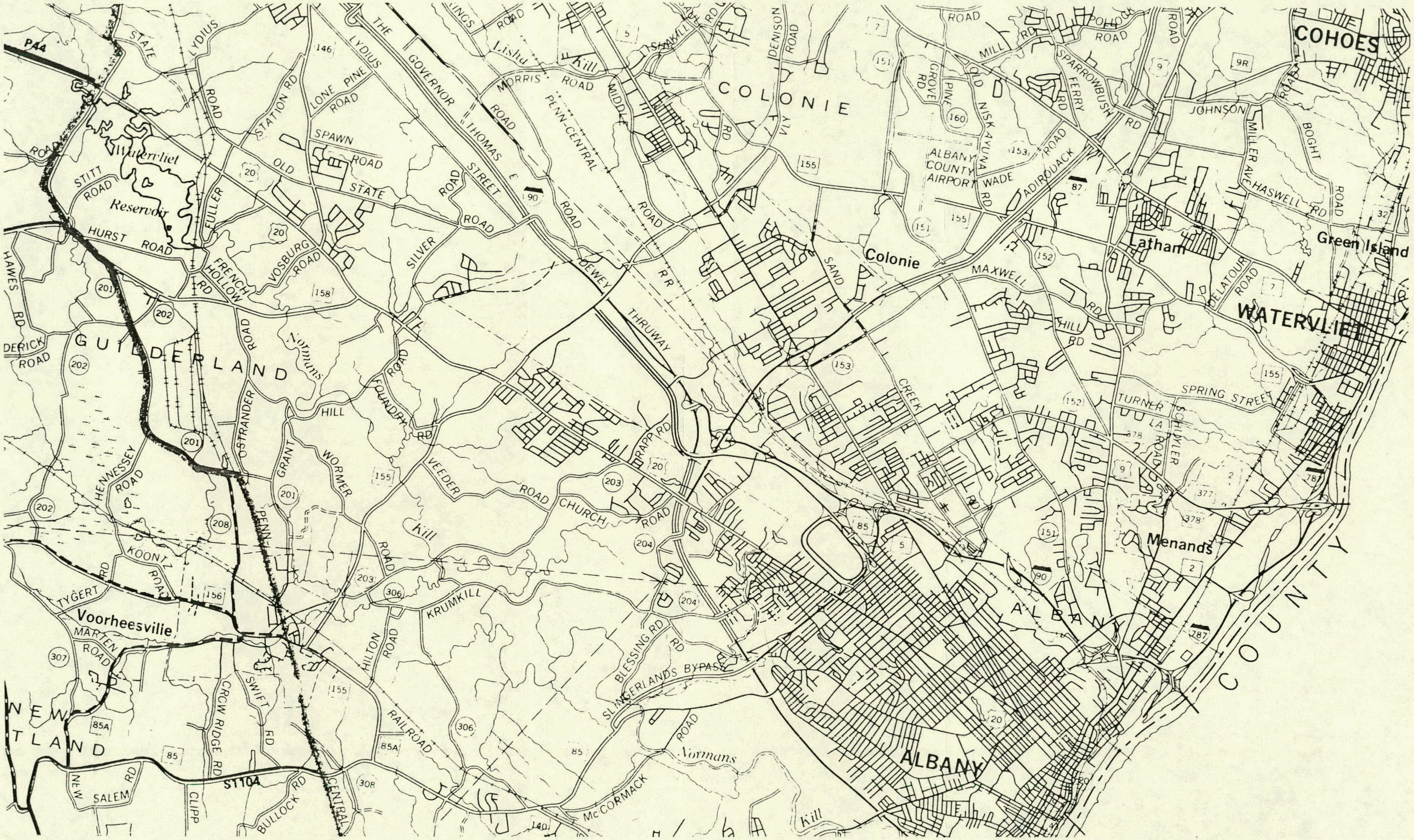
Line 33. Present Worth of Residual Value - Since the analysis period and the assumed equipment life are equal (50 years) by definition, the residual or the remaining value of the project at the end of 50 years is zero in the example depicted as Figure 44.

Line 34. Present Worth of Credits - The sum of Lines 32 and 33.

Line 35. Present Worth of Net Cost - This is the total project cost minus the total credits derived from power production (Line 29 minus Line 34).

Line 36. Ranking by Lease Net Cost Present Worth - The alternatives are ranked No. 1 through No. 78, No. 1 being the alternative with the least net cost and therefore the optimum alternative.

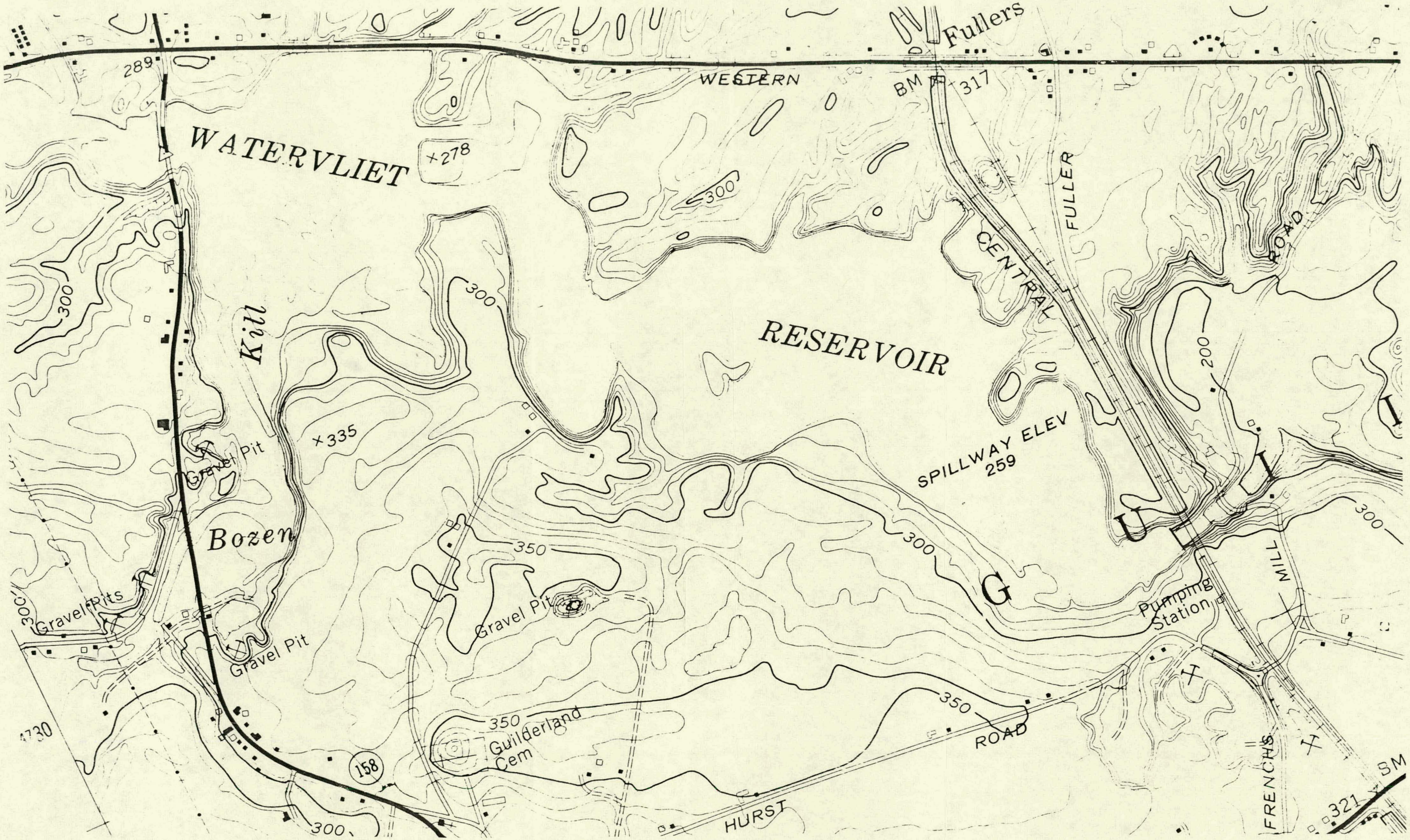
This program was run for two classes of projects, one being the rehabilitation of existing facilities and the other being construction of a completely new facility. The rehabilitation class includes Option No. 1. The new construction class consists of Options No. 2 through No. 8. An optimum alternative from each of these classes has been selected and will be discussed further in the Economic Analysis.



SITE LOCATION IN SMSA

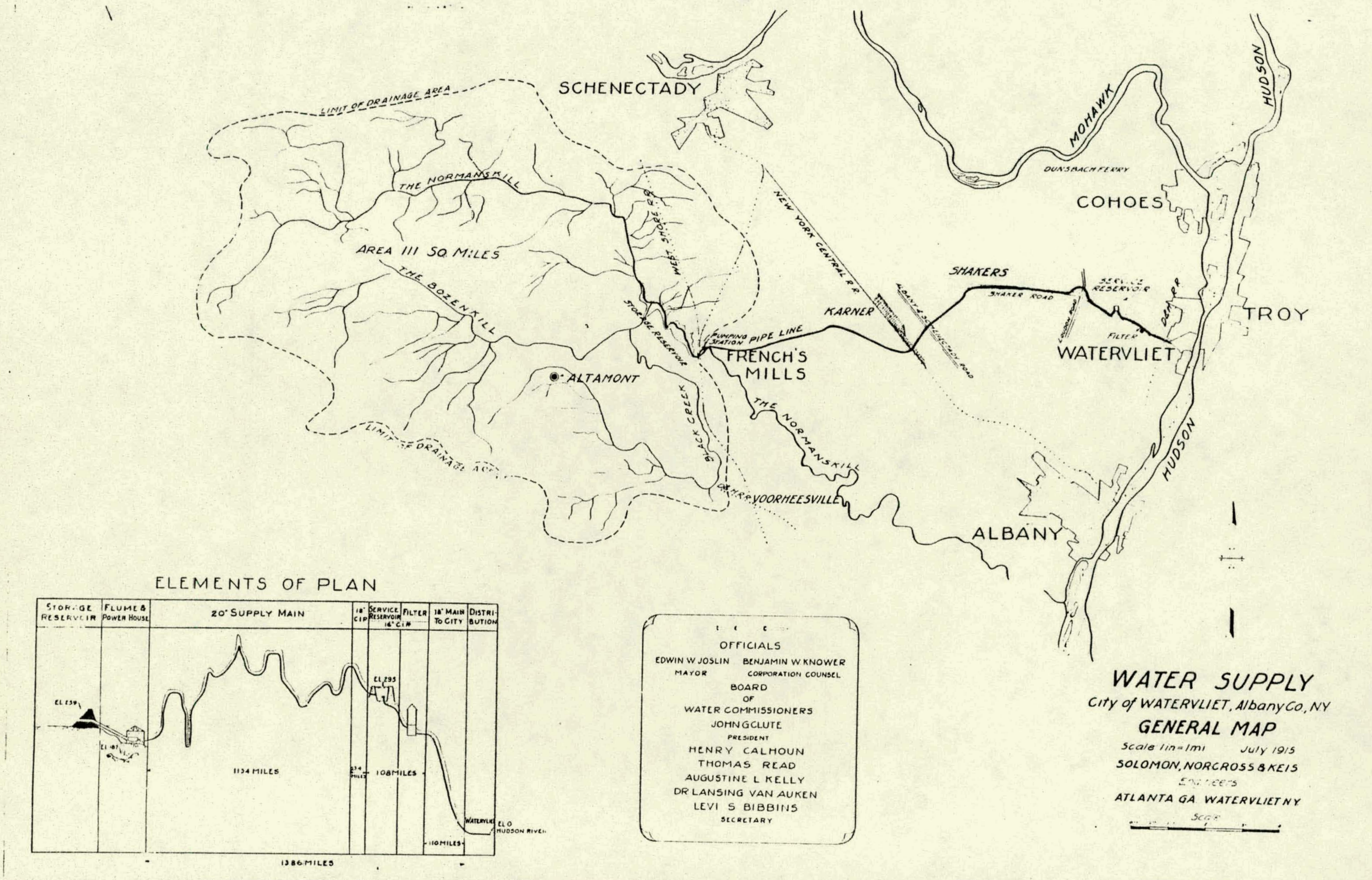
NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



SITE LOCATION
(USGS)

NORMANSKILL HYDROELECTRIC FACILITY
FEASIBILITY ASSESSMENT-EW-78-F-07-1765

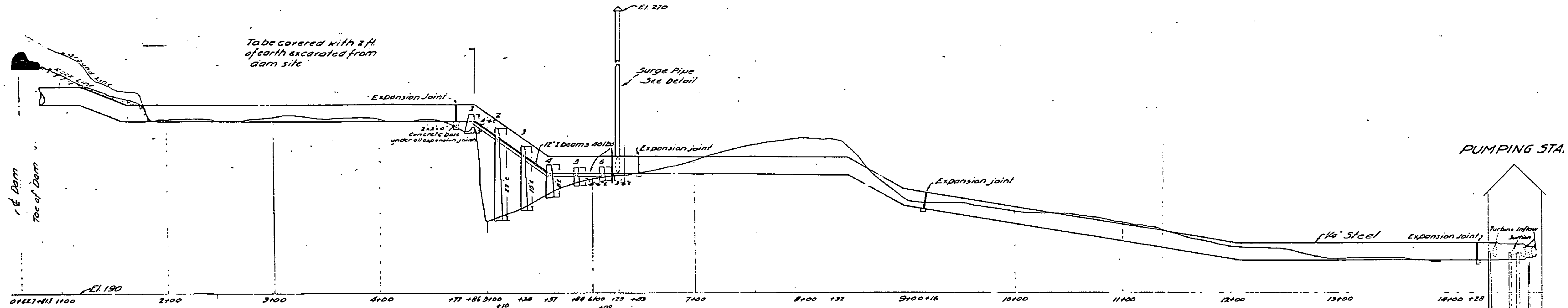


NORMANSKILL HYDROELECTRIC FACILITY

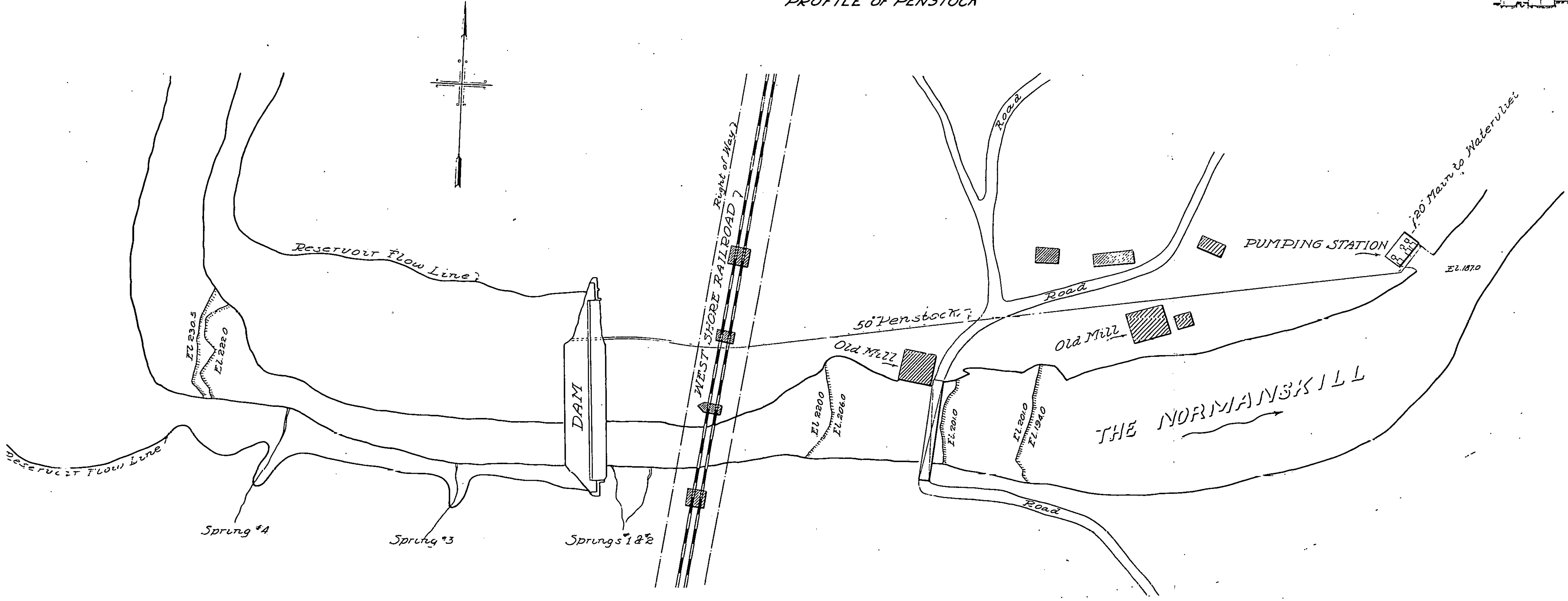
FEASIBILITY ASSESSMENT-EW-78-F-07-1765

WATER SUPPLY SYSTEM

(KEIS 1915)



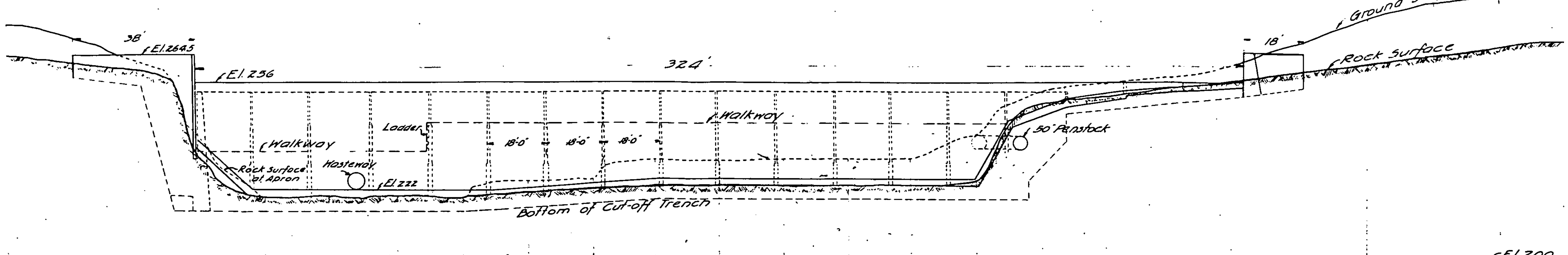
PROFILE OF PENSTOCK



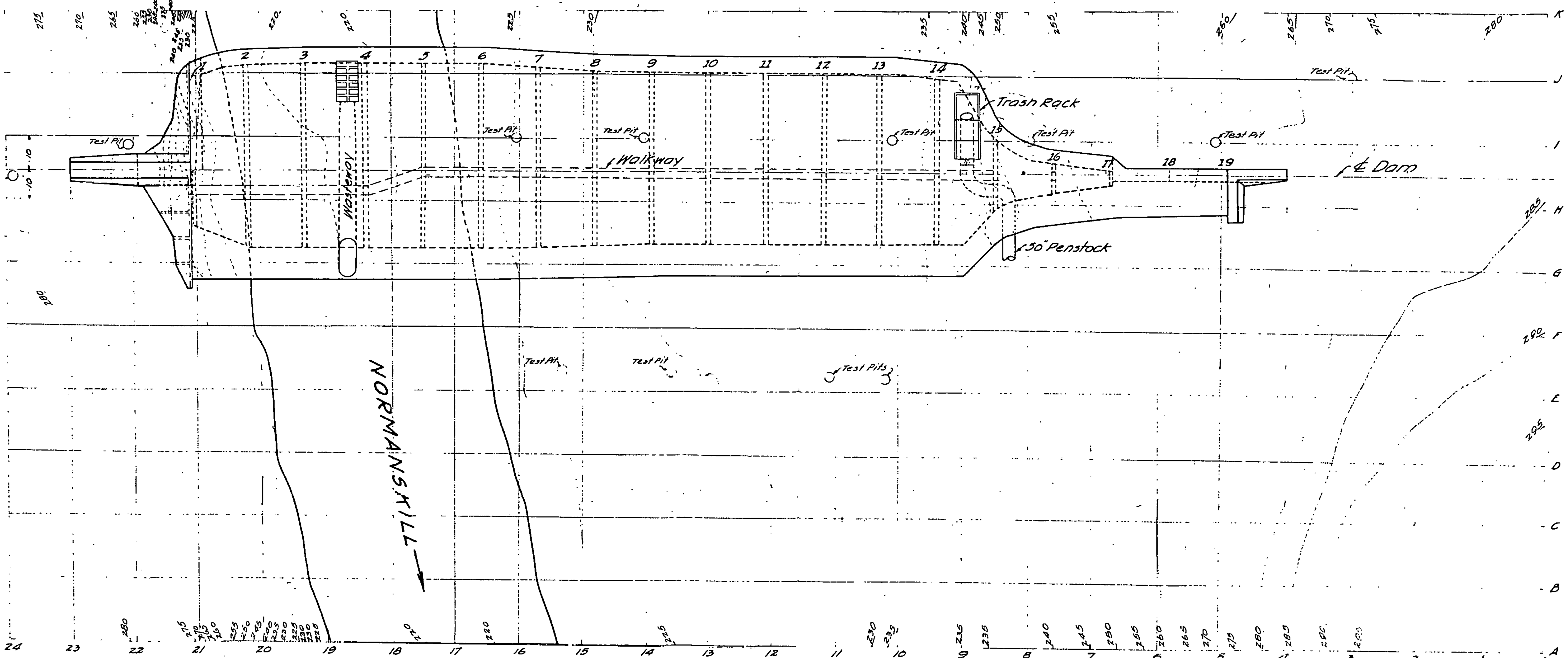
PLAN & PROFILE (KEIS 1915)

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



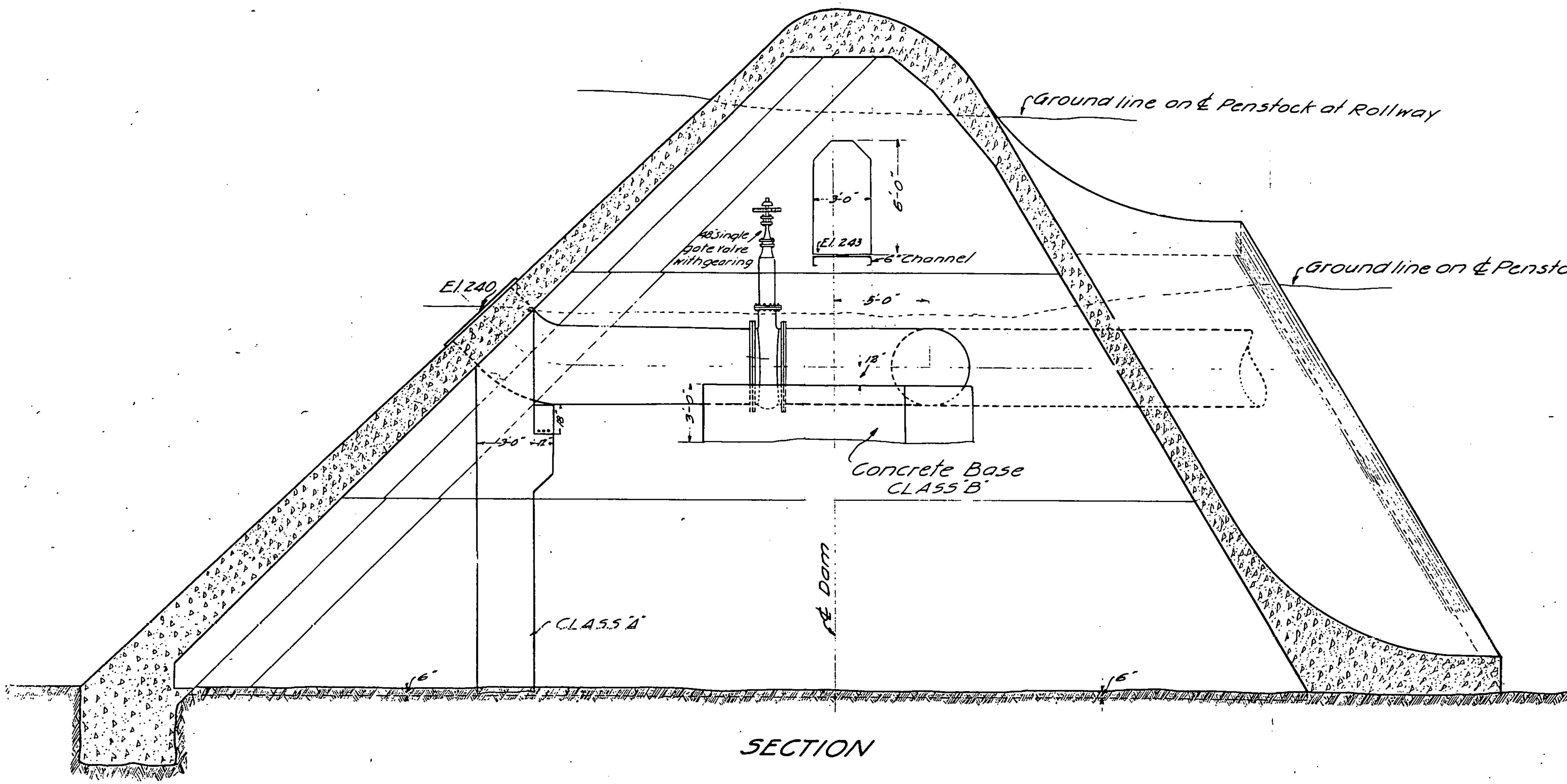
ELEVATION



GENERAL PLAN OF STORAGE RESERVOIR DAM

DAM
PLAN & PROFILE

NORMANSKILL HYDROELECTRIC FACILITY
FEASIBILITY ASSESSMENT-EW-78-F-07-1765



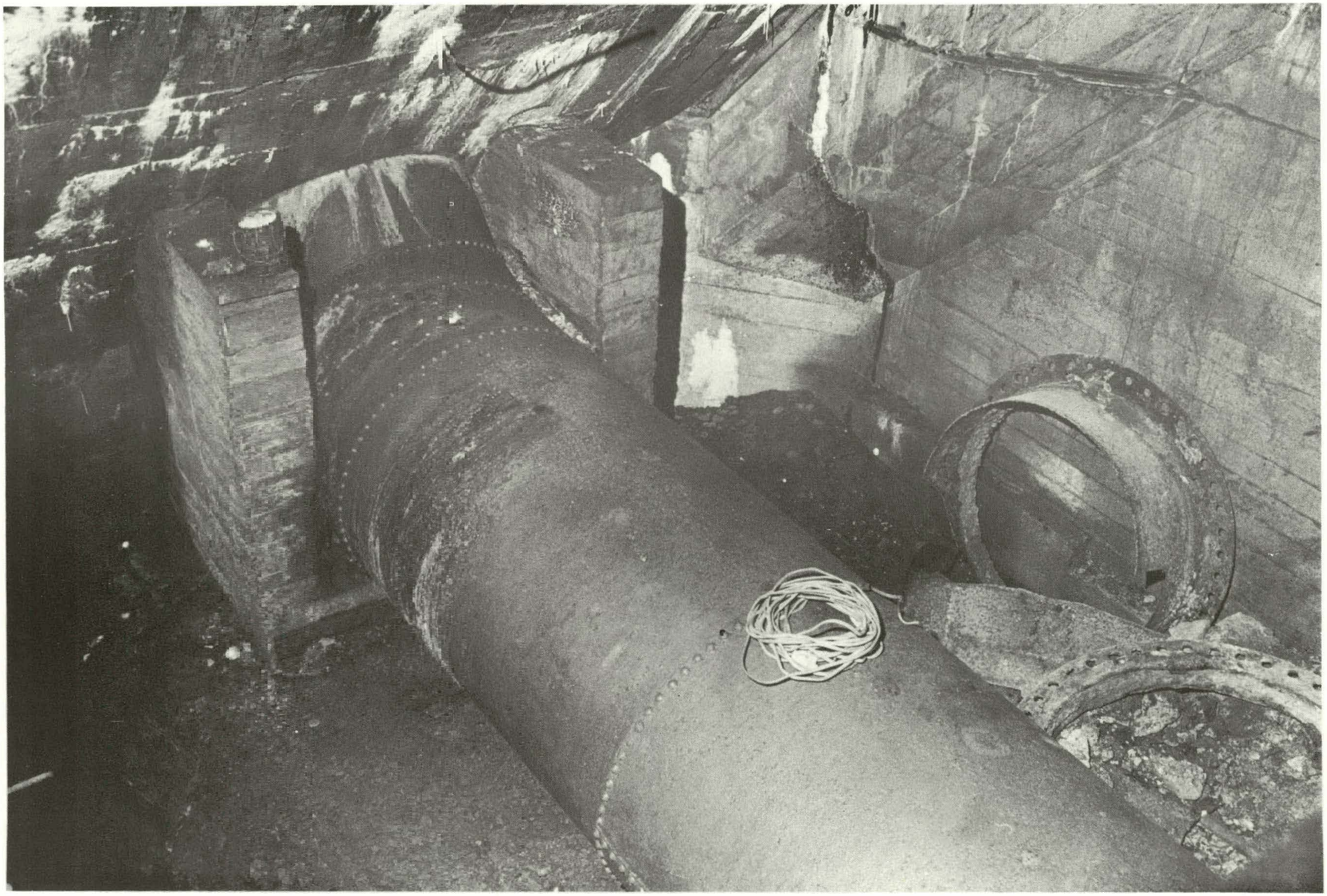
SECTION

PENSTOCK THRU DAM

DAM-SECTION

NORMANSKILL HYDROELECTRIC FACILITY

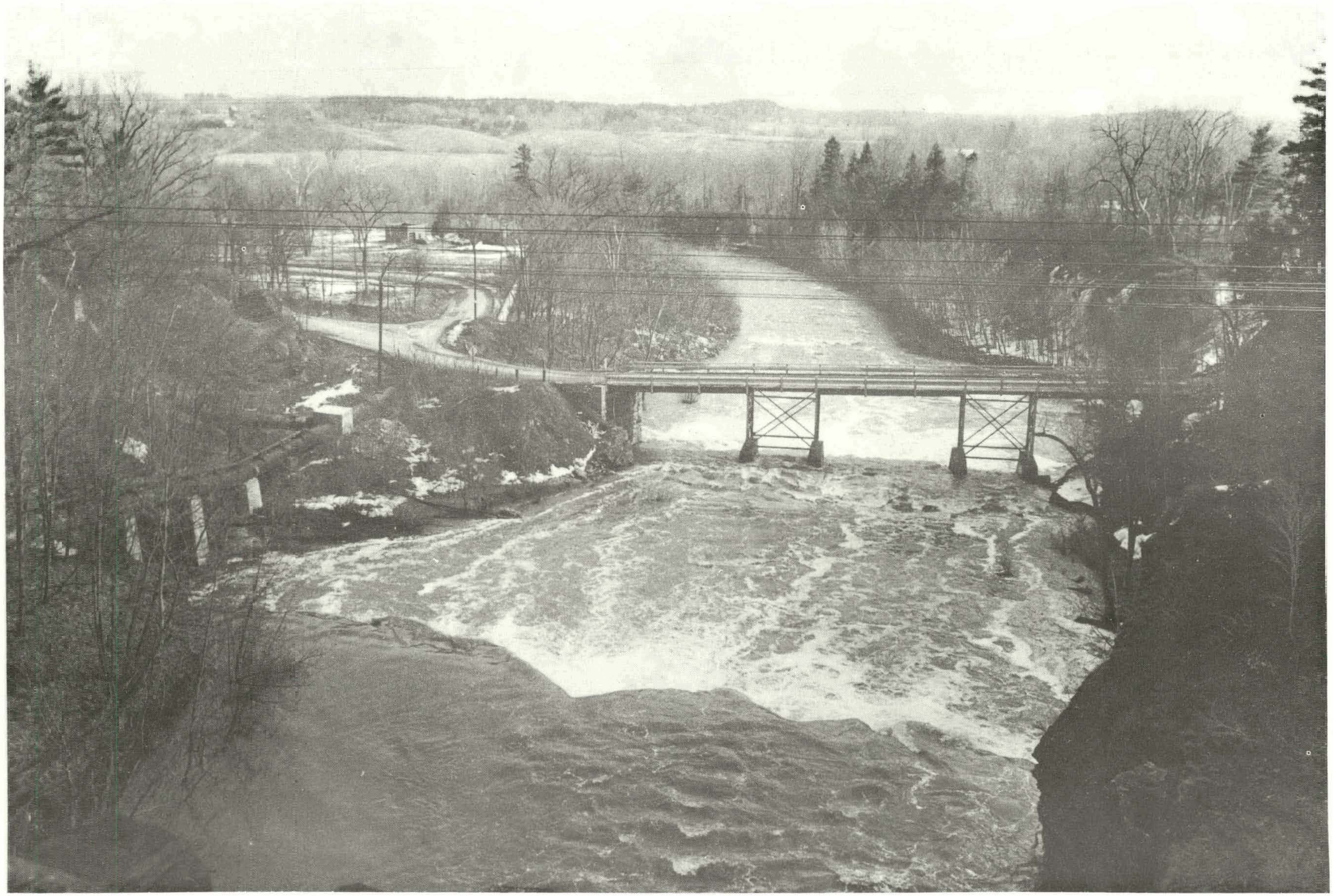
FEASIBILITY ASSESSMENT-EW-78-F-07-1765



NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

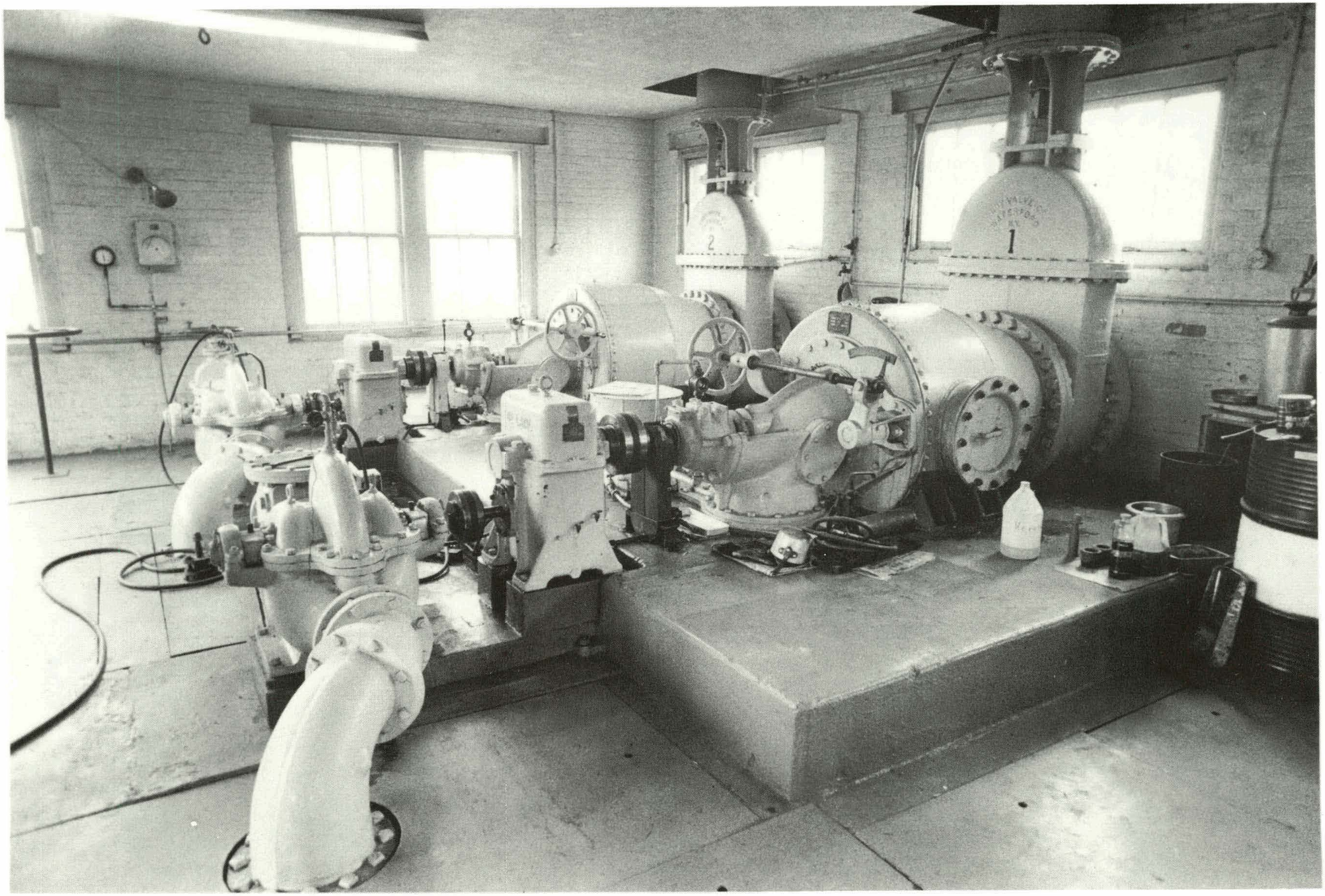
EXIST. PENSTOCK AT INTAKE



NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

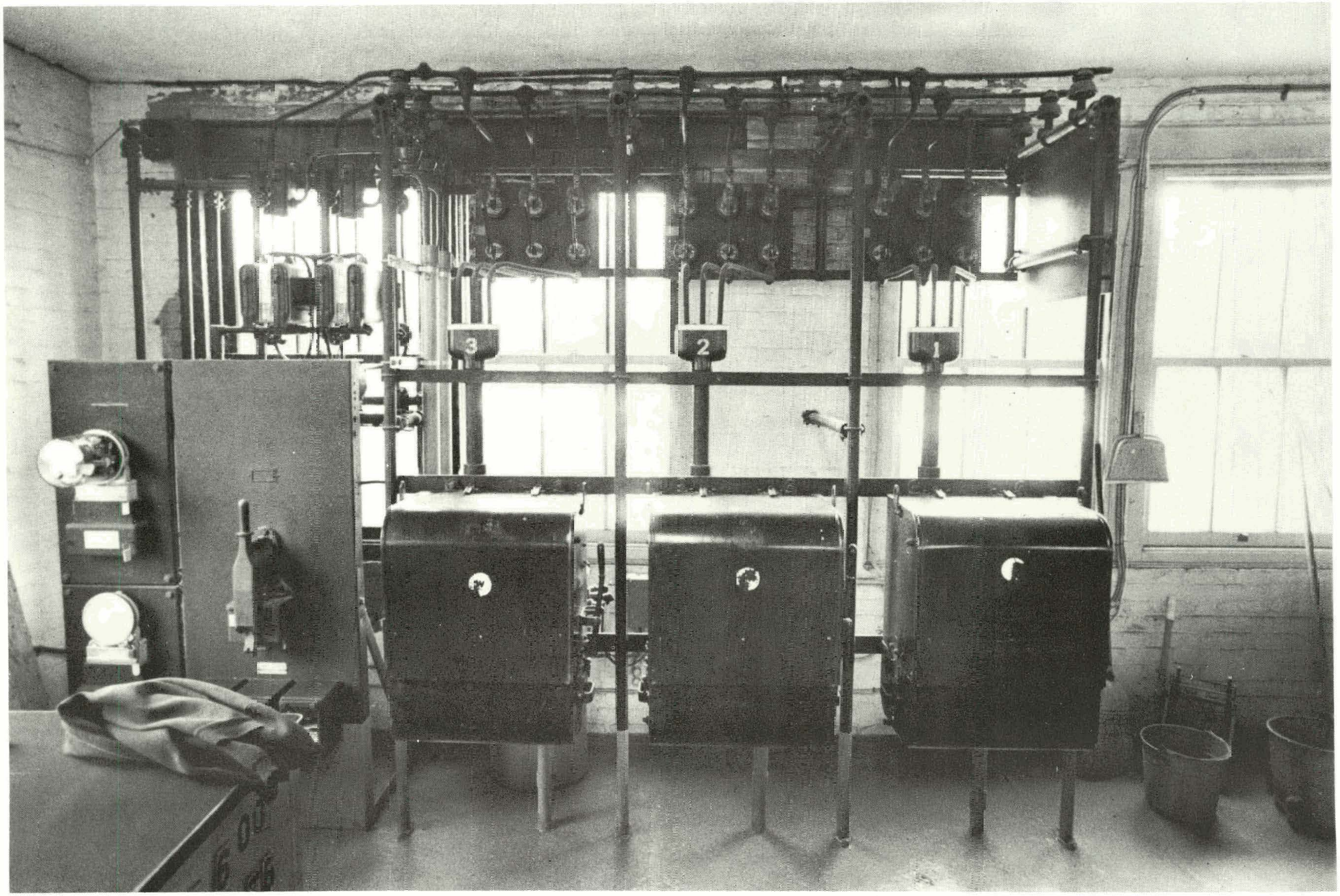
NORMANSKILL BELOW DAM



NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

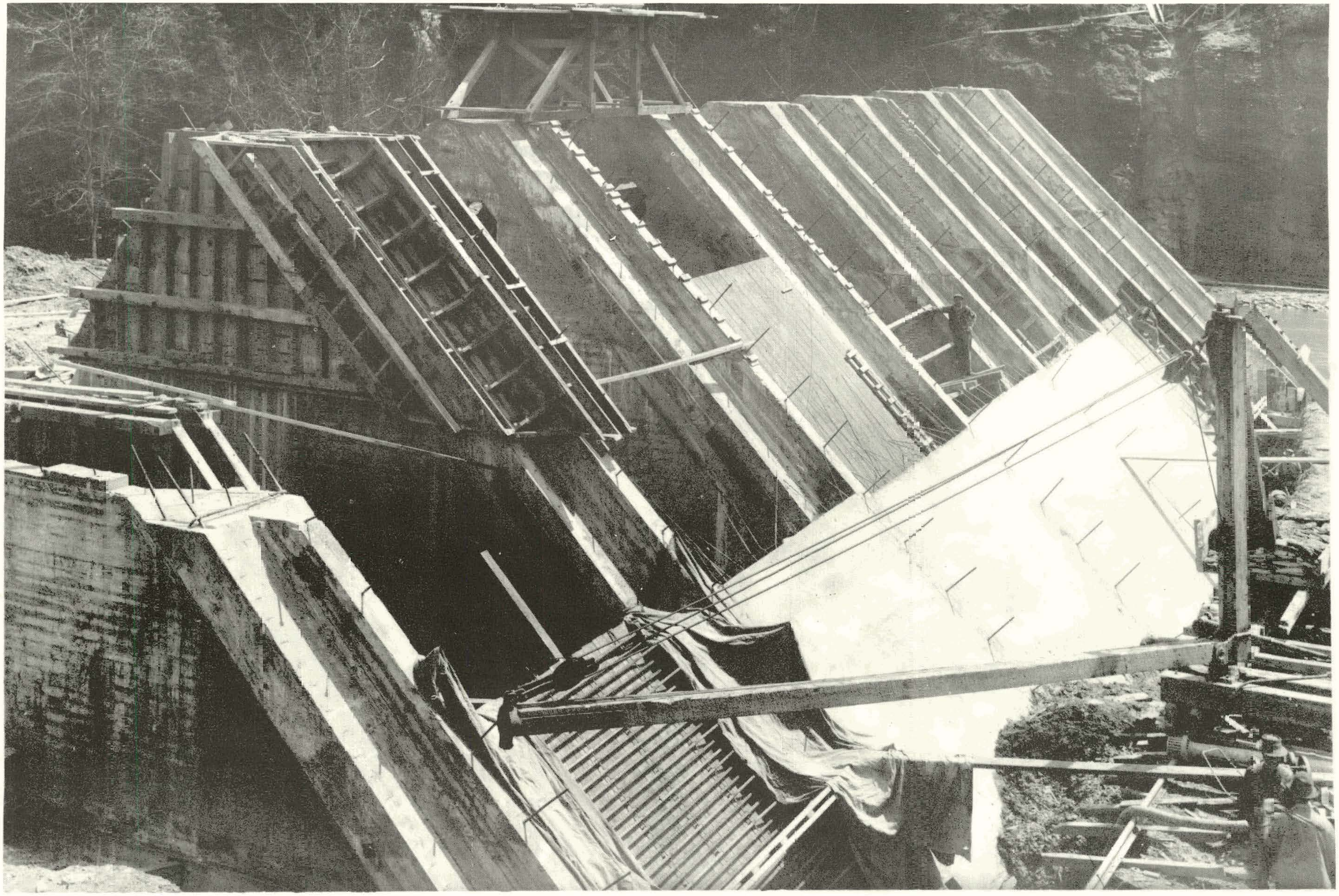
EXISTING
TURBINES & PUMPS



NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

EXISTING SWITCHGEAR



NORMANSKILL HYDROELECTRIC FACILITY

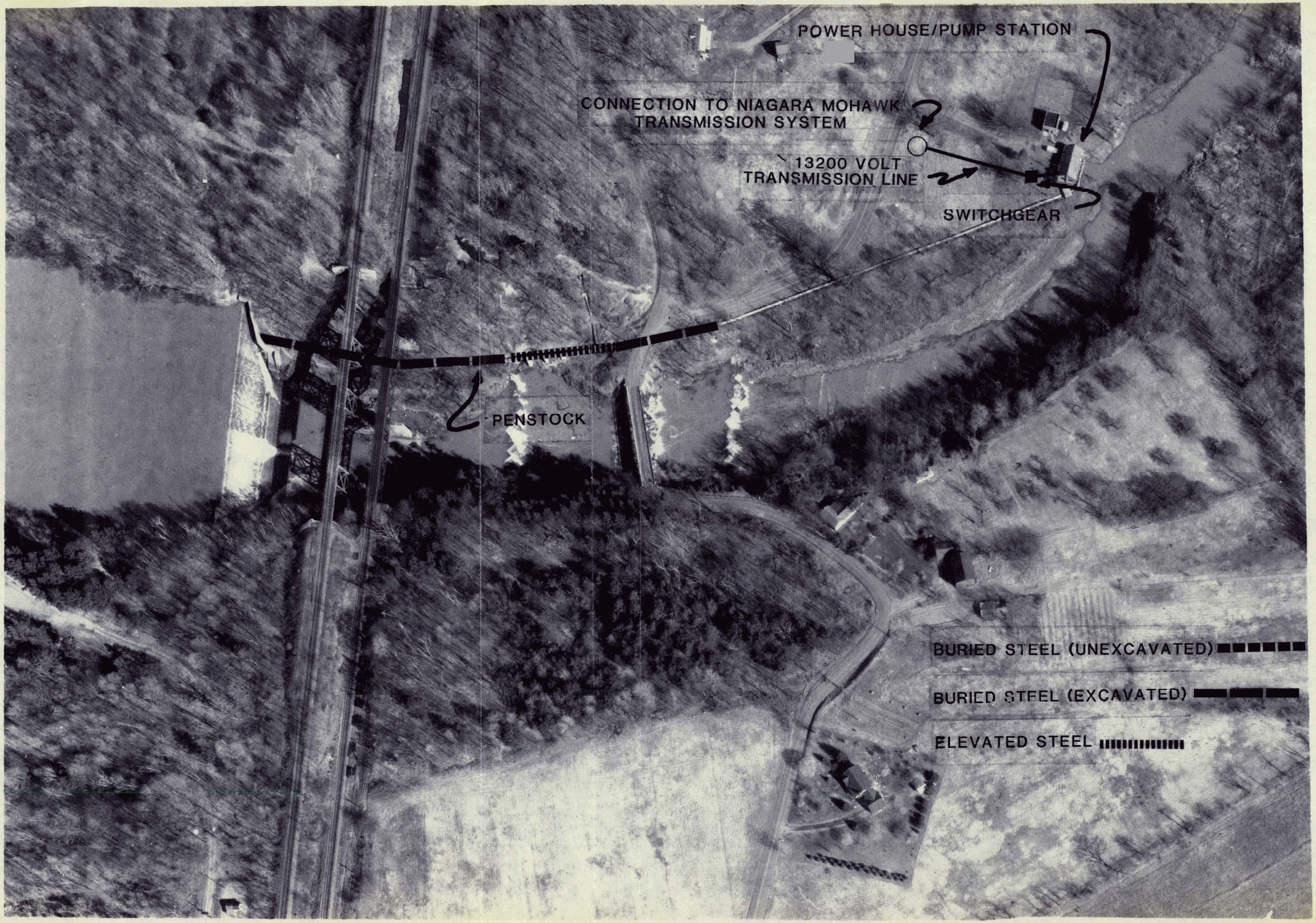
FEASIBILITY ASSESSMEN⁻-EW-78-F-07-1765

DAM UNDER CONSTRUCTION

c.1914

40

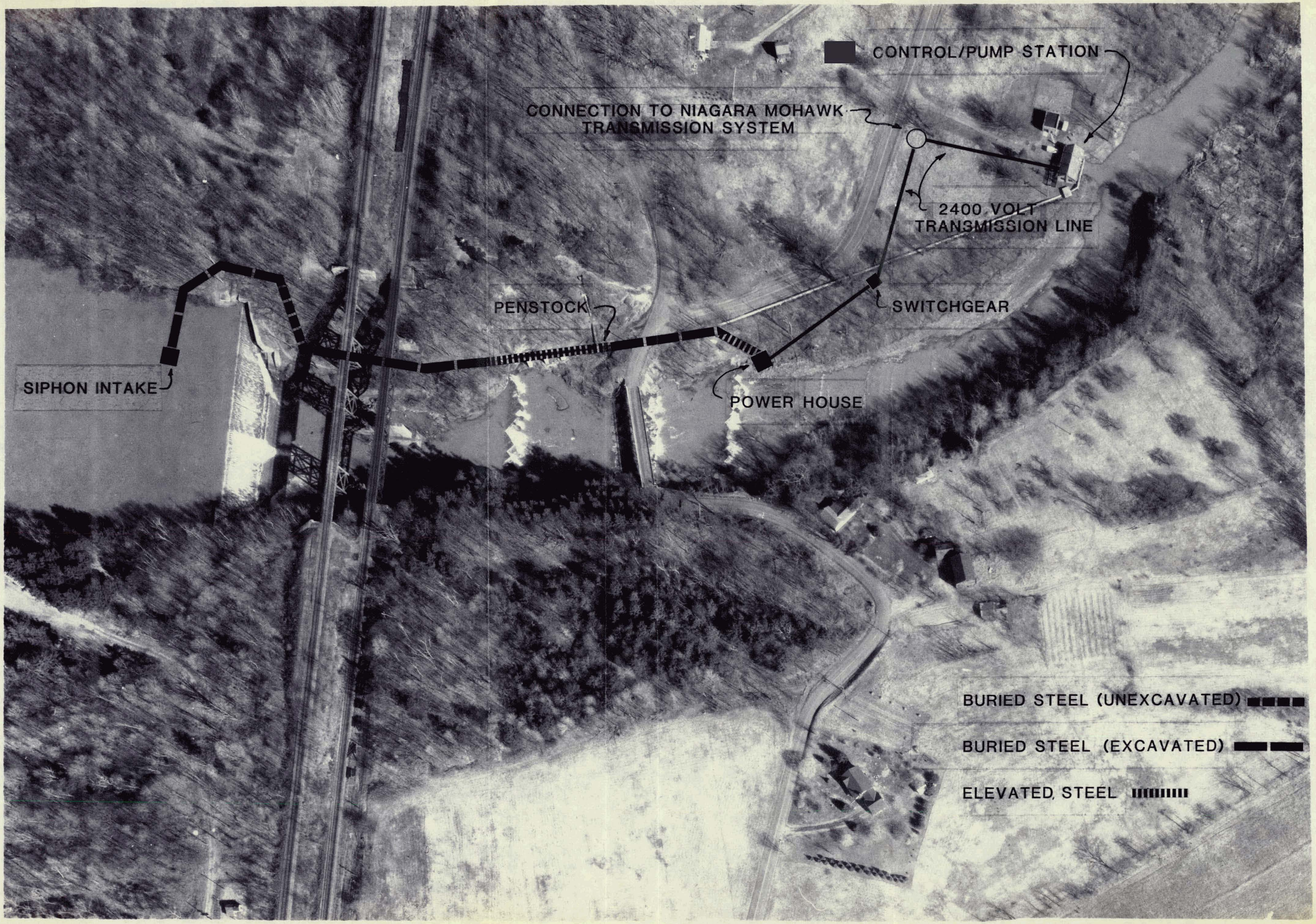
41A



SITE OPTIONS
1.01 thru 1.03

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



SITE OPTIONS
2.01 thru 2.12

NORMANSKILL HYDROELECTRIC FACILITY
FEASIBILITY ASSESSMENT-EW-78-F-07-1765

41C

SITE OPTION No. 3

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

41D

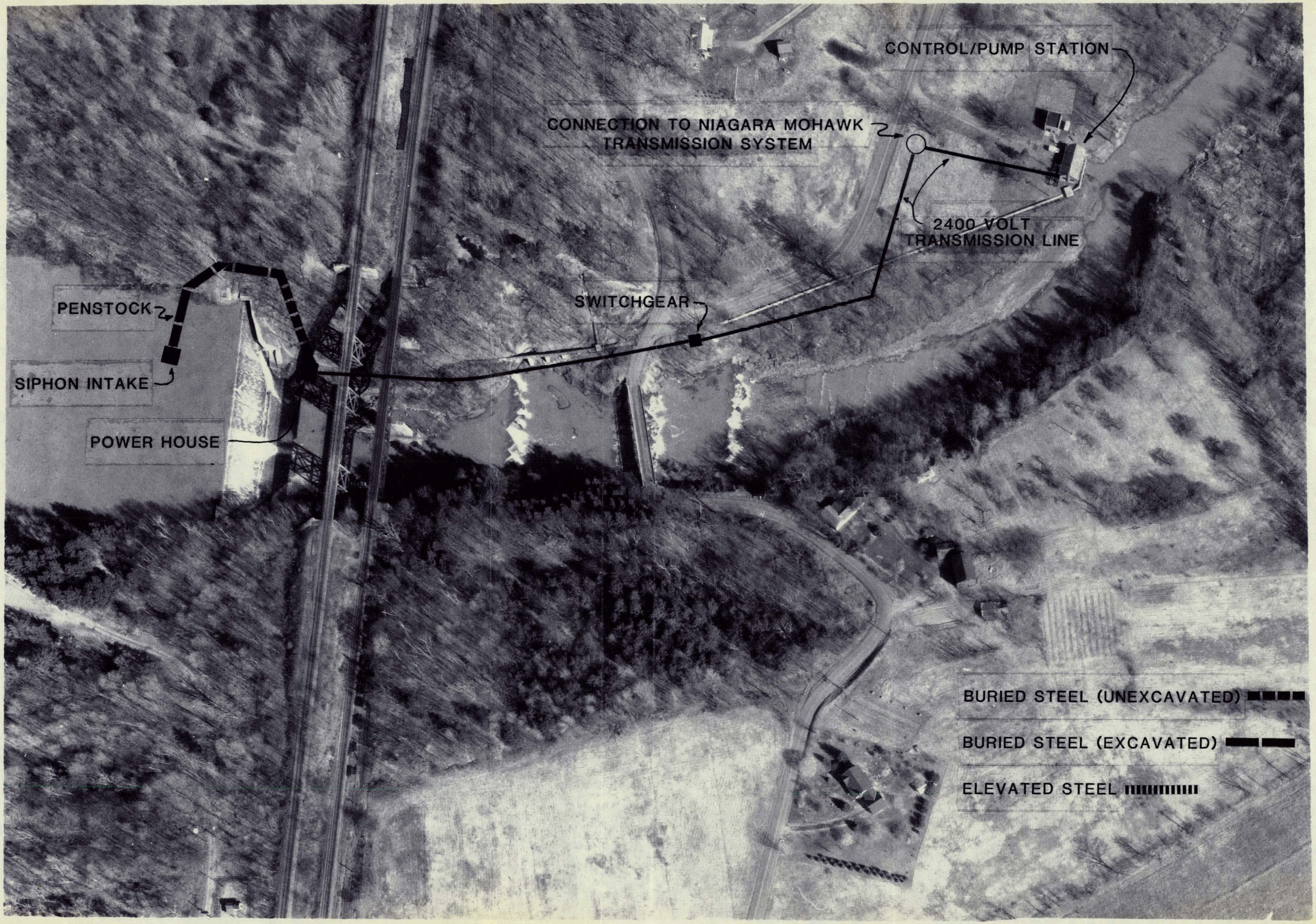
SITE OPTIONS 4.01 thru 4.11

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

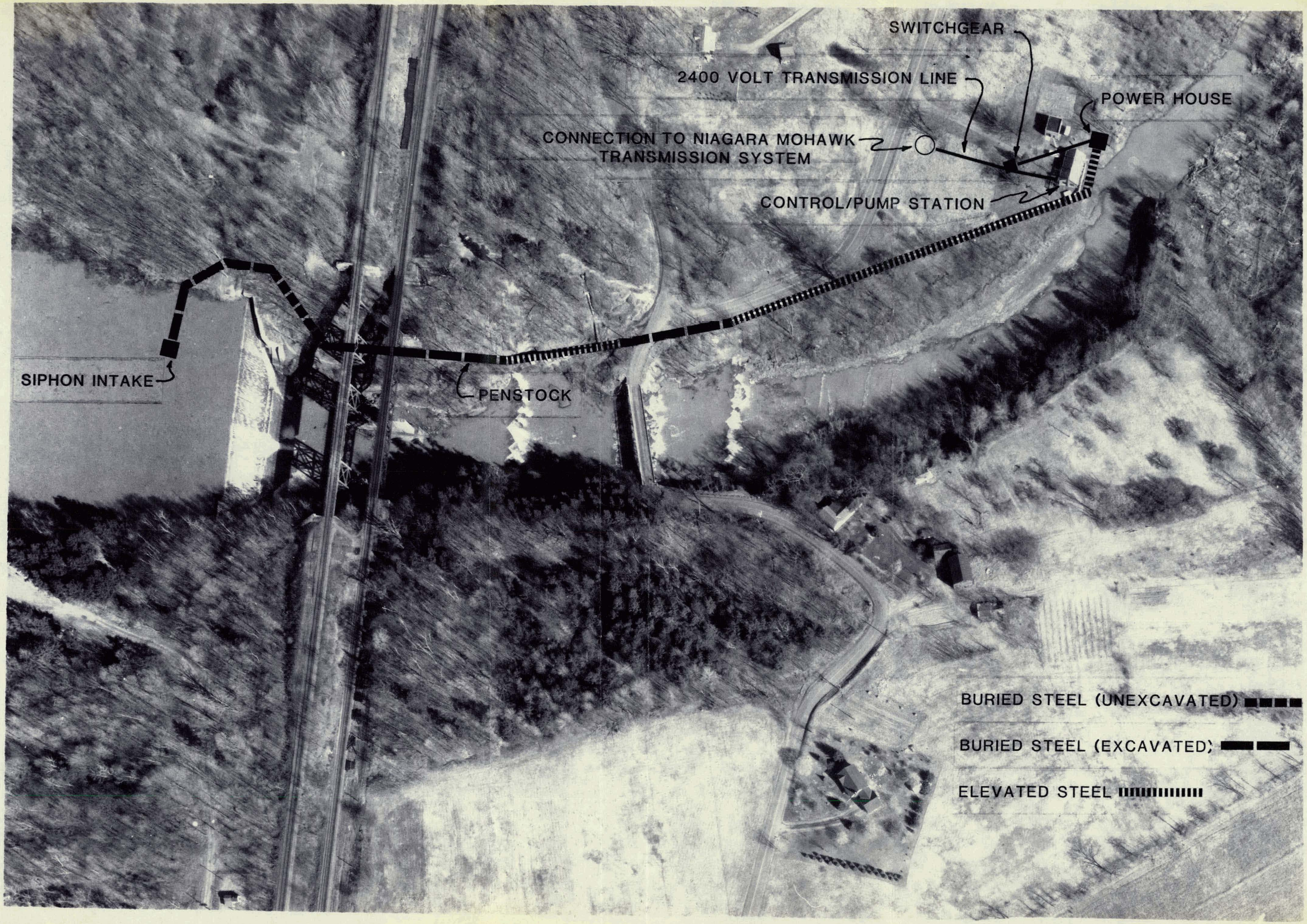
41E

SITE OPTIONS
5.01 thru 5.13



NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



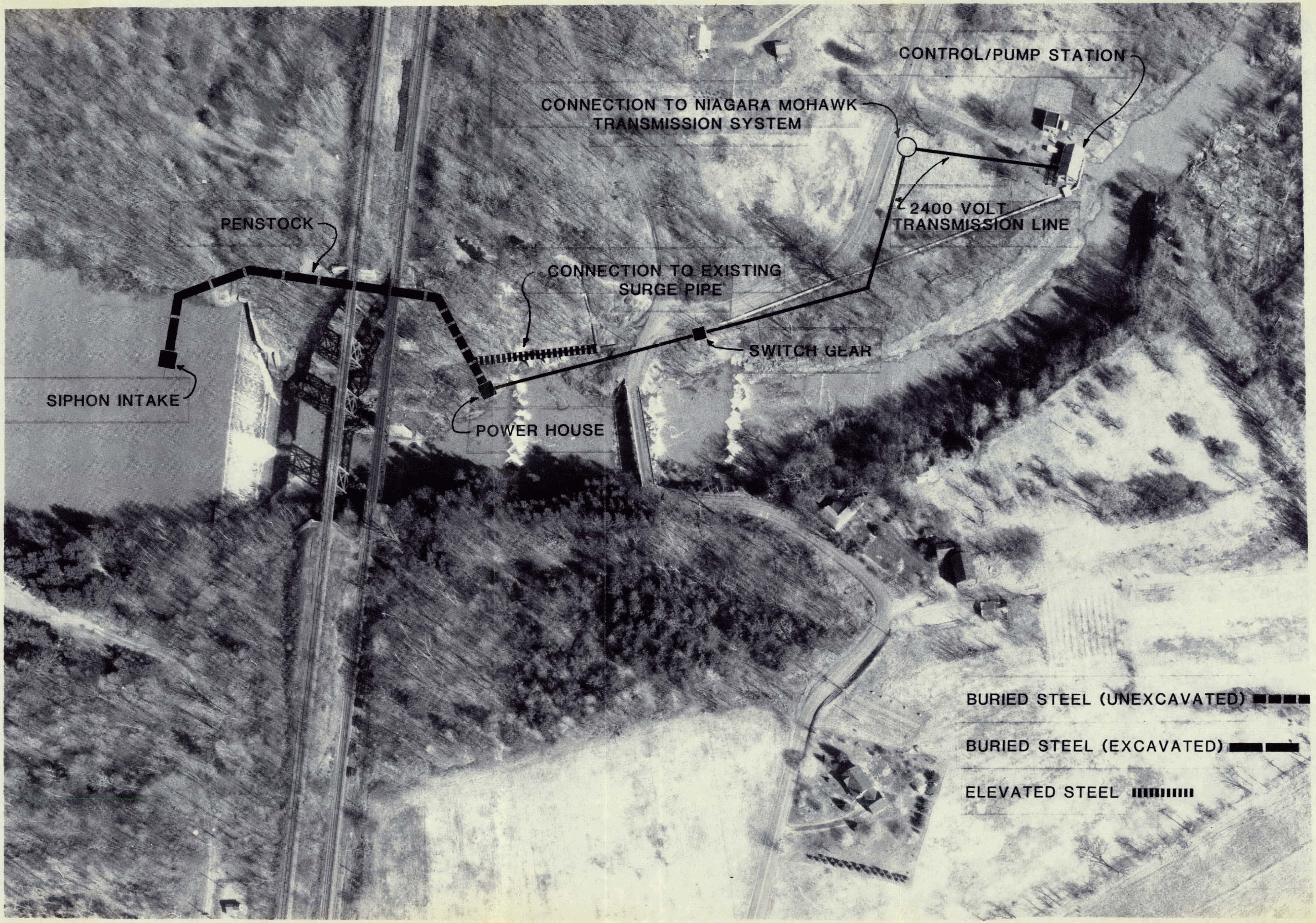
41F

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

SITE OPTIONS

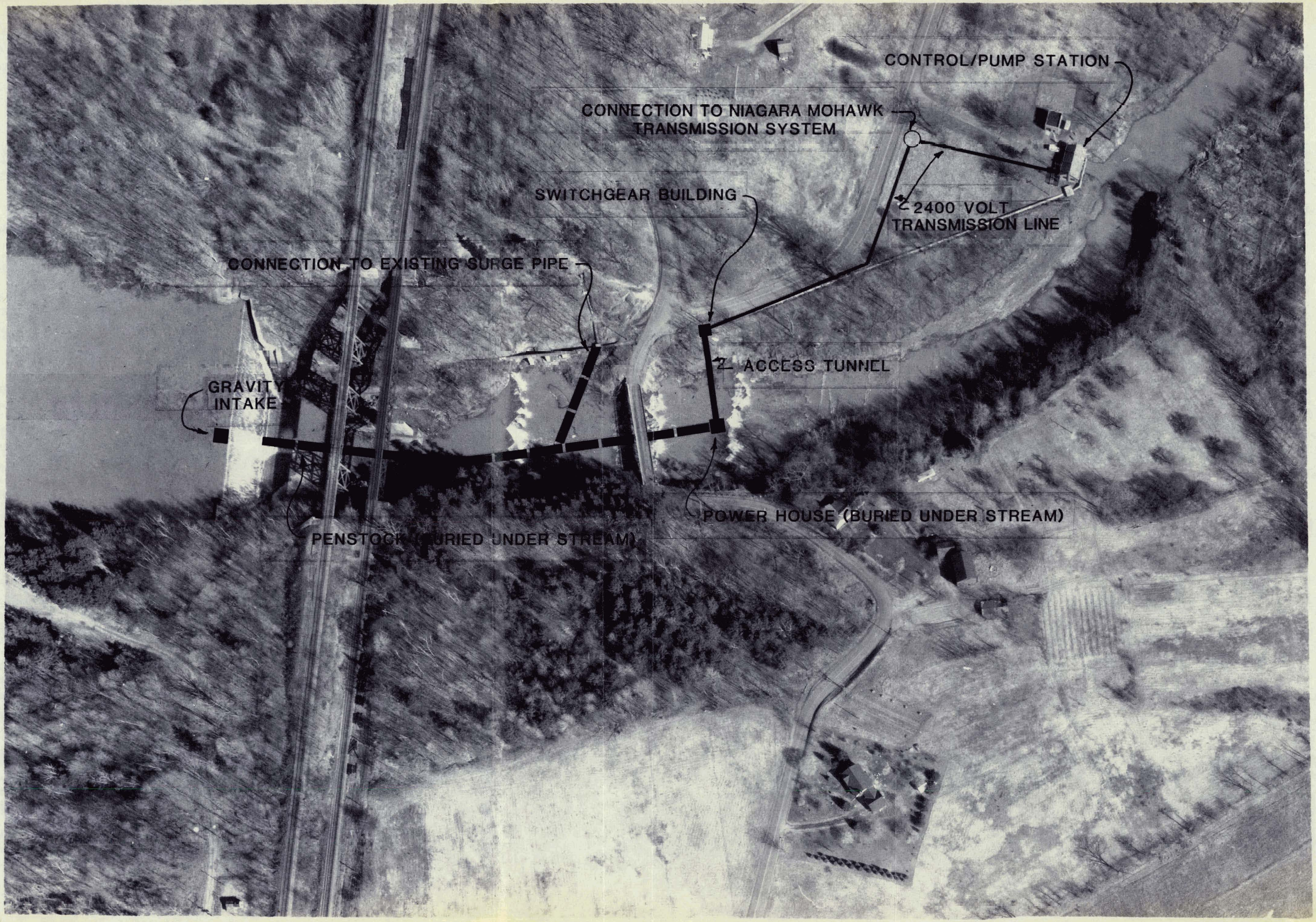
6.01 thru 6.13



SITE OPTIONS
7.01 thru 7.13

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

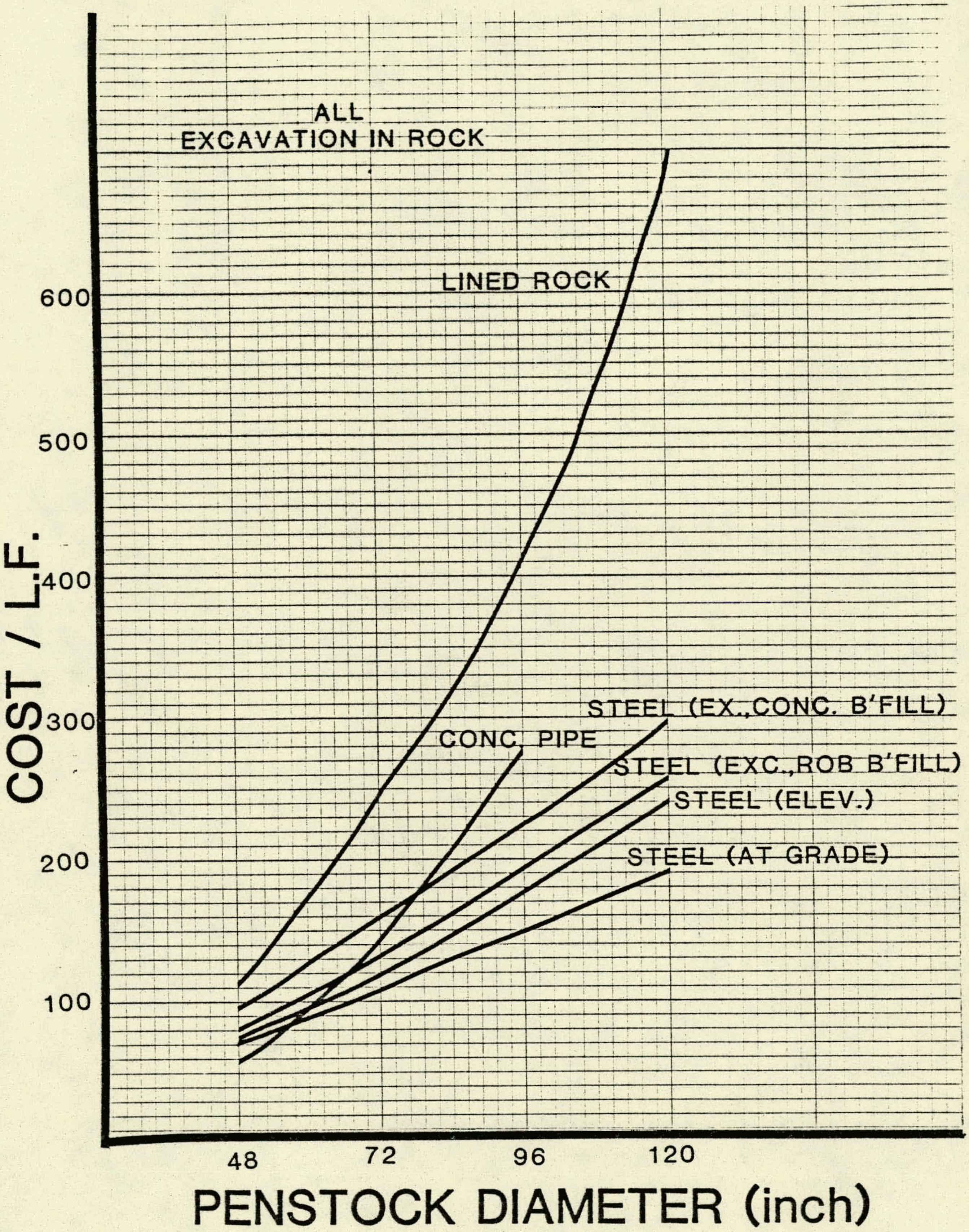


41H

SITE OPTIONS
8.01 thru 8.13

NORMANSKILL HYDROELECTRIC FACILITY

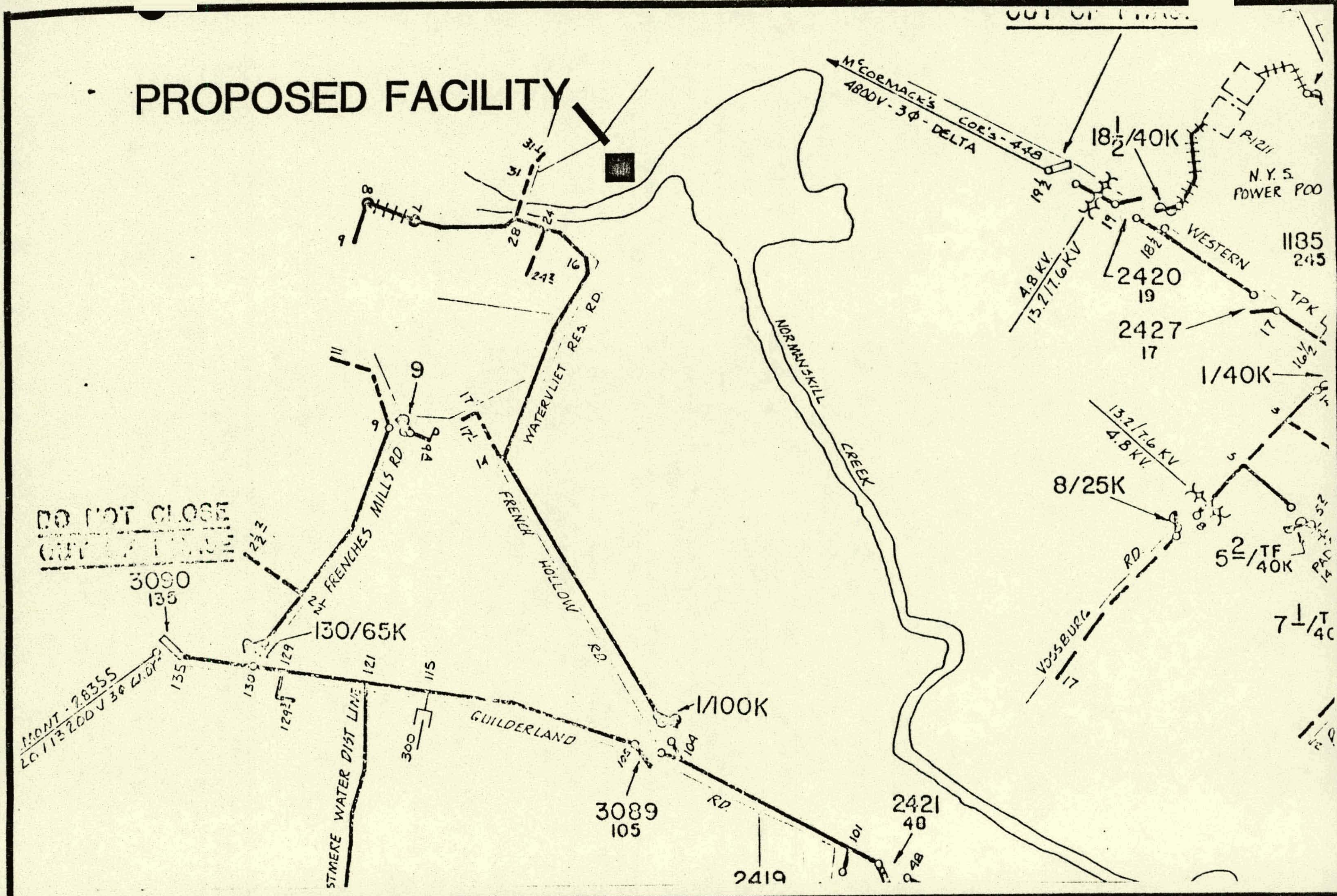
FEASIBILITY ASSESSMENT-EW-78-F-07-1765



PENSTOCK UNIT COST

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

N.M.P.C. DISTRIBUTION SYSTEM

OPTIMUM CONFIGURATION

ALTERNATES 1.01 - 8.13

PERIOD	50 YEARS
DISCOUNT RATE	8.0%
O & M GRADIENT	4.0%
ENERGY GRADIENT	7.0%

MACHINE TYPE:

1 VERT. FRANCIS
2 HORZ. FRANCIS
3 HORZ. PROPELLER(ADJ.)
4 VERT. PROPELLER(FIXED)

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
OPTIMUM CONFIGURATION PROGRAM (OCP#1)
50 YEAR SERVICE PERIOD PRESENT WORTH ANALYSIS
BASED UPON 50 YEAR EQUIPMENT LIFE AND 8.000 PERCENT DISCOUNT RATE

1. ALTERNATIVE NO.		1.01	1.02	1.03
2. DESIGN FLOW	(CFS)	35	100	100
3. GROSS HEAD	(FEET)	65.4	65.4	65.4
4. PENSTOCK DIAMETER	(INCHES)	48	48	48
5. INTAKE AREA	(SQ.FT.)	132	50	50
6. NET HEAD	(FEET)	60.7	50.6	50.6
7. TURBINE TYPE		2	1	4
8. RUNNER DIAMETER	(INCHES)	12.7	25.0	29.5
9. SETTING	(FEET)	9.8	3.5	6.0
10. SPECIFIC SPEED		73.4	80.1	119.7
11. UNIT EFFICIENCY @ F.L.	(%)	78.0	82.0	82.0
12. COMPOSITE EFFICIENCY	(%)	75.5	78.3	78.3
13. NET POWER	(KW)	136	335	335
14. PENSTOCK LENGTH	(FEET)	1500	1500	1500
15. PENSTOCK COST	($)	68400	68400	68400
16. INTAKE COST	($)	53700	53700	53700
17. POWERHOUSE COST	($)	42800	91200	91200
18. SWITCHGEAR COST	($)	194200	201500	201500
19. MACHINE COST	($)	107900	257500	258900
20. ANC. EQUIP. COST	($)	70300	70300	70300
21. MOBIL. & TEMP. SERV. COST	($)	126400	136600	136700
22. ADMIN., LEGAL & TECH. COST	($)	113100	130300	130400
23. INT. DURING CONSTRUCTION	($)	31100	40400	40400
24. TOTAL CAPITAL COST	($)	807900	1049900	1051500
25. P.W. OF CAPITAL COSTS	($)	807900	1049900	1051500
26. BASE YEAR ANNUAL O & M COST	($)	37100	45200	45300
27. O & M CMPD. COST GRADIENT	(%)	4.0	4.0	4.0
28. P.W. OF 50 YEAR O & M COST	($)	818400	997100	999300
29. P.W. OF COSTS [25 & 28]	($)	1626300	2047000	2050800
30. BASE VALUE/YR ENERGY GEN'D.	($)	53900	89500	89500
31. ENERGY CMPD. VALUE GRADIENT	(%)	7.0	7.0	7.0
32. P.W. OF 50 YEARS OF ENERGY	($)	2145100	3561900	3561900
33. P.W. OF RESIDUAL VALUE	($)	0	0	0
34. P.W. OF CREDITS [32 & 33]	($)	2145100	3561900	3561900
35. P.W. OF NET COST [29 - 34]	($)	¯518800	¯1514900	¯1511100
36. RANKING BY LEAST NET COST P.W.		3	1	2

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
OPTIMUM CONFIGURATION PROGRAM (OCP#2)
50 YEAR SERVICE PERIOD PRESENT WORTH ANALYSIS
BASED UPON 50 YEAR EQUIPMENT LIFE AND 8.000 PERCENT DISCOUNT RATE

1. ALTERNATIVE NO.		2.01	2.02	2.03	2.04	2.05	2.06	2.07	2.08	2.09	2.10
2. DESIGN FLOW	(CFS)	100	100	100	100	100	200	200	200	300	300
3. GROSS HEAD	(FEET)	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4
4. PENSTOCK DIAMETER	(INCHES)	48	60	72	84	96	60	72	96	72	84
5. INTAKE AREA	(SQ.FT.)	50	50	50	50	50	100	100	100	150	150
6. NET HEAD	(FEET)	58.3	62.1	63.3	63.8	64.0	55.3	60.4	63.2	56.0	60.1
7. TURBINE TYPE		1	1	1	1	1	1	1	1	1	1
8. RUNNER DIAMETER	(INCHES)	27.3	27.3	27.1	27.1	27.1	39.1	38.3	38.4	47.9	47.2
9. SETTING	(FEET)	8.4	9.5	8.9	8.2	8.6	9.4	9.2	9.1	10.0	9.8
10. SPECIFIC SPEED		74.9	72.6	71.9	71.7	71.6	76.8	73.6	72.0	76.3	73.8
11. UNIT EFFICIENCY @ F.L.	(%)	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0
12. COMPOSITE EFFICIENCY	(%)	78.3	78.3	78.3	78.3	78.3	80.7	80.7	80.7	75.3	75.3
13. NET POWER	(KW)	386	411	419	423	424	755	825	863	1070	1149
14. PENSTOCK LENGTH	(FEET)	900	900	900	900	900	900	900	900	900	900
15. PENSTOCK COST	($)	65600	85500	108300	134000	158200	85500	108300	158200	108300	134000
16. INTAKE COST	($)	388100	388100	388100	388100	388100	408800	408800	408800	426400	426400
17. POWERHOUSE COST	($)	78900	78900	78000	78000	78000	128000	124500	124900	168300	165000
18. SWITCHGEAR COST	($)	289700	290700	291100	291200	291300	303100	305300	306500	312600	314700
19. MACHINE COST	($)	275200	288100	295500	301700	307300	382500	403600	422600	455800	476200
20. ANC. EQUIP. COST	($)	70300	70300	70300	70300	70300	70300	70300	70300	70300	70300
21. MOBIL. & TEMP. SERV. COST	($)	137900	139600	141100	142700	144200	148400	150500	154100	156600	158800
22. ADMIN., LEGAL & TECH. COST	($)	162700	165300	167600	170100	172400	178000	182100	187400	191200	194500
23. INT. DURING CONSTRUCTION	($)	58700	60300	61600	63000	64400	68200	70100	73300	75600	77600
24. TOTAL CAPITAL COST	($)	1527100	1566800	1601600	1639100	1674200	1773600	1823500	1906100	1965100	2017500
25. P.W. OF CAPITAL COSTS	($)	1527100	1566800	1601600	1639100	1674200	1773600	1823500	1906100	1965100	2017500
26. BASE YEAR ANNUAL O & M COST	($)	56400	57700	58900	60200	61400	64800	66500	69300	71300	73100
27. O & M CMPD. COST GRADIENT	(%)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
28. P.W. OF 50 YEAR O & M COST	($)	1244200	1272900	1299400	1328000	1354500	1429500	1467000	1528800	1572900	1612600
29. P.W. OF COSTS [25 & 28]	($)	2771300	2839700	2901000	2967100	3028700	3203100	3290500	3434900	3538000	3630100
30. BASE VALUE/YR ENERGY GEN'D.	($)	97200	100300	101200	101500	101700	106800	111500	113900	108500	112500
31. ENERGY CMPD. VALUE GRADIENT	(%)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
32. P.W. OF 50 YEARS OF ENERGY	($)	3868300	3991700	4027500	4039500	4047400	4250400	4437400	4532900	4318000	4477200
33. P.W. OF RESIDUAL VALUE	($)	0	0	0	0	0	0	0	0	0	0
34. P.W. OF CREDITS [32 & 33]	($)	3868300	3991700	4027500	4039500	4047400	4250400	4437400	4532900	4318000	4477200
35. P.W. OF NET COST [29 - 34]	($)	¯1097000	¯1152000	¯1126500	¯1072400	¯1018700	¯1047300	¯1146900	¯1098000	¯780000	¯847100
36. RANKING BY LEAST NET COST P.W.		18	14	16	19	21	20	15	17	31	24

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
OPTIMUM CONFIGURATION PROGRAM (OCPH2)
50 YEAR SERVICE PERIOD PRESENT WORTH ANALYSIS
BASED UPON 50 YEAR EQUIPMENT LIFE AND 8.000 PERCENT DISCOUNT RATE

1. ALTERNATIVE NO.		2.11	2.12	4.01	4.02	4.03	4.04	4.05	4.06	4.07	4.08
2. DESIGN FLOW	(CFS)	300	500	100	100	100	200	200	200	200	300
3. GROSS HEAD	(FEET)	64.4	64.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4
4. PENSTOCK DIAMETER	(INCHES)	96	96	48	60	96	60	72	84	96	72
5. INTAKE AREA	(SQ.FT.)	150	250	50	50	50	100	100	100	100	150
6. NET HEAD	(FEET)	62.0	59.1	34.3	34.9	35.3	33.7	34.5	34.8	35.0	33.6
7. TURBINE TYPE		1	1	3	3	3	3	3	3	3	3
8. RUNNER DIAMETER	(INCHES)	47.3	61.1	24.9	24.8	24.9	35.2	35.2	35.1	35.3	43.2
9. SETTING	(FEET)	9.7	10.2	¯1.0	¯1.8	¯1.8	¯1.9	¯1.9	¯1.9	¯1.8	¯1.7
10. SPECIFIC SPEED		72.7	74.4	154.6	153.5	152.9	155.6	154.2	153.7	153.4	155.8
11. UNIT EFFICIENCY @ F.L.	(%)	82.0	82.0	81.0	81.0	81.0	81.0	81.0	81.0	81.0	81.0
12. COMPOSITE EFFICIENCY	(%)	75.3	74.3	81.3	81.3	81.3	81.7	81.7	81.7	81.7	81.7
13. NET POWER	(KW)	1185	1858	236	240	243	466	477	481	484	697
14. PENSTOCK LENGTH	(FEET)	900	900	50	50	50	50	50	50	50	50
15. PENSTOCK COST	($)	158200	158200	3300	4300	8300	4300	5700	7100	8300	5700
16. INTAKE COST	($)	426400	457000	264400	264400	264400	276700	276700	276700	276700	287800
17. POWERHOUSE COST	($)	165500	233800	308800	308800	308800	308800	308800	308800	308800	308800
18. SWITCHGEAR COST	($)	315700	332300	343300	343500	343700	353800	354200	354400	354400	362000
19. MACHINE COST	($)	488500	601700	81300	82900	83900	152000	154900	156000	156700	206200
20. ANC. EQUIP. COST	($)	70300	70300	70300	70300	70300	70300	70300	70300	70300	70300
21. MOBIL. & TEMP. SERV. COST	($)	160700	172200	53600	53700	54000	58300	58500	58700	58800	62000
22. ADMIN., LEGAL & TECH. COST	($)	197300	214200	149200	149400	149800	156600	157000	157200	157400	162500
23. INT. DURING CONSTRUCTION	($)	79300	89600	51000	51100	51300	55200	55400	55600	55700	58600
24. TOTAL CAPITAL COST	($)	2061900	2329300	1325200	1328400	1334500	1436000	1441500	1444800	1447100	1523900
25. P.W. OF CAPITAL COSTS	($)	2061900	2329300	1325200	1328400	1334500	1436000	1441500	1444800	1447100	1523900
26. BASE YEAR ANNUAL O & M COST	($)	74600	83700	49500	49600	49900	53300	53500	53600	53700	56300
27. O & M CMPD. COST GRADIENT	(%)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
28. P.W. OF 50 YEAR O & M COST	($)	1645700	1846500	1092000	1094200	1100800	1175800	1180200	1182400	1184600	1242000
29. P.W. OF COSTS [25 & 28]	($)	3707600	4175800	2417200	2422600	2435300	2611800	2621700	2627200	2631700	2765900
30. BASE VALUE/YR ENERGY GEN'D.	($)	114400	114700	69500	70500	71100	84100	85200	85600	85900	87500
31. ENERGY CMPD. VALUE GRADIENT	(%)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
32. P.W. OF 50 YEARS OF ENERGY	($)	4552800	4564800	2765900	2805700	2829600	3347000	3390800	3406700	3418600	3482300
33. P.W. OF RESIDUAL VALUE	($)	0	0	0	0	0	0	0	0	0	0
34. P.W. OF CREDITS [32 & 33]	($)	4552800	4564800	2765900	2805700	2829600	3347000	3390800	3406700	3418600	3482300
35. P.W. OF NET COST [29 - 34]	($)	¯845200	¯389000	¯348700	¯383100	¯394300	¯735200	¯769100	¯779500	¯786900	¯716400
36. RANKING BY LEAST NET COST P.W.		26	57	60	58	56	40	34	32	30	43

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
OPTIMUM CONFIGURATION PROGRAM (OCP#2)
50 YEAR SERVICE PERIOD PRESENT WORTH ANALYSIS
BASED UPON 50 YEAR EQUIPMENT LIFE AND 8.000 PERCENT DISCOUNT RATE

1. ALTERNATIVE NO.		4.09	4.10	4.11	5.01	5.02	5.03	5.04	5.05	5.06	5.07
2. DESIGN FLOW	(CFS)	300	300	500	100	100	100	100	100	200	200
3. GROSS HEAD	(FEET)	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4
4. PENSTOCK DIAMETER	(INCHES)	84	96	96	48	60	72	84	96	60	72
5. INTAKE AREA	(SQ.FT.)	150	150	250	50	50	50	50	50	100	100
6. NET HEAD	(FEET)	34.4	34.8	33.9	31.1	33.7	34.5	34.9	35.0	29.4	32.6
7. TURBINE TYPE		3	3	3	1	1	1	1	1	1	1
8. RUNNER DIAMETER	(INCHES)	43.1	43.0	55.6	28.6	28.3	28.3	28.3	28.4	41.6	40.4
9. SETTING	(FEET)	¯1.5	¯1.7	¯1.8	10.4	10.0	9.9	9.7	9.9	10.8	11.0
10. SPECIFIC SPEED		154.4	153.7	155.3	99.0	95.8	94.9	94.4	94.3	101.2	97.1
11. UNIT EFFICIENCY @ F.L.	(%)	81.0	81.0	81.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0
12. COMPOSITE EFFICIENCY	(%)	81.7	81.7	82.2	78.3	78.3	78.3	78.3	78.3	80.7	80.7
13. NET POWER	(KW)	713	722	1179	206	223	229	231	232	402	445
14. PENSTOCK LENGTH	(FEET)	50	50	50	400	400	400	400	400	400	400
15. PENSTOCK COST	($)	7100	8300	8300	31400	43700	55100	66500	79600	43700	55100
16. INTAKE COST	($)	287800	287800	308200	388100	388100	388100	388100	388100	408800	408800
17. POWERHOUSE COST	($)	308800	308800	308800	83900	82700	82700	82700	83100	139200	133800
18. SWITCHGEAR COST	($)	362600	362800	376300	312900	313900	314200	314400	314400	322400	324100
19. MACHINE COST	($)	209800	211500	294900	205500	217800	225100	231200	236800	284900	303700
20. ANC. EQUIP. COST	($)	70300	70300	70300	70300	70300	70300	70300	70300	70300	70300
21. MOBIL. & TEMP. SERV. COST	($)	62300	62500	68300	105600	106800	107800	108700	109600	114500	115800
22. ADMIN., LEGAL & TECH. COST	($)	162900	163100	172200	154600	156600	158100	159400	160900	168400	170500
23. INT. DURING CONSTRUCTION	($)	58900	59000	64300	54100	55200	56100	56900	57700	62100	63300
24. TOTAL CAPITAL COST	($)	1530500	1534100	1671600	1406400	1435100	1457500	1478200	1500500	1614300	1645400
25. P.W. OF CAPITAL COSTS	($)	1530500	1534100	1671600	1406400	1435100	1457500	1478200	1500500	1614300	1645400
26. BASE YEAR ANNUAL O & M COST	($)	56500	56600	61300	52300	53300	54000	54700	55500	59300	60400
27. O & M CMPD. COST GRADIENT	(%)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
28. P.W. OF 50 YEAR O & M COST	($)	1246400	1248600	1352300	1153800	1175800	1191300	1206700	1224400	1308200	1332400
29. P.W. OF COSTS [25 & 28]	($)	2776900	2782700	3023900	2560200	2610900	2648800	2684900	2724900	2922500	2977800
30. BASE VALUE/YR ENERGY GEN'D.	($)	88600	89200	90800	60700	65300	66700	67300	67500	76200	80800
31. ENERGY CMPD. VALUE GRADIENT	(%)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
32. P.W. OF 50 YEARS OF ENERGY	($)	3526100	3549900	3613600	2415700	2598800	2654500	2678400	2686300	3032600	3215600
33. P.W. OF RESIDUAL VALUE	($)	0	0	0	0	0	0	0	0	0	0
34. P.W. OF CREDITS [32 & 33]	($)	3526100	3549900	3613600	2415700	2598800	2654500	2678400	2686300	3032600	3215600
35. P.W. OF NET COST [29 - 34]	($)	¯749200	¯767200	¯589700	144500	12100	¯5700	6500	38600	¯110100	¯237800
36. RANKING BY LEAST NET COST P.W.		38	35	50	73	68	65	66	70	64	63

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
OPTIMUM CONFIGURATION PROGRAM (OCP#2)
50 YEAR SERVICE PERIOD PRESENT WORTH ANALYSIS
BASED UPON 50 YEAR EQUIPMENT LIFE AND 8.000 PERCENT DISCOUNT RATE

1. ALTERNATIVE NO.		5.08	5.09	5.10	5.11	5.12	5.13	6.01	6.02	6.03	6.04
2. DESIGN FLOW	(CFS)	200	200	300	300	300	500	100	100	100	100
3. GROSS HEAD	(FEET)	35.4	35.4	35.4	35.4	35.4	35.4	65.4	65.4	65.4	65.4
4. PENSTOCK DIAMETER	(INCHES)	84	96	72	84	96	96	48	60	72	84
5. INTAKE AREA	(SQ.FT.)	100	100	150	150	150	250	50	50	50	50
6. NET HEAD	(FEET)	33.7	34.5	29.5	32.3	33.6	30.7	52.9	60.8	63.3	64.3
7. TURBINE TYPE		1	1	1	1	1	1	1	1	1	1
8. RUNNER DIAMETER	(INCHES)	40.0	40.0	50.1	49.6	49.1	64.0	27.7	27.7	27.4	27.3
9. SETTING	(FEET)	10.3	10.2	11.4	11.3	10.6	11.7	9.2	9.4	8.8	8.9
10. SPECIFIC SPEED		95.8	94.9	101.1	97.5	95.9	99.5	78.4	73.4	71.9	71.4
11. UNIT EFFICIENCY @ F.L.	(%)	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0
12. COMPOSITE EFFICIENCY	(%)	80.7	80.7	75.3	75.3	75.3	74.3	78.3	78.3	78.3	78.3
13. NET POWER	(KW)	460	471	564	617	642	965	351	403	419	426
14. PENSTOCK LENGTH	(FEET)	400	400	400	400	400	400	1750	1750	1750	1750
15. PENSTOCK COST	($)	66500	79600	55100	66500	79600	79600	135400	187600	237500	287400
16. INTAKE COST	($)	408800	408800	426400	426400	426400	457000	388100	388100	388100	388100
17. POWERHOUSE COST	($)	132000	132000	178900	176400	174000	248900	80400	80400	79200	78700
18. SWITCHGEAR COST	($)	324800	325200	328700	330600	331500	341600	202200	204400	205100	205400
19. MACHINE COST	($)	313400	322000	338400	358000	369600	444600	263000	285300	295500	302800
20. ANC. EQUIP. COST	($)	70300	70300	70300	70300	70300	70300	70300	70300	70300	70300
21. MOBIL. & TEMP. SERV. COST	($)	116800	117900	120900	122400	123600	133100	207800	211600	214600	217400
22. ADMIN., LEGAL & TECH. COST	($)	172000	173700	178300	180600	182300	196600	165700	171600	176200	180500
23. INT. DURING CONSTRUCTION	($)	64200	65200	67900	69200	70300	78900	60500	64000	66700	69200
24. TOTAL CAPITAL COST	($)	1668800	1694700	1764900	1800400	1827600	2050600	1573400	1663300	1733200	1800000
25. P.W. OF CAPITAL COSTS	($)	1668800	1694700	1764900	1800400	1827600	2050600	1573400	1663300	1733200	1800000
26. BASE YEAR ANNUAL O & M COST	($)	61200	62100	64500	65700	66600	74200	58000	61000	63400	65700
27. O & M CMPD. COST GRADIENT	(%)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
28. P.W. OF 50 YEAR O & M COST	($)	1350100	1370000	1422900	1449400	1469200	1636900	1279500	1345700	1398600	1449400
29. P.W. OF COSTS [25 & 28]	($)	3018900	3064700	3187800	3249800	3296800	3687500	2852900	3009000	3131800	3249400
30. BASE VALUE/YR ENERGY GEN'D.	($)	82300	83300	76400	80400	82200	79900	92100	99300	101200	101900
31. ENERGY CMPD. VALUE GRADIENT	(%)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
32. P.W. OF 50 YEARS OF ENERGY	($)	3275300	3315100	3040500	3199700	3271400	3179800	3665400	3951900	4027500	4055400
33. P.W. OF RESIDUAL VALUE	($)	0	0	0	0	0	0	0	0	0	0
34. P.W. OF CREDITS [32 & 33]	($)	3275300	3315100	3040500	3199700	3271400	3179800	3665400	3951900	4027500	4055400
35. P.W. OF NET COST [29 - 34]	($)	¯256400	¯250400	147300	50100	25400	507700	¯812500	¯942900	¯895700	¯806000
36. RANKING BY LEAST NET COST P.W.		61	62	74	71	69	75	28	22	23	29

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
OPTIMUM CONFIGURATION PROGRAM (OCP#2)
50 YEAR SERVICE PERIOD PRESENT WORTH ANALYSIS
BASED UPON 50 YEAR EQUIPMENT LIFE AND 8.000 PERCENT DISCOUNT RATE

1. ALTERNATIVE NO.		6.05	6.06	6.07	6.08	6.09	6.10	6.11	6.12	6.13	7.01
2. DESIGN FLOW	(CFS)	100	200	200	200	200	300	300	300	500	100
3. GROSS HEAD	(FEET)	65.4	65.4	65.4	65.4	65.4	65.4	65.4	65.4	65.4	51.4
4. PENSTOCK DIAMETER	(INCHES)	96	60	72	84	96	72	84	96	96	48
5. INTAKE AREA	(SQ.FT.)	50	100	100	100	100	150	150	150	250	50
6. NET HEAD	(FEET)	64.7	48.9	58.0	61.7	63.3	50.0	57.6	61.0	54.1	45.8
7. TURBINE TYPE		1	1	1	1	1	1	1	1	1	1
8. RUNNER DIAMETER	(INCHES)	27.2	39.3	38.8	39.0	38.7	47.9	47.5	47.9	62.1	28.0
9. SETTING	(FEET)	8.9	9.9	9.2	9.2	9.2	9.8	9.3	9.7	10.5	9.7
10. SPECIFIC SPEED		71.2	81.4	75.1	72.8	71.9	80.5	75.3	73.3	77.6	83.9
11. UNIT EFFICIENCY @ F.L.	(%)	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0
12. COMPOSITE EFFICIENCY	(%)	78.3	80.7	80.7	80.7	80.7	75.3	75.3	75.3	74.3	78.3
13. NET POWER	(KW)	429	668	792	843	864	956	1101	1166	1701	303
14. PENSTOCK LENGTH	(FEET)	1750	1750	1750	1750	1750	1750	1750	1750	1750	700
15. PENSTOCK COST	($)	343200	187600	237500	287400	343200	237500	287400	343200	343200	58000
16. INTAKE COST	($)	388100	408800	408800	408800	408800	426400	426400	426400	457000	388100
17. POWERHOUSE COST	($)	78400	128900	126600	127600	126300	168300	166400	168300	239000	81500
18. SWITCHGEAR COST	($)	205500	214300	218400	219900	220600	223300	227400	229200	242700	298800
19. MACHINE COST	($)	308800	361000	396000	412700	422800	432200	466900	484900	577400	245900
20. ANC. EQUIP. COST	($)	70300	70300	70300	70300	70300	70300	70300	70300	70300	70300
21. MOBIL. & TEMP. SERV. COST	($)	220500	219300	223700	227100	230400	228700	233000	236900	247300	121300
22. ADMIN., LEGAL & TECH. COST	($)	185200	183400	190000	195100	200000	197400	203900	209600	224700	159600
23. INT. DURING CONSTRUCTION	($)	72000	70900	74900	78000	80900	79400	83300	86800	96100	56900
24. TOTAL CAPITAL COST	($)	1872000	1844500	1946200	2026900	2103300	2063500	2165000	2255600	2497700	1480400
25. P.W. OF CAPITAL COSTS	($)	1872000	1844500	1946200	2026900	2103300	2063500	2165000	2255600	2497700	1480400
26. BASE YEAR ANNUAL O & M COST	($)	68100	67200	70600	73400	76000	74600	78100	81200	89400	54800
27. O & M CMPD. COST GRADIENT	(%)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
28. P.W. OF 50 YEAR O & M COST	($)	1502300	1482500	1557500	1619200	1676600	1645700	1722900	1791300	1972200	1208900
29. P.W. OF COSTS [25 & 28]	($)	3374300	3327000	3503700	3646100	3779900	3709200	3887900	4046900	4469900	2689300
30. BASE VALUE/YR ENERGY GEN'D.	($)	102200	100300	109300	112600	114000	102300	110100	113400	109400	83400
31. ENERGY CMPD. VALUE GRADIENT	(%)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
32. P.W. OF 50 YEARS OF ENERGY	($)	4067300	3991700	4349900	4481200	4536900	4071300	4381700	4513000	4353900	3319100
33. P.W. OF RESIDUAL VALUE	($)	0	0	0	0	0	0	0	0	0	0
34. P.W. OF CREDITS [32 & 33]	($)	4067300	3991700	4349900	4481200	4536900	4071300	4381700	4513000	4353900	3319100
35. P.W. OF NET COST [29 - 34]	($)	¯693000	¯664700	¯846200	¯835100	¯757000	¯362100	¯493800	¯466100	116000	¯629800
36. RANKING BY LEAST NET COST P.W.		45	47	25	27	36	59	51	54	72	4[illegible]

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
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50 YEAR SERVICE PERIOD PRESENT WORTH ANALYSIS
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1. ALTERNATIVE NO.		7.02	7.03	7.04	7.05	7.06	7.07	7.08	7.09	7.10	7.11
2. DESIGN FLOW	(CFS)	100	100	100	100	200	200	200	200	300	300
3. GROSS HEAD	(FEET)	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4
4. PENSTOCK DIAMETER	(INCHES)	60	72	84	96	60	72	84	96	72	84
5. INTAKE AREA	(SQ.FT.)	50	50	50	50	100	100	100	100	150	150
6. NET HEAD	(FEET)	49.3	50.4	50.8	51.0	43.9	48.0	49.6	50.3	44.2	47.7
7. TURBINE TYPE		1	1	1	1	1	1	1	1	1	1
8. RUNNER DIAMETER	(INCHES)	27.6	27.6	27.5	27.5	39.2	41.0	39.0	39.0	48.1	48.2
9. SETTING	(FEET)	9.7	9.4	9.4	9.3	9.6	9.8	10.0	9.7	10.4	10.1
10. SPECIFIC SPEED		81.1	80.2	79.9	79.8	85.5	82.1	80.8	80.3	85.2	82.3
11. UNIT EFFICIENCY @ F.L.	(%)	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0
12. COMPOSITE EFFICIENCY	(%)	78.3	78.3	78.3	78.3	80.7	80.7	80.7	80.7	75.3	75.3
13. NET POWER	(KW)	327	334	337	338	600	656	677	687	845	912
14. PENSTOCK LENGTH	(FEET)	700	700	700	700	700	700	700	700	700	700
15. PENSTOCK COST	($)	82700	101700	120700	145400	82700	101700	120700	145400	101700	120700
16. INTAKE COST	($)	388100	388100	388100	388100	408800	408800	408800	408800	426400	426400
17. POWERHOUSE COST	($)	80000	80000	79600	79600	128400	136400	127600	127600	169300	169800
18. SWITCHGEAR COST	($)	299800	300200	300300	300400	310700	312600	313400	313700	318700	320800
19. MACHINE COST	($)	259100	266600	272600	278400	343200	362700	373400	381000	408100	428000
20. ANC. EQUIP. COST	($)	70300	70300	70300	70300	70300	70300	70300	70300	70300	70300
21. MOBIL. & TEMP. SERV. COST	($)	123200	124500	125800	127300	131400	133800	134900	136500	138900	141000
22. ADMIN., LEGAL & TECH. COST	($)	162500	164600	166500	168900	175100	178800	180500	182900	186500	189600
23. INT. DURING CONSTRUCTION	($)	58600	59800	61000	62300	66000	68200	69200	70600	72800	74700
24. TOTAL CAPITAL COST	($)	1524300	1555800	1584900	1620700	1716600	1773300	1798800	1836800	1892700	1941300
25. P.W. OF CAPITAL COSTS	($)	1524300	1555800	1584900	1620700	1716600	1773300	1798800	1836800	1892700	1941300
26. BASE YEAR ANNUAL O & M COST	($)	56300	57400	58300	59600	62800	64700	65600	66900	68800	70500
27. O & M CMPD. COST GRADIENT	(%)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
28. P.W. OF 50 YEAR O & M COST	($)	1242000	1266300	1286100	1314800	1385400	1427300	1447200	1475800	1517800	1555300
29. P.W. OF COSTS [25 & 28]	($)	2766300	2822100	2871000	2935500	3102000	3200600	3246000	3312600	3410500	3496600
30. BASE VALUE/YR ENERGY GEN'D.	($)	87900	89200	89700	89900	95000	99400	101100	101800	95800	99700
31. ENERGY CMPD. VALUE GRADIENT	(%)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
32. P.W. OF 50 YEARS OF ENERGY	($)	3498200	3549900	3569800	3577800	3780800	3955900	4023500	4051400	3812600	3967800
33. P.W. OF RESIDUAL VALUE	($)	0	0	0	0	0	0	0	0	0	0
34. P.W. OF CREDITS [32 & 33]	($)	3498200	3549900	3569800	3577800	3780800	3955900	4023500	4051400	3812600	3967800
35. P.W. OF NET COST [29 - 34]	($)	¯731900	¯727800	¯698800	¯642300	¯678800	¯755300	¯777500	¯738800	¯402100	¯471200
36. RANKING BY LEAST NET COST P.W.		41	42	44	48	46	37	33	39	55	52

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1. ALTERNATIVE NO.		7.12	7.13	8.01	8.02	8.03	8.04	8.05	8.06	8.07	8.08
2. DESIGN FLOW	(CFS)	300	500	100	100	100	100	100	200	200	200
3. GROSS HEAD	(FEET)	51.4	51.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4
4. PENSTOCK DIAMETER	(INCHES)	96	96	48	60	72	84	96	60	72	84
5. INTAKE AREA	(SQ.FT.)	150	250	50	50	50	50	50	100	100	100
6. NET HEAD	(FEET)	49.3	46.0	58.3	62.1	63.3	63.8	64.0	56.5	60.9	62.6
7. TURBINE TYPE		1	1	3	3	3	3	3	3	3	3
8. RUNNER DIAMETER	(INCHES)	47.9	61.9	24.8	24.5	24.5	24.7	24.7	35.1	34.8	34.7
9. SETTING	(FEET)	10.2	10.6	¯3.6	¯4.4	¯4.0	¯4.0	¯4.0	¯3.5	¯4.2	¯4.4
10. SPECIFIC SPEED		81.1	83.7	123.7	120.3	119.2	118.8	118.7	125.5	121.3	119.8
11. UNIT EFFICIENCY @ F.L.	(%)	82.0	82.0	81.0	81.0	81.0	81.0	81.0	81.0	81.0	81.0
12. COMPOSITE EFFICIENCY	(%)	75.3	74.3	81.3	81.3	81.3	81.3	81.3	81.7	81.7	81.7
13. NET POWER	(KW)	942	1446	401	427	435	439	440	781	842	866
14. PENSTOCK LENGTH	(FEET)	700	700	900	900	900	900	900	900	900	900
15. PENSTOCK COST	($)	145400	145400	77000	111200	136800	162500	196700	111200	136800	162500
16. INTAKE COST	($)	426400	457000	264400	264400	264400	264400	264400	276700	276700	276700
17. POWERHOUSE COST	($)	168300	238000	162000	162000	162000	162000	162000	162000	162000	162000
18. SWITCHGEAR COST	($)	321700	335300	312600	313700	314100	314200	314300	326200	328100	328900
19. MACHINE COST	($)	439800	535500	134300	141600	143900	144900	145200	223600	235600	240200
20. ANC. EQUIP. COST	($)	70300	70300	70300	70300	70300	70300	70300	70300	70300	70300
21. MOBIL. & TEMP. SERV. COST	($)	142800	153300	51000	53200	54600	55900	57600	58500	60500	62000
22. ADMIN., LEGAL & TECH. COST	($)	192300	207900	145100	148500	150800	152900	155600	157000	160000	162500
23. INT. DURING CONSTRUCTION	($)	76300	85700	48700	50600	51900	53100	54600	55400	57200	58600
24. TOTAL CAPITAL COST	($)	1983300	2228400	1265400	1315500	1348800	1380200	1420700	1440900	1487200	1523700
25. P.W. OF CAPITAL COSTS	($)	1983300	2228400	1265400	1315500	1348800	1380200	1420700	1440900	1487200	1523700
26. BASE YEAR ANNUAL O & M COST	($)	71900	80200	47500	49200	50300	51400	52800	53500	55000	56300
27. O & M CMPD. COST GRADIENT	(%)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
28. P.W. OF 50 YEAR O & M COST	($)	1586100	1769200	1047900	1085400	1109600	1133900	1164800	1180200	1213300	1242000
29. P.W. OF COSTS [25 & 28]	($)	3569400	3997600	2313300	2400900	2458400	2514100	2585500	2621100	2700500	2765700
30. BASE VALUE/YR ENERGY GEN'D.	($)	101500	100200	100000	102900	103800	104200	104400	109800	113800	115200
31. ENERGY CMPD. VALUE GRADIENT	(%)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
32. P.W. OF 50 YEARS OF ENERGY	($)	4039500	3987700	3979800	4095200	4131000	4146900	4154900	4369800	4529000	4584700
33. P.W. OF RESIDUAL VALUE	($)	0	0	0	0	0	0	0	0	0	0
34. P.W. OF CREDITS [32 & 33]	($)	4039500	3987700	3979800	4095200	4131000	4146900	4154900	4369800	4529000	4584700
35. P.W. OF NET COST [29 - 34]	($)	¯470100	9900	¯1666500	¯1694300	¯1672600	¯1632800	¯1569400	¯1748700	¯1828500	¯1819000
36. RANKING BY LEAST NET COST P.W.		53	67	10	8	9	11	12	6	1	2

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1. ALTERNATIVE NO.		8.09	8.10	8.11	8.12	8.13
2. DESIGN FLOW	(CFS)	200	300	300	300	500
3. GROSS HEAD	(FEET)	64.4	64.4	64.4	64.4	64.4
4. PENSTOCK DIAMETER	(INCHES)	96	72	84	96	96
5. INTAKE AREA	(SQ.FT.)	100	150	150	150	250
6. NET HEAD	(FEET)	63.3	57.0	60.7	62.3	59.1
7. TURBINE TYPE		3	3	3	3	3
8. RUNNER DIAMETER	(INCHES)	34.7	43.0	42.7	42.4	55.3
9. SETTING	(FEET)	¯4.3	¯3.8	¯4.0	¯4.3	¯4.1
10. SPECIFIC SPEED		119.2	125.0	121.5	120.1	123.0
11. UNIT EFFICIENCY @ F.L.	(%)	81.0	81.0	81.0	81.0	81.0
12. COMPOSITE EFFICIENCY	(%)	81.7	81.7	81.7	81.7	82.2
13. NET POWER	(KW)	875	1182	1259	1292	2055
14. PENSTOCK LENGTH	(FEET)	900	900	900	900	900
15. PENSTOCK COST	($)	196700	136800	162500	196700	196700
16. INTAKE COST	($)	276700	287800	287800	287800	308200
17. POWERHOUSE COST	($)	162000	162000	162000	162000	162000
18. SWITCHGEAR COST	($)	329200	337900	340000	340900	359100
19. MACHINE COST	($)	242000	295400	307500	312700	415800
20. ANC. EQUIP. COST	($)	70300	70300	70300	70300	70300
21. MOBIL. & TEMP. SERV. COST	($)	63800	64500	66500	68500	75600
22. ADMIN., LEGAL & TECH. COST	($)	165300	166300	169400	172500	183200
23. INT. DURING CONSTRUCTION	($)	60200	60800	62600	64500	70800
24. TOTAL CAPITAL COST	($)	1566200	1581800	1628600	1675900	1841700
25. P.W. OF CAPITAL COSTS	($)	1566200	1581800	1628600	1675900	1841700
26. BASE YEAR ANNUAL O & M COST	($)	57700	58200	59800	61400	67100
27. O & M CMPD. COST GRADIENT	(%)	4.0	4.0	4.0	4.0	4.0
28. P.W. OF 50 YEAR O & M COST	($)	1272900	1283900	1319200	1354500	1480300
29. P.W. OF COSTS [25 & 28]	($)	2839100	2865700	2947800	3030400	3322000
30. BASE VALUE/YR ENERGY GEN'D.	($)	115800	115400	119100	120600	121900
31. ENERGY CMPD. VALUE GRADIENT	(%)	7.0	7.0	7.0	7.0	7.0
32. P.W. OF 50 YEARS OF ENERGY	($)	4608600	4592600	4739900	4799600	4851300
33. P.W. OF RESIDUAL VALUE	($)	0	0	0	0	0
34. P.W. OF CREDITS [32 & 33]	($)	4608600	4592600	4739900	4799600	4851300
35. P.W. OF NET COST [29 - 34]	($)	¯1769500	¯1726900	¯1792100	¯1769200	¯1529300
36. RANKING BY LEAST NET COST P.W.		4	7	3	5	13

ENVIRONMENTAL, SOCIAL, CULTURAL, HISTORICAL AND ARCHAEOLOGICAL ANALYSIS

The Environmental, Social, Cultural, Historical and Archaeological Analysis has explored and defined the potential impacts of construction and operation of a hydroelectric facility at the Watervliet Reservoir. The environmental analysis performed was categorized into four areas of possible concern: reservoir related impacts, stream related impacts, recreational impacts and other (drinking water) impacts. In addition, a cultural and historical preliminary survey has been performed to document any potentially sensitive areas in this regard. Finally, a determination of pertinent and applicable local, county, state and federal statutes and regulations has been made.

Reservoir Related Considerations

The major impact of any proposed hydroelectric project on the reservoir is related to the lowering of the surface water level. The actual water levels will vary depending on the frequency, intensity and timing of the proposed drawdown. The maximum proposed drawdown will be approximately three feet, measured from the top of the dam flashboards to the spillway elevation at two-hundred and fifty-nine feet. Once the water level elevation reaches the two-hundred and fifty nine foot mark, all use of the water for hydroelectric generation will cease. The actual timing of these drawdowns will depend upon the eventual marketing scheme, since it will essentially determine the hours of peak demand and thus the times of generator operation.

The reservoir presently fluctuates as much as five feet [Ref. 96] during a given period of time depending on the amount of runoff occurring throughout the watershed or the severity of drought conditions.

The immediate area surrounding the reservoir is predominantly forest land with some wetland areas along the western shore. A small golf course, a few residences, highways, croplands and pastures penetrate the reservoir's forest perimeter.

Vegetation

The western portion of the reservoir contains most of the aquatic vegetation. Plants typically occurring there include cattails (Typha SP), coontails (Ceratophyllum demersum), water lillies (Nymphaea SP) and water chestnut (Trapa natans) [Ref. 97].

A major infestation of water chestnut presently covers sixty to eighty acres in this area. The appearance of water chestnut in a water body has serious ramifications to fishing and useful food and habitat for wildlife. Gradual drawdowns, similar to those presently occurring will permit only a limited number of annual plants [Ref. 94].

The plant itself has very little value to wildlife and tends to crowd out desireable aquatic plants which provide food and shelter to fish and water fowl [Ref. 67].

Operation of the reservoir for hydroelectric generation will have little or no effect on the water chestnut since the seeds of the plant easily drift to areas containing adequate water conditions and remain viable for twelve or more years. The only realistic means of controlling the plant is to physically remove it each year prior to the production of seed pods or by application of chemical herbicides.

The eastern, southern and western shores are forested with trees of the following species:

American Beech	American Elm
Ash	Birch
Black Cherry	Black Willow
Canadian Hemlock	Grey Dogwood
Locust	Oak
Poplar	Red Maple
Red Pine	Redstem Dogwood
Sugar Maple	White Pine
White Birch	

Wildlife

The effects of reservoir drawdown on wildlife varies especially in relation to the type of wildlife under consideration. It is important to note at this point that there have been no reported sitings of endangered species and no unique habitats identified by the Department of Environmental Conservation [Ref. 100]. The obvious impacts will occur with those species whose livelihood is related to the water's edge.

Fish

In June of 1977, a fisheries survey was completed for the Reservoir. In the course of the survey, eleven species of fish were collected or observed. These are:

1. Large Mouth Bass
2. Pickeril
3. Blue Gill
4. Yellow Perch
5. Black Crappie
6. White Crappie
7. Pumpkin Seed
8. White Sucker
9. Walleye
10. Northern Pike
11. Brown Bullhead

The effect of drawdown on fish will again depend on the timing and frequency of the drawdown. The major impact on fish will occur if the drawdown occurs during the spawning and nesting season. Generally, spawning and nesting take place in calm waters that are two to three feet deep. Fish will abandon nests if the water level in their particular area approaches a foot or less [Ref. 97]. If the nests are abandoned, the eggs are open to preditation. If the spawning beds are exposed to air, the eggs will die. Typically, this drawdown will have a greater effect on resident game fish such as bass. The major impact on fisheries of a daily drawdown occurring throughout the spawning season would be a major change in the makeup of the fish population and a severe reduction in game fish value. The dominant fish species in waters with a constant drawdown situation are carp and suckers. If the drawdown is gradual or the daily drawdown is controlled during the spawning season, the impact on fish would be greatly minimized.

Biomass Decay

Concern has been expressed as to the effect of water fluctuations on aquatic vegetation and resulting die-off and decay. The impact of biomass decay on a water body, in general, is reduced water quality and reduced dissolved oxygen levels. The significance of these factors is relative to the quantity of biomass decaying, the time of the year in which die-off and decay occurs and the original water quality. Normally, exposure of fourteen days or more will eliminate most forms of emergent vegetation. However, reservoirs typically have an abrupt blending of terrestrial and aquatic environments. This condition caused by the constant lowering of the water level results in little or no emergent vegetation along shorelines [101].

The lack of impact from decaying biomass caused by the fluctuation of the water level has been suggested by Douglas Sheppard of the N.Y.S. Department of Environmental Conservation in his experience with reservoirs in the Delaware Basin. On-site inspections revealed that the exposed shoreline in the eastern portion of the reservoir was virtually free of emergent vegetation.

Effects of Decaying Biomass Eutrophication

The Watervliet Reservoir is presently considered eutrophic. This term describes a state resulting from the enrichment of waters by nutrients, usually phosphorus and nitrogen. This enrichment occurs naturally in a watershed when water runoff picks up decaying matter and soil particles and deposits them in a water body. The enrichment can also occur as a result of man's activities such as introduction of septic tank effluent or agricultural related waste. The occurrence of these nutrients causes the excessive production of algae and other vegetation. When the plant material dies, oxygen is consumed during decomposition. If a massive amount of organic material is decaying the dissolved oxygen levels of the water can be significantly reduced. If this reduction is severe enough, it will result in problems associated with water quality and fish habitat. (Most fish require a dissolved oxygen level of between 3-6 mg/ litre of water. Once dissolved oxygen goes below that level, the water is unsuitable for support of fish.)

According to the D.E.C. fisheries survey, approximately 53% of the reservoir bottom is presently unsuitable for fish production because of low oxygen levels. Chronically low levels will eventually result in an undesireable fish population characterized by carp and suckers. The absence of dissolved oxygen will also lead to the development of anaerobic conditions which pose odor, taste, treatment and filtering problems related to drinking water.

The effects of eutrophication, massive plant growth, can be controlled chemically, however, these chemicals do have serious effects on fish populations as well. A second effect is the reduction of recreational value in cases of severe eutrophication. The present eutrophic condition of the Watervliet Reservoir does not preclude its safe use for municipal or recreational purposes.

Distinctions should be made regarding biomass decay, eutrophiction and water level fluctuations. A eutrophic water body will produce a greater quantity of "biomass" than a similar non-eutrophic water body. This occurs independent of any water level fluctuations. The nature of the fluctuations will, however, determine to a certain degree, what types of plants will be able to grow.

Other Effects on Vegetation

The hydroelectric proposal may necessitate some minimal lowering and refilling of the reservoir. This type of drawdown would allow for the establishment of perennial vegetation along exposed shoreline aiding in the reduction of erosion.

The effect of reduced water volume as it relates to crowding of fish populations is not considered serious. Crowding will not adversely affect the fish if it is temporary and if water conditions are not unusual. Again it should be noted that the drawdown for hydroelectric purposes will cease at the present spillway elevation and will not exaggerate the water level changes presently occurring.

Several of the hydroelectric proposals call for modification to the present water intake at the dam. This modification will not cause any localized problems with fish. According to Charles Luckey, operator of the dam, the present intake does not develop enough velocity to draw fish against the protective screen. The only problem encountered to date concerned eels that were able to pass through the protective screen. This is not a common occurrence. The new intake will develop less velocity than its predecessor, thus, there should be no localized problems with fish at the intake.

Waterfowl

There are currently populations of ducks utllizing the Watervliet Reservoir for breeding and brood rearing including mallards, blacks and teal [Ref. 100]. These birds migrate to the reservoir during the spring and fall of the year. Nesting occurs for approximately four to six weeks beginning about May 1.

Lowering the water table daily during the nesting season could impact the breeding population by making the nests, eggs and ducklings more susceptible to preditation by raccoons and other land predators, especially if land links to the nests are exposed. [Ref. 90]. Conceivably, certain vegetative food types for the ducks could be disrupted. Conversely, establishment of permanent emergent vegetation would provide an additional food and habitat resource.

It is questionable whether the hydroelectric option would aggravate present conditions since the water level in the reservoir presently fluctuates.

Other Wildlife

With the exception of a fisheries survey, no wildlife inventory has been conducted in this area. If a specific development proposal is forwarded for this area, the N.Y.S. Department of Environmental Conservation will conduct one.

Certain species of wildlife are known to inhabit this area. Resident wildlife is representative of species occurring in a sociation with the water's edge and with typical local habitats such as muskrat, raccoon, fox, white-tailed deer and a variety of commonly occurring reptiles and amphibians.

Perhaps the most obvious wildlife inhabitant is the muskrat. On-site observation has verified that a number of the animals currently occupy the western portion of the reservoir. The effect of the proposal is related to the fact that muskrat utilize water as a protective barrier against predators. Drastic drawdowns could expose their huts to land predators. It should be noted, however, that the muskrat population has successfully adapted to the fluctuations presently taking place. The effect of drawdown on their main food source, cattails, appears to be minimal as evidenced by a large cattail community in the western portion of the reservoir (Figure 45).

Erosion

The effects of rapid drawdown on reservoir embankment stability is more a function of erosive forces rather than moisture content. According to the Department of Agriculture and Soil Conservation Service, wind and ice action on the toe of embankments presently accounts for most of the shoreline erosion problems.

Tree growth on affected shorelines seems to have little impact on preventing erosion. There seem to be two possible ways of reducing the erosion potential of shorelines. One is to place a gravel blanket on affected areas as per N.Y.S.D.O.T. specification. The other is to establish specialized emergent vegetation to reduce the effect of wave action. These perennial plants would be most successful in an environment where there is a daily fluctuation of the water table rather than constant slow lowering [Ref. 94].

The raising and lowering of the reservoir will also slightly effect water table levels in the immediate area. The conditions forwarded by this proposal are not unlike those presently occurring and will thus have little increased impact.

Siltation Disturbance

An additional reservoir-related concern is the impact of the overall hydro proposal on siltation characteristics. Siltation is occurring at all times and occurs mainly as a result of erosion throughout the watershed. When silt particles reach the reservoir, they are deposited in areas of reduced water velocity and depth. The major siltation deposits occur where the Bozen Kill and the Normans Kill enter the reservoir.

In addition, siltation occurs from the erosion of surrounding banks and shoreline. The major cause of bank erosion in the Watervliet Reservoir is an unstable soil condition aggravated by water and ice action on the toe of steep slopes. Affected areas are illustrated on the surface conditions map.

Generally, increased siltation or disturbance of silt deposits affects a water body in several ways. The turbidity level of the water increases posing immediate concerns in terms of water quality. Many sediments are also nutrients and can thus further promote eutrophicatlon. Siltation affects the useful life span of a reservoir by constant infilling of the lake bottom. In addition, transported sediment may also affect the operation of water-related machinery, although this is not presently a problem at the reservoir.

The effect of the proposed hydroelectric facility on siltation wlll not be significantly different from present levels since the limits of water fluctuation will remain essentially the same. The added frequency of drawdown will not increase erosion levels. As previously stated, bank erosion is aggravated by wave and ice action at the toe of steep slopes. Erosion would be more severe if the water level were raised above present levels. Daily drawdown of the water level coupled with a bank stabilization program will actually reduce local erosion potential.

An additional reservoir-related impact will occur due to modifications to the dam. The hydroelectric project will necessitate construction of a large superstructure on the reservoir side of the dam. This superstructure might possibly be constructed on land prior to coupling with the dam. A construction site near the dam will have to be established and an assessment performed analyzing specific impacts.

The types of impacts expected relate to the clearing and grading of the site, erosion from exposed soil, impact from construction machinery and disturbance of the shoreline in the immediate construction area.

These impacts will be temporary and should constitute no irreversible environmental impact. To the extent possible, these effects should be mitigated by responsible construction techniques.

Stream Related Considerations

General

The impact area under consideration is directly downstream from the dam and consists of the Normans Kill Creek bed and immediate environs, including a two-hundred and fifty foot strip on the northerly creek bank from the dam to the existing powerhouse facility. The creek bed itself is exposed shale. The water flow over this bed is variable. For most of the year, it receives a steady flow of water from the reservoir. For temporary periods, however, usually in the summer, there is virtually no flow between the dam and the powerhouse. This condition lasts for periods of up to three months, although the average dry period is shorter [Ref. 96]. This occurrence of a no-flow condition severely limits the aquatic environment in this portion of the creek.

The surrounding land is mostly forested although there is some farmland abuting the immediate impact area. Just downstream from the existing powerhouse facility is a wetland (as indicated on the vegetation map) that has been identified by N.Y.S.D.E.C. as significant and will be a consideration in assessing the possible impacts of the project.

Slopes in the area vary although the existing powerhouse rests on relatively flat land. The area adjacent to the creek near the dam is quite steep with slopes ranging from eight to fifteen percent or more. It should be noted that a bedrock outcropping occurs on the north stream bank within the project area [Ref. 103]. Soils are generally favorable to development activities. In addition, there are two roads in the area, French's Mill Road and Fuller Station Road. ConRail maintains two railroad trestles across the Normans Kill in the immediate project area.

The hydroelectric proposal considers eight development options for the eventual generation of power. These options will impact the immediate environment in several different ways depending mostly upon their physical location.

The basic areas of impact consideration are the two-hundred and fifty foot strip previously decscribed, eight-hundred foot strip of the stream bed and the area of the existing powerhouse facility.

Vegetation

Terrestrial vegetation in the form of indigenous trees and understory will be removed during the construction process if the options one, two, six and seven are followed. The removal is necessary in order to provide access to construction machinery and to allow placement of the Penstock.

Erosion and Sedimentation

For all options involving installation of the new Penstock, excavation will take place either for burial of the pipe or construction of footings. Where this excavation takes place on the stream banks (Options 2,5,6,7), there is a high potential for soil erosion which is further compounded by the nature of the slopes. Excavation in the stream bed will have a significantly lower potential for erosion since the slope is much less and the component material is bedrock. Sediment and rubble, however, could be introduced into downstream and wetland environments.

The soils in the upper excavation areas and in the existing powerhouse vicinity are not highly erosive by nature. As all options approach the existing powerhouse, the slopes reduce significantly as does the resulting erosion potential.

In conjunction with the various penstock options, several powerhouse generating and switching facility options are under consideration. The potential environmental impacts are essentially the same.

With the exception of Option 8, construction and facility operations will impact the historic resources of the area. The extent of possible disruption can be determined when the historic assessment is completed.

None of the construction options present irreversible, detrimental environmental impacts. Mitigating measures are expected to be undertaken to prevent undue environmental stress during construction and operation of the facility. Areas disturbed by excavation activities will be stabilized by backfilling and replanting to prevent any long-term erosion potential.

Construction activities for this portion of the project will take place during the no-flow period of the stream. Excavation material will have to be removed from the site and deposited in an approved spoil site, thus being prevented from entering downstream aquatic and wetland environments.

In the event that the stream does not dry up due to an especially wet year, special measures will have to be taken to divert water around construction activities.

The option with the least overall impact on the environment is option no. 8 which involves the burial of the Penstock and generating facilities in the stream bed. Erosion and sedimentatlon potential are diminished as is any potential visual impact since the stream bed will be rehabilitated to its preconstruction condition.

Wildlife

Wildlife resources in the immediate construction areas are not expected to be severely impacted. The land area in question is not considered a significant wildlife habitat. The aquatic environment is presently severely limited as to the variety and quantity of fish and plant life due to the fact that the stream bed is in a no-flow, no-water condition for portions of the year. The most probable, potential impacts to wildlife will occur downstream from the project where water flows are more consistent.

The fish population in the viable portions of the Normans Kill was surveyed in June and September of 1972 by N.Y.S.D.E.C. At that time, the following species were found:

Striped Bass	Cutlips Minnow
American Shad	Blacknose Dace
White Perch	Common Shiner
Pumpkinseed	Johnny Darter
American Eel	Largemouth Bass
White Sucker	Brown Bullhead
Carp	Rock Bass
Goldfish	Creek Chub
Spottail Shiner	Bluegill
Golden Shiner	Northern Hog Sucker
Smallmouth Bass	Longnose Dace
Redbreast Sunfish	Banded Killifish
Fallfish	Redfin Pickerel

Facility Operation

Operation of the facility itself will slightly reduce the average stream release during normal periods and slightly lengthen the time of no-flow condition between the dam and powerhouse. These factors are not expected to be of such a magnitude that they will further aggravate the impacts presently occurring.

Each of the options will release reservoir water into the Normans Kill at a powerhouse site. This release will have several downstream benefits. The most significant is the re-oxygenization of the water entering the stream.

Powerhouse locations (Options 2, 7 and 8) are just upstream from the Town of Guilderland sewer treatment outfall. The re-oxygenated releases at this point will aid in improving the ability of the stream to process this material. The rehabilitation option will release below the sewer outfall and will have a somewhat lesser although positive impact on water quality.

Recreational

Recreational Impact

The City of Watervliet and the New York State Department of Environmental Conservation have entered into a cooperative agreement that will allow public access and fishing, via a permit process, to portions of the Watervliet Reservoir. The fishing activities will necessitate the construction of several parking lots and access trails to designated fishing spots (Figure 46).

The drawdown of water, if conducted in a manner that responds to the spawning cycle of game fish, will not have a significant impact on fish or fish production within the reservoir. As mentioned earlier, temporary crowding of fish does not constitute a major detriment to aquatic life. Drawdown could affect access to the water in areas of gradual shoreline drop-off

The most significant impact on fish populations is the low dissolved oxygen content in the water. The eutrophic condition of the water does not permit the stocking of salmonoides (trout), however, a significant number of bass and pan fish will continue to make the reservoir a popular fishing spot.

As part of the recreation agreement, ice-fishing will be allowed. Drawdown of the reservoir as prescribed by hydroelectric operations will not affect overall ice safety. Once an ice layer forms on the lake, it wlll naturally bend to meet lower water levels without becoming unsafe. The only effect on the ice would be at the edge where a certain amount of cracking could occur.

The hydroelectric proposal, as previously discussed, will release water back into the Normans Kill at the powerhouse site. This water will be re-oxygenated, to a certain extent, at its point of release. This water will have a beneficial impact in the immediate area of release by increasing the water's ability to support aquatic life and to process waste materials.

Other Impacts

There are no other impacts on recreation as a result of the hydroelectric generating facility. A combination of factors, however, do place constraints on certain uses. The fact that the reservoir is a drinking water supply coupled with the relatively small amount of land held by the city around the reservoir would limit the types of activities that could otherwise take place. In addition, there has been a lack of cooperation between some of the surrounding landholders and the Department of Environmental Conservation concerning easements for recreational purposes.

Drinking Water Related

The Watervliet Reservoir is presently considered a eutrophic water body. As such, it is subject to algal bloom, low dissolved oxygen levels and resulting anaerobic growth which all affect water quality to a certain degree. Generally speaking, eutrophication does not make water unuseable for municipal purposes; it only necessitates the use of special filters and chemical treatment. The vegetation in the reservoir can and has been treated with copper sulfate to reduce the impacts of eutrophication. The chemical is not known to have an effect on humans, however, it does collect in sediment layers and effects phytoplankton and algae. These factors impact fish populations by reducing food sources. In some cases, eutrophic water has taste and odor problems, however, this is not yet a problem at the Watervliet Reservoir.

Concern has been expressed regarding suspended solids and turbidity and the effect the proposal will have on increasing these levels. These factors do have an effect on water quality. The immediate concern to the Watervliet Reservoir is somewhat questionable, however, presently the western end of the reservoir with its wetlands and shallows is acting as a natural filter for the water supply. Water quality samples from representative portions of the Reservoir illustrate that the municipal intake is at the eastern end. For this reason and the fact that the hydro proposal will not significantly alter turbidity and suspended solid levels, these factors are not expected to adversely affect the water supply.

Cultural and Historical

Prehistoric Cultural Resources

Archeological evidence indicates that Albany County was an area of considerable prehistoric activity, but not one of extensive prehistoric settlement [Ref. 25]. Native American populations transected the region with trails running between the excellent riverine resources of the Hudson and Mohawk. Trails have been found along the banks and high bluffs of these major rivers, as well as along their tributaries [Ref. 93]. Numerous sites have been recorded along the Normanskill in close proximity to the project area [Ref. 25]. The Nott site [Ref. 76] and the Lizzie I and II sites have recently been reported along the Hunger Kill near Route 20 in Guilderland [Ref. 65]. These three sites date to the Archaic Period and diagnositic artifacts indicate sporadic occupation from 3500 - 2500 B.C. These camp/workshops were probably used during the spring-summer phase of the seasonal cycle, when substantial numbers of people would gather at low-lying streams and creeks to exploit fish and aquatic food resources. With the advent of cold weather, freezing of streams and southward migration of birds, these groups were forced to split into smaller nuclear units and move inland to back-country camps, where they exploited deer and other browsing animals. Route 20 follows a former Indian trail, and sites have been reported along its path at Dunnsville, Fullers Station and McKnowville [Ref. 25]. Evidence of Indian settlement from all three phases of prehistoric occupation (Paleo-Indian 10,500-8,000 B.C.; Archaic 8,00001,000 B.C.; and Woodland 1000-1500 A.D.) are found ln the Pine Bush region [Ref. 26]. During the early historic period, Albany County was inhabited mainly by the Manikan Indians, with the Schaghticoke occupying scattered, small settlements [Ref. 25]. In 1730, about the time of Europena settlement, several Indian villages and "work places" existed in the Guilderland area [Ref. 66].

Within the proposed project area a campsite is recorded at French's Mills, near the falls [Ref. 25]. T. Cassavant records "the largest and most productive of Indian sites around Albany" is the Vosburg Farm site which is situated on the north bank of the Normans Kill, about one-half mile from French's Mills. The site lies on a flat hill that slopes down to the creek and has produced pestles, gouges, chisels, celts, bannerstones, steatite pottery, semilunar choppers, sinewstone knives, drills, spears and projectiles. Many scattered artifacts have been found directly opposite the Vosburg site, extending along the south side of the creek and on the flats near the mills. "Camp sites seem to be abundant in this vincinity" [Ref. 25].

This report is confirmed by the residents of the area who report finding artifacts when farming and gardening in the area surrounding the reservoir. This conforms to the model of prehistoric settlement patterns that predicts a higher density of site locations along the Hudson floodplain and inland streams [Ref. 69:6].

Historical and Cultural Resources

Permanent settlement of the Albany area began in 1629 when the Dutch West India Company initiated a policy of rapid settlement of New Netherlands in order to increase the power and wealth of the Company. Kilian Van Rensselaer, a pearl and diamond merchant in Amsterdam and a director of the Dutch West India Company, took advantage of the Company's policy. In 1630 he purchased his first tract of land from the Indians, and within seven years, his "manor" extended for twenty-four miles on each side of the Hudson River, embracing what is now Albany, Rensselaer and part of Columbia Counties. It was the duty of the Patroon to encourage settlement of his land and in the years following 1630, colonies from Holland came to the region and were provided with homes and land leases in Fort Orange (now Albany) and the surrounding area. Albany County, one of the original ten counties of New York State was formed in 1683. Modifications of the County's boundaries continued throughout the 18th and 19th centuries, until its present limits were firmly established in 1809. The Town of Watervliet, formed on March 3, 1788, originally encompassed the Town of Guilderland. When the two towns were separated in 1803, Guilderland included Knowersville (now Altamont), Guilderland Center, French's Hollow and Hamiltonville (now Guilderland). The town was well settled prior to the Revolution. A 1767 map of the Manor of Rensselaerwyck (Figure 49) indicates there were 148 families living west of the Hudson River. A battle of the Revolution, the Battle of the Normans Kill was fought in the town during August 1777:

> "On the 13th of August (1777) the same day on which Col. Harper so opportunely led troops to Schoharie, Lt. Col. Schermerhorn proceeded to the Normanskill with a body of Schenectada militia, and forty Rhode Island troops, - in all about 100 men - to root up a Tory gathering at that place. The expedition was very successful. David Springer, a noted Royalist was killed. Thirteen of his comrades captured, the remainder dispersed and confidence again restored, where all was doubt and disaffection, without the loss of a single man on the part of the Americans." [Ref. 12]

The town continued to expand both socially and economically after the Revolution. One of the early industries of Albany County, a glass factory, was established in Hamiltonville (now Guilderland) in 1792. The company manufactured window glass and by 1813 according to Spaffords Gazetteer, 500,000 feet of window glass were produced annually [Ref. 25]. The procedure for making glass required large quantities of wood. Much of the land in the vicinity of the factory had been cleared and the cost of transporting wood from increasing distances eventually made the glass business unprofitable and it closed in 1815. In addition to the glass factory, the other early industries in the town were the cloth factories at Sloans (now Guilderland), Knowersville(now Altamont) and French's Mills and several flour and grist mills [Ref. 25]. There were few saw mills due to the scarcity of lumber [Ref. 16]. Most of the people were engaged in farming.

As additional roads were laid out and improved, postal routes and stage lines were established and numerous taverns were opened along the roadside. One such tavern was established at French's Mills in 1800 by Jacob Aker. The railroads, especially the Athens-Schenectady (West Shore) line, gave impetus to the economic growth of the community. By 1896, the Town of Guilderland had a cider and vinegar factory, a sash and door factory, a general store, a bootery and shoe factory and two hotels [Ref. 25].

Within the project area, the 1767 Bleecker Map (Figure 49), depicts the homestead of Col. Abraham Wemple. The Wemple house was built in 1760 by Vrooman, who used the clay deposits near the barn to make the bricks for the house. Over the course of the next two and one-half centuries the house was owned by the Wemples, Sigsbees, Myers and Woodrichs. It was destroyed when the Reservoir was flooded in 1915 [Ref. 12]. In 1795, Peter B. Broeck established "clothing works" at French's Mills. Abel French established another clothing factory there in 1800 [Ref. 16]. A grist mill was also located on the creek at French's Mills [Ref. 66, 92]; Gregg, personal communication, 1978). By the 1880's, the mill properties had passed from their original owners to the Reynolds and from the Reynolds E. Spawn & Co. Spawn was the proprietor of the flour and feed mills and grown to a population of 450 [Ref. 16]. By 1896, the mills were no longer operating, although the buildings associated with its operation remained standing [Ref. 25].

The house (Figures 53, 54, 55), located on the northeast side of the bridge was formerly owned by the E. Spawn family. The house was probably built about 1820. It has a double stone foudation and the original wide planked wood floors. The oldest wing of the house is centered around the kitchen, whose interior doors contain the original hand-wrought iron latches. The main entrance has etched sidelight and transom windows. The house is currently owned by Mr. and Mrs. Pospisil.

Prior to the flooding of the Reservior "when the Normanskill and Bozenkill moved sluggishly to their confluence . . . the meadows that bordered the banks of the stream were held to be the richest farm lands in the Town of Guilderland." [Ref. 12]. The Reservoir was flooded in 1915. The covered bridge across the creek was replaced by an iron structure in the early 1930's [Ref. 98] (Figure 52).

Analysis and Recommendations

The literature search, research and interviews indicate there is a high potential for finding evidence of both prehistoric and historic activity directly within the proposed project area. The extremely sensitive nature of the area surrounding the reservoir mandates that further archeological investigation and field reconnaissance be undertaken. Snow cover made it impossible to conduct a general walkover of the area. This will have to be done in order to resolve conflicting reports [Ref. 92] as to the existence of foundations associated with the early mills on the creek. Subsurface testing must also be done to determine if the proposed construction or its associated activity (this would include grading, movement and/or storage of heavy equipment, construction of temporary access roads or field headquarters, etc.) will disturb any buried prehistoric or historic site. If testing will have to be done to delineate its boundaries. If the site cannot be avoided by the proposed construction activity, then a survey must be done in order to obtain and adequate sample from the site and precautions must be taken (i.e. fences erected) so that minimal damage is inflicted upon the site.

Pertinent Statutes and Regulations

National Environmental Policy Act of 1969 (N.E.P.A.)

The act was established to underline the federal government's responsibility to reduce adverse environmental impacts and to assure, where possible, the long term enhancement of the environment resulting from federal programs and projects. The act requires that proponent federal agencies assess projects and policies in terms of their environmental impact, adverse impacts (if any), alternatives to the proposed actions, long-term social effects and any irreversible impacts that might occur as a result of the proposal [Section 102 (2) (C)].

The Basic procedure requires that the environmental assessment be submitted to the Environmental Protection Agency by the recipient of the federal funds. This assessment will be utilized to determine if an environmental impact statement need be prepared and to prepare one if required [Section 104 (b) (c)]. The act prohibits any final administrative action on the proposal until the environmental review and determination is complete [Section 108 (A)].

Environmental Conservation Law 8-0101 ART 7 - (S.E.Q.R.)

The purpose of S.E.Q.R. [Section 617.1 (C)] is to promote efforts which will prevent or eliminate damage to the environment from various programs, projects and actions undertaken by a state or local agency and which balance ecological factors with social and economic factors [Section 617.1 (D)].

In the broadest sense, the act allows for environmental review, by the appropriate state or local agency of any public project undertaken or funded by that agency or any private project requiring a permit from a state or local agency [Section 617].

The initial action by the reviewing agency under S.E.Q.R. is to determine the significance of a proposed action. If it is determined that the project will have little or no impact, it is considered a Type II action and no further review is required. If, however, the lead agency determines that the proposed action will have a significant impact, an environmental impact statement will be required [Section 617.4 (A-J)].

The lead agency may, in light of its review, approve or reject funding of the proposed project or approve or reject granting of the various permits needed to initiate the project [Section 617.5].

When the proposed project involves a federal agency and a draft and final environmental impact statement is prepared under the National Environmental Policy Review Act of 1969, that agency will have no obligation to prepare an additional EIS for the state. However, the project will still be subject to compliance with S.E.Q.R. and final federal actions are not controlling on any state or local agency under this act [Section 617.16].

Freshwater Wetlands Act - N.Y.E.C.L. Sections 24,0101 New York State Regulatlon - 6 NYCRR 662 - Wetlands Filling

New York State, recognizing the value of freshwater wetlands has made it a state policy to preserve, protect and conserve freshwater wetlands, to prevent despoilation and destruction and to regulate the use and development of these wetlands. As part of this act, the state has, or is in the process of defining and mapping significant wetlands within the state. In general, a freshwater wetland is considered significant if it has an area of at least 12-4/10 acres, or if less than 12-4/10 acres, is of unusual local importance as determined by the Commissioner of Environmental Conservation.

Any person desiring to conduct, on freshwater wetlands, as designated, any form of drainage, dredging, excavation, dumping, filling, construction of structures in or any activity which substantially impairs the functioning of a particular wetland will require a permit from the appropriate local governing body or the commissioner.

Certain activities related to agriculture and public health activities are excluded from regulated activities.

The New York State rules and regulations are promulgated under Freshwater Wetlands Act concerning interim wetlands permits. These regulations are presently being updated to comply with S.E.Q.R. The new rules and regulations are expected by May, 1979.

New York State Environmental Conservation Law
Article 15 Water Resources - New York State Regulations 6 NYCRR 608 - Use and Protection of Waters

New York State Environmental Conservation Law, Article 15 gives statutory authority for the part 608 regulations. Section 608.1 of the regulations states that no person or public corporation, other than a state department or a state public corporation shall change, modify or disturb the course or bed of any stream classified as AA, AA(G), A, A(T), B, B(T), or C(T) without having applied for and obtained a written permit from the Department of Environmental Conservation. No permit will be required for local public corporations if the corporation has entered into a written memorandum of understanding with the Department of Environmental Conservation outlining the procedures to be followed in completing the activities affecting the system.

In addition to stream bed and bank modifications, a permit is required for any construction, reconstruction or repair of any dam unless a permit has been obtained. All applications concerning dams are forwarded by the local permit agent to the central permit agent to the Albany office. Generally, the application for permit concerning a dam will also be forwarded to the State Department of Transportation. These regulations will be revised by February, 1979 to comply with S.E.Q.R. requirements.

Fish and Wildlife Coordination Act 661-666

Section 661 recognizes the vital contribution of wildlife resources to the nation in light of public interest and significance due to expansion of national economy. This section provides means in which wildlife conservation shall receive equal consideration and be coordinated with other features of water resources development projects. Authority to administer this act is given to the Secretary of the Interior. The Secretary is authorized to (1) provide assistance to and cooperate with federal, state and public or private agencies in development and protection of wildlife resources and their habitat, (2) to make wildlife surveys and investigations of the public domain, and (3) to accept donations of land and/or funds to carry out the purpose of this act [Section 661]. Whenever the waters of any stream or other body of water are proposed or authorized to be impounded, developed, the channel deepened or the stream or other body of water otherwise controlled or modified by a federal agency or by any agency under federal permit or license that agency will consult with the U.S Fish and Wildlife Service, Department of Interior and with the head of the state agency with administration over wildlife. This consultation will discuss the impacts of the project development on wildlife. The reports and recommendations generated by this consultation shall be responsible for authorizing or licensing the project [Section 662].

Any project covered by this act will make adequate provision, consistent with the primary purpose of the project for the use of these waters and adjust lands for conservation, maintenance and management of wildlife resources and habitat [Section 663].

The act also covers the administration of lands made available to the Department of Interior for wildlife conservation purposes and provides for cooperation between the Secretary and the state department responsible [Section 664].

Endangered Species Act of 1973 - 16 USCA SS 1531-1543

Provides for the protection of threatened or endangered species as identified in the rules promulgated under the act and gives the Secretary of the Interior authority to issue prohibitions deemed necessary under Section 9 (A) (1) of the act relating to any endangered species.

New York State Agricultural and Districting Act (New York Agriculture and Markets Law, Article 25AA)

The intent of the agricultural districting legislation is to encourage the continuance of a strong agricultural industry by allowing protection from a portion of the expanding costs of public facilities and services and to provide adequate hinderances to residential, industrial and commercial development within established agricultural districts. Through county legislation, farmers may form agricultural districts which give them special considerations under New York State Department of Environmental Conservation law.

In short, local ordinances cannot restrict structures and activities normal to farming; public agencies cannot take farmland in an established district without special justification; special public service districts for sewer, water, lights or non-farm drainage may not impose special ad valorem levies on land used for agricultural production beyond a house and lot within an agricultural district; property tax assessment may be made an agricultural instead of market value.

There are no agricultural districts within the project area.

Open Space Land Act - 42 USCA Sections 1500 - 15,000

Provided for a federal program to curb urban blight to encourage more economic and desirable urban development, to assist in preserving areas of historic, recreation and conservation value by making grants for land purchase.

Authority to make grants was terminated after January 1, 1975

Migratory Bird Act - 16 USCA Sections 715-7155

This act established a federal commission, headed by the chairman of the Interior Department to consider and pass upon any area of land recommended for purchase, rental or as a gift for migratory bird refuge.

It also gives the Department of Interior authority to control activities in designated national wlldlife refuges.

Local Zoning - Local Law No. 1 of 1971 - Town of Guilderland

The Town of Guilderland has a zoning ordinance in effect, promulgated under its authority to protect the health and welfare of its citizens.

The zoning designations in areas adjacent to the reservoir are agricultural, industrial and light commercial.

Under normal circumstances, the zoning board reviews projects as to conformance with zoning regulations and either grants or denies permits for conflicting uses.

Hudson River Valley Commission - New York Executive Law 721

The law provides for review of any project occurring within one mile of the Hudson River or two miles if visible from the River. The purpose of the law was to protect the scenic, recreational and natural resources of the Hudson River Valley.

The Agency has advisory power only and cannot veto a particular project. The commission does, however, have injunctive power in order to force submission of projects for review.

The Commission has not fully funded recently and has not reviewed any projects since 1976. In addition, all of the Commissioner's terms have expired.

Freshwater Wetlands Act - N.Y. E.C.L. and N.Y.S. Regulations 6 NYCRR 672

The regulations are promulgated under the wetlands act and refer to any wetlands affected by the project. Significant wetlands do occur in the immediate project area and adjacent to it. A wetlands permit will likely be required since there will be a possible impact on these wetlands.

Fish and Wildlife Coordination Act

If N.E.P.A. review regulations are in effect, the project will be reviewed by various federal agencies. This act insures that the project be reviewed by the Secretary of the Interior and his comments noted concerning fish and wildlife impacts in any final determination.

The act would also apply if any federal permits, such as an Army Corps of Engineers permit, were required.

Local Zoning Law

The local zoning board, in actions involving the state or federal government cannot actually deny construction of the project. However, the impact of the project in light of local zoninq regulations will be noted under S.E.Q.R. review by the Guilderland Zoning Board.

Statute Applicabllity

The previous description of laws and acts was comprehensive in nature, forwarding a basic description of potentially applicable laws but not determining whether the given law actually affected the reservoir project. The laws basically define the roles of the federal, state and local governments in environmental and land-use decision making. The various laws are forwarded to insure that projects conform to the public interest. The following laws and acts apply specifically to the proposed project.

The National Environmental Policy Act of 1969 and the New York State Environmental Quality Review Act

These are federal and state laws with similar goals, the applicability of which depends on the funding agency involved. If it is determined that the project is a federal project, the applicant wlll go through the N.E.P.A. assessment process and will most likely necessitate the filing of an environmental impact statement with the sponsoring federal agency. If an impact statement is required under N.E.P.A., it will satisfy similar requirements under S.E.Q.R. The review of the project, however, will go through federal, state and local channels, especially since various state permits will be required.

If it is determined that the project is state funded, it must conform to S.E.Q.R. regulations. The S.E.Q.R. process must be instituted and a determination made as to the type of impact resulting from the project prior to the issuing of any other state or local permits.

The sources contacted by the consultant at the New York State Department of Environmental Conservation and the New York State Energy Research and Development Authority indicated that the project will most likely fall under S.E.Q.R. review. In any case, the project will necessarily be subjected to an environmental impact review.

New York State Regulations 6 NYCRR 608 are the regulations promulgated under Article 15 of the Environmental Conservation Law. The project will be subject to stream protection permits and review by the Department of Environmental Conservation.

General Assessment - Historic Preservation Laws

Historic Sites, Buildings and Antiquities Act 16 USCA SS461-467

Section 461 of the Historic Sites, Buildings and Antiquities Act establishes as a national policy the preservation and protection of significant historic sites, buildings and objects for the benefit of the American public. The power to administer this national policy is given to the Secretary of the Interior ("Secretary") through the National Park Service. The Secretary's responsibilities, enumerated in Section 462, include conducting surveys to identify historic and archeological sites, acquiring title to such sites, insuring the preservation of such sites, establishing museums, erecting site markers and providing pertinent site data to the public. The Secretary also has the power to appoint an eleven member advisory board [Section 463] and to use congressionally appropriated money to pay for required technical and professional services [Section 464]. Congress is given the authority to allocate the funds necessary to carry out the stated policy [Section 466]. The laws enumerated in this title take priority over any other laws relating to similar subject matter [Section 467].

National Historic Preservation Act of 1966 16 USCA SS470 et. seq.

The primary thrust of the National Historic Preservation Act of 1966 is the expansion and encouragement of historic preservation programs and activities by the Federal government. The Secretary of the Interior ("Secretary") is authorized to maintain and enlarge a national register of districts, sites, buildings, structures and objects significant in American history and prehistory. The Secretary is further authorized to establish a matching grant-in-aid to States for projects that preserve historic sites and to establish a matching grant-in-aid to the National Trust for Historic Preservation in the United States .[Section 470a]. Grant applications must be submitted to the Secretary in accordance with both his prescribed rules and with the established state-wide historic preservation plan. The grantee is responsible for procuring from 30%-50% of project funds from sources outside of the Federal government and for assuming upon completion of the grant, maintenance and preservation costs [Section 470b]. The Department of Housing and Urban Development is authorized to make grants to aid in the restoration and preservation of buildings of architectural and historic significance [Section 470b-1]. The Secretary has the power to apportion funds for state-wide surveys in accordance with priorities established by him [Section 470c]. Federal assistance is available from only one Federal agency per project [Section 470d].

Prior to the approval of funds or the granting of a license for any Federal or Federally assisted project, the effect such project may have on a site that is on, or is eligible for the National Register of Historic Places must be considered and submitted to the Historic Preservation Advisory Council for comment [Section 470f]. This Advisory Council is an in dependent agency of the United States whose purpose it is to render advice and make recommendations relative to the national policy for historic preservation [Section 470i].

Archeological Conservation Act of 1974 - 16 USCA S469

Sections 469-469c provide for the preservation and protection of archeological and historic sites that may be destroyed or irreparably damaged by flooding, road construction, erection of workman's communities, relocation of railroads, highways and other alterations to the land caused by the construction of dams, or any Federal or federally licensed activity or program.

Pursuant to Section 469a, the Secretary of the Interior ("Secretary") must be given written notice before a license can be issued for dam construction. This notice must indicate both the location of the proposed dam and the approximate area to be flooded or altered by the planned construction. However, if (1) a floodwater retarding dam is to be built which provides less than 5,000 acre-feet of detention capacity or (2) any type of dam creates a reservoir of less than 40 acres, then the provisions of this section apply only if the construction company finds during preliminary surveys that historic or archeological sites exist or may be present in the proposed reservoir area.

Section 469a-1 provides that if a Federal agency finds or is notified in writing that a federal construction project or a federally licensed project, activity or program may cause irreparable loss or destruction to a significant historic or archeological site, the agency must so notify the Secretary in writing. After providing the Secretary with information concerning the nature of the project, the agency may request the Secretary undertake the recovery, protection and preservation of data from the site, or the agency may undertake the activity itself. Copies of any reports prepared pursuant to this section should be forwarded to the Secretary.

When a Federal agency provides financial assistance to a private or public concern, the Secretary may conduct a survey of the affected area and recover data with funds appropriated expressly for this purpose. The Secretary may provide compensation for damages that result in delays in construction or in temporary loss of use of nonfederally owned lands.

If upon notification, the Secretary determines that significant historic or archeological data is being destroyed or irrevocably lost by any federal or federally licensed project, he may conduct or cause to be conducted a project to recover and preserve such data. No survey or recovery work can be required if it will interfere with projects undertaken in recognition or anticipation of an emergency or national disaster. The Secretary must initiate the recovery program within sixty days after being notified of the situation pursuant to Section 469a or within a mutually agreed upon time between himself and the funding or licensing agency. The Secretary may provide appropriate compensation for any damages resulting from construction delays or loss of use of nonfederally owned land.

The Secretary must issue progress reports on survey activities to the agency responsible for funding or licensing the project [Section 4691-3]. He is also responsible for determining the proper repository for specimens found during the course of such survey activities, and must issue annual reports detailing agency activities of the past year.

Section 469c provides that a federal agency responsible for a construction project may provide the Secretary with funds equally not more than one percent of the total amount appropriated for such project. However, the one percent limitation does not apply for projects involving $50,000 or less. The costs of the survey, analysis and publication are considered nonreimbursable project costs.

Sections 469d-i pertain to the protection, preservation and interpretation of the nationally significant values of the Wisconsin Continental glaciation, and especially the evidence of such glaciation in the State of Wisconsin.

State Nature and Historical Preserve Act - NYECL S 45-0101 et. seq.

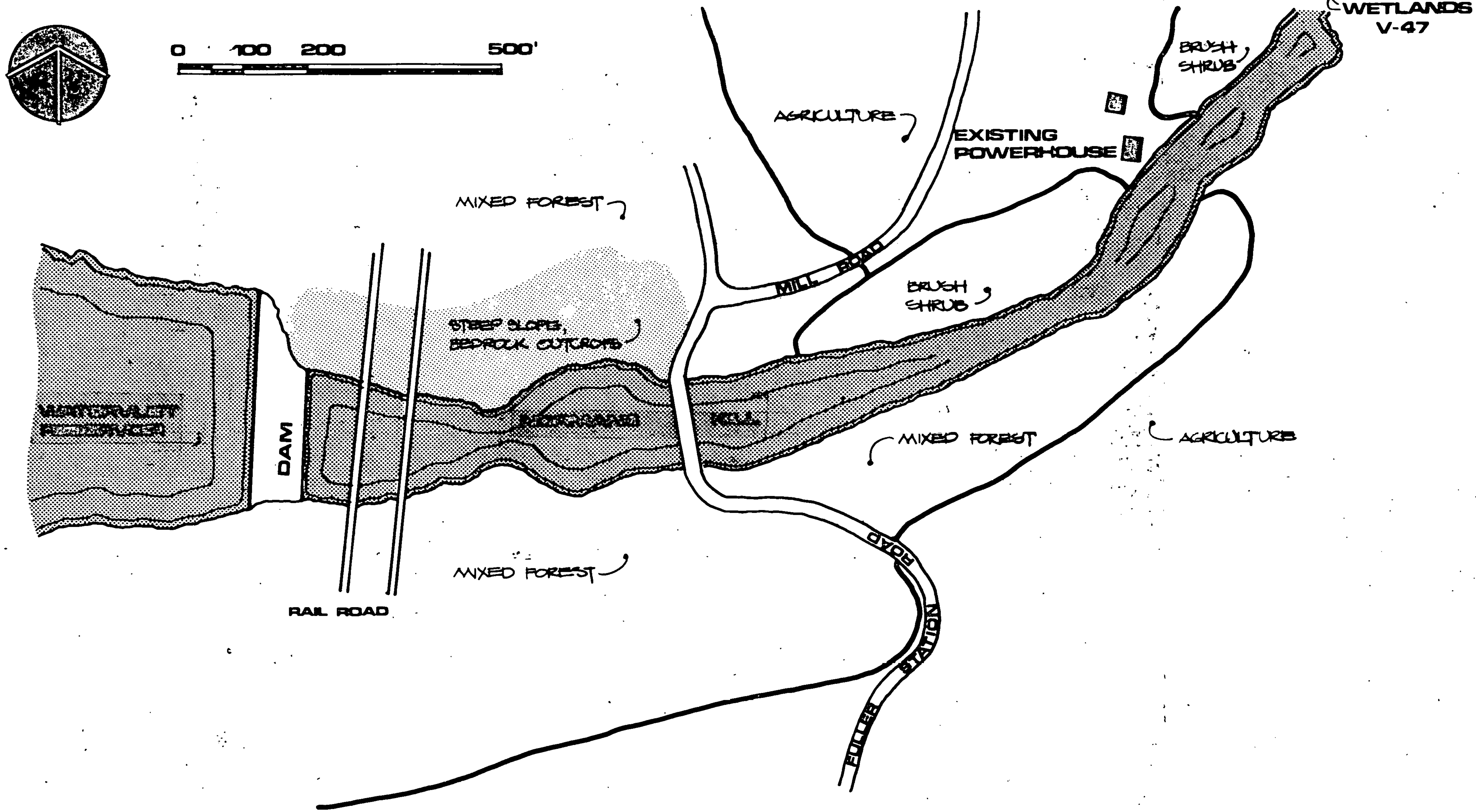
The goal of New York's Nature and Historic Preservation policy is to preserve and protect lands of natural beauty, wilderness or geological, ecological or historical significance. The policy is administered through the State Nature and Historical Preserve Trust. This trust is composed of a Board of Trustees and the Commissioner of Environmental Conservation, who serves as its chairman. The functions of the board include: recommending to the governor and legislature real properties that should be included in the preserve, preparing and submitting an annual report, maintaining an inventory of property dedicated to the preserve, requesting aid from other state agencies when appropriate, and making the rules and regulations necessary to sucessfully administer New York's Nature and Historic Preserve policy. The department may acquire lands when funds are authorized by the legislature and will maintain control over any such properties purchased pursuant to this section.

The foregoing laws establish the leadership roles of the Federal and State governments in preserving, restoring and maintaining the prehistoric, historic and cultural resources of the nation and state, respectively. Federal agencies are responsible for administration of cultural properties, the initiation of criteria that assure that federally owned sites, structures, and objects of historical, architectural and archeological significance are preserved, restored and maintained and the institution of procedures that contribute to the preservation and enhancement of non-federally owned sites, structures and objects of historical, architectural and archeological significance. The national policy is administered by the Secretary of the Interior through the National Park Service and the state policy by the Board of Trustees of the State Nature and Historical Preserve Trust.

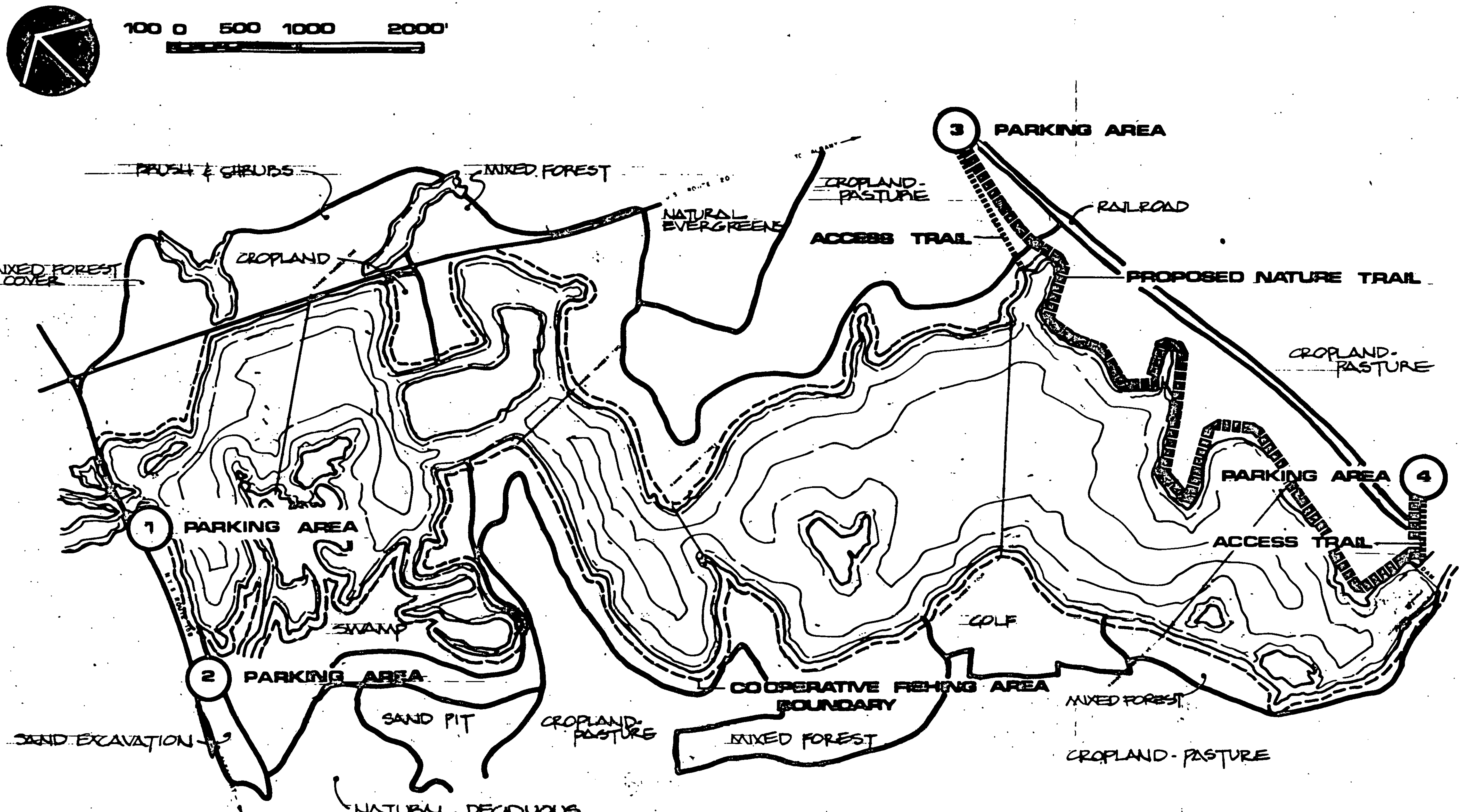
Section 469 of the United States Code expressly applies to any damage or destruction that may result from dam construction, and therefore may be relevant to the Watervliet Reservoir project. A procedure is established for notifying the Secretary of the Interior concerning the allocation and nature of the proposed activity and the effect it will have on surrounding terrain, including prehistoric and historic sites. Upon notification that a cultural resource may be disturbed, the Secretary is responsible for exercising supervisory control over the initiation, financing and recovery of data from the site, and for assuring that significant historical, architectural, and archeological properties are protected and maintained.

Measures for obtaining grants to aid in preservation policies are detailed in Section 470 of the United States Code.

It is to be noted that regulations regarding procedures for effectuating the policies set forth in the foregoing statutes and for assuring compliance with such statutes will have to be consulted prior to execution of this project.



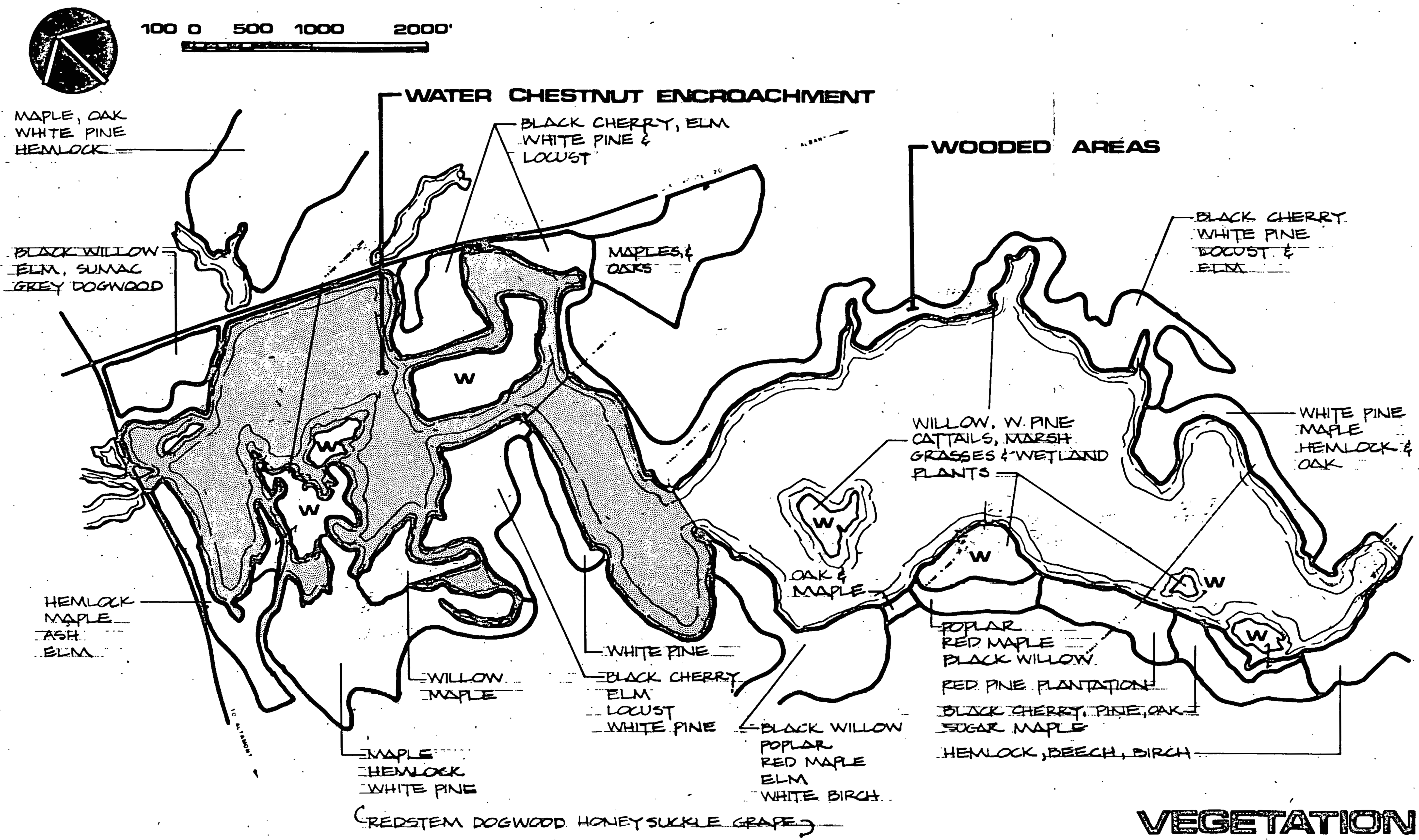
STREAM RELATED LANDUSE & VEGETATION



LAND USE RECREATION

ENVIRONMENTAL

NORMANSKILL HYDROELECTRIC FACILITY
FEASIBILITY ASSESSMENT-EW-78-F-07-1765

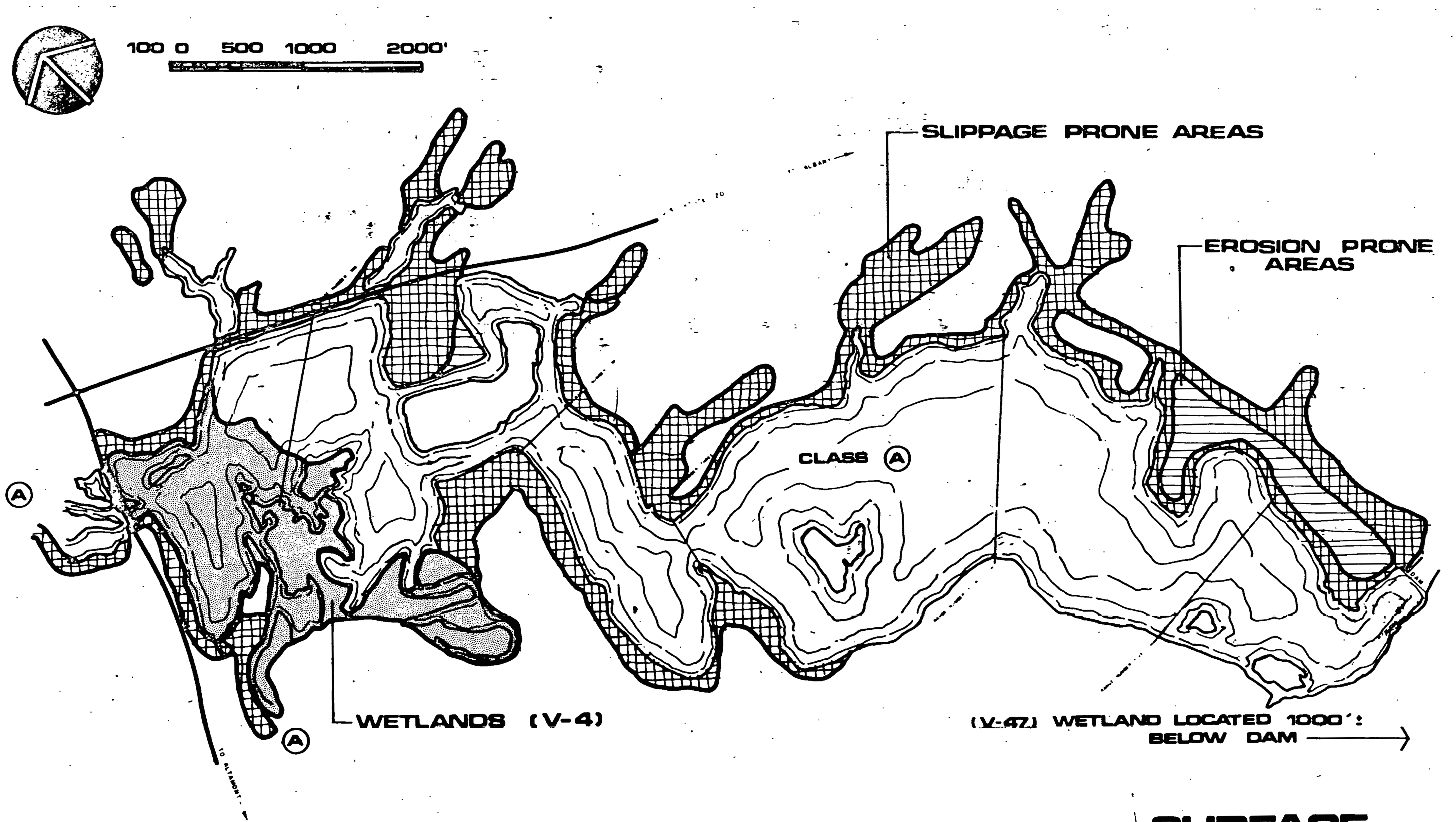


VEGETATION

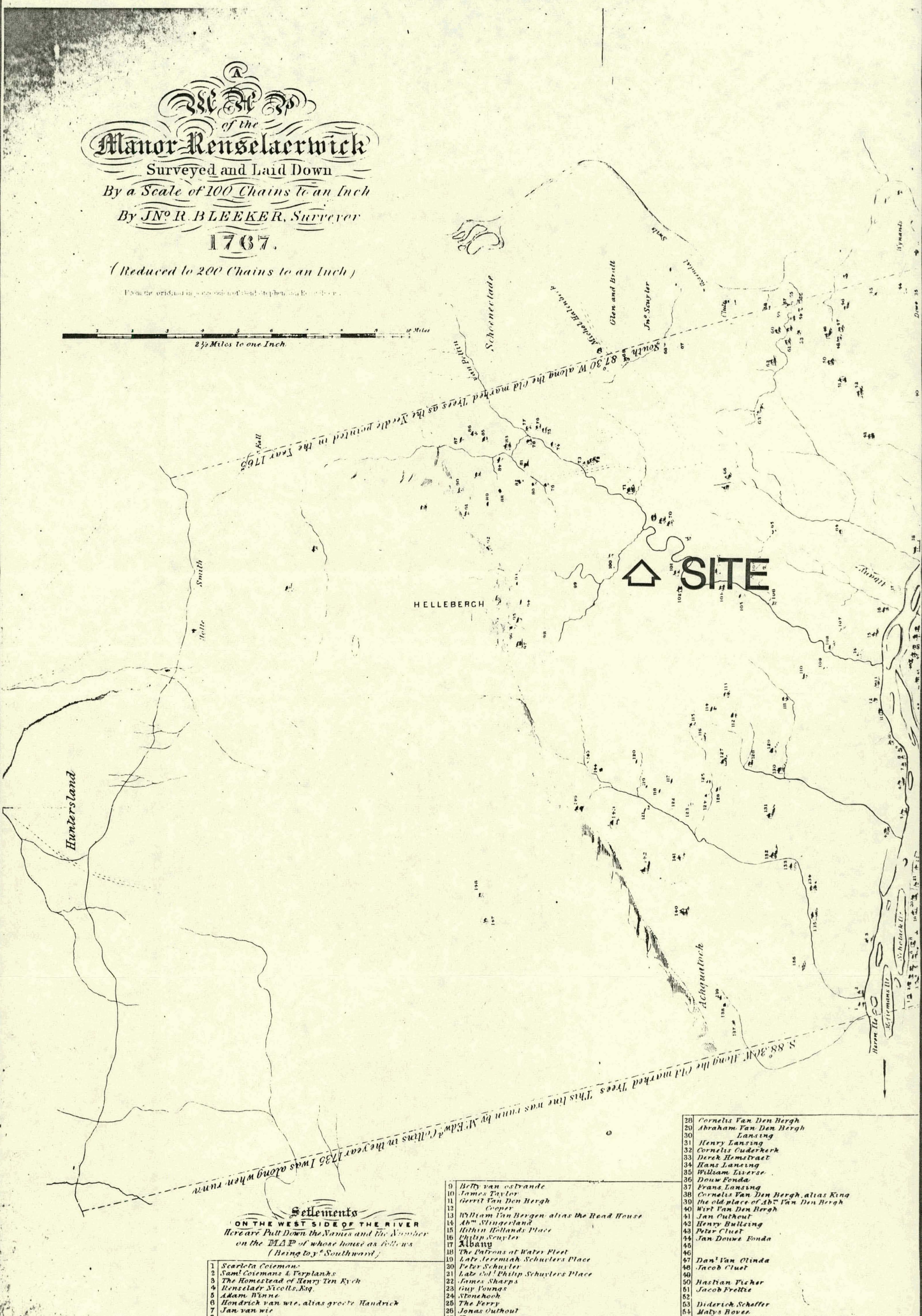
ENVIRONMENTAL

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



SURFACE CONDITIONS



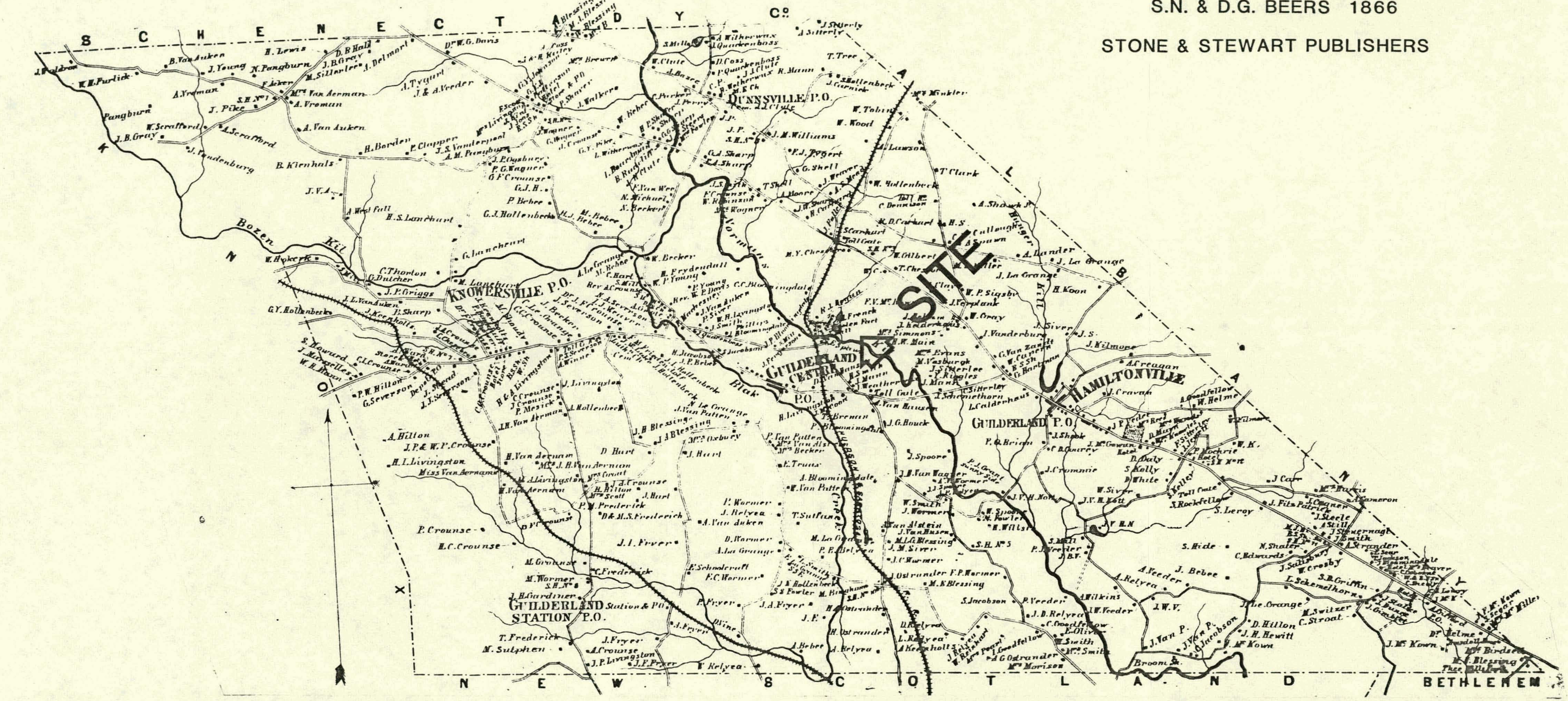
NORMANSKILL HYDROELECTRIC FACILITY FEASIBILITY ASSESSMENT-EW-78-F-07-1765	BLEEKER MAP 1767	49

NEW TOPO ATLAS OF

ALBANY & SCHENECTADY COUNTIES

S.N. & D.G. BEERS 1866

STONE & STEWART PUBLISHERS



BEERS MAP 1866

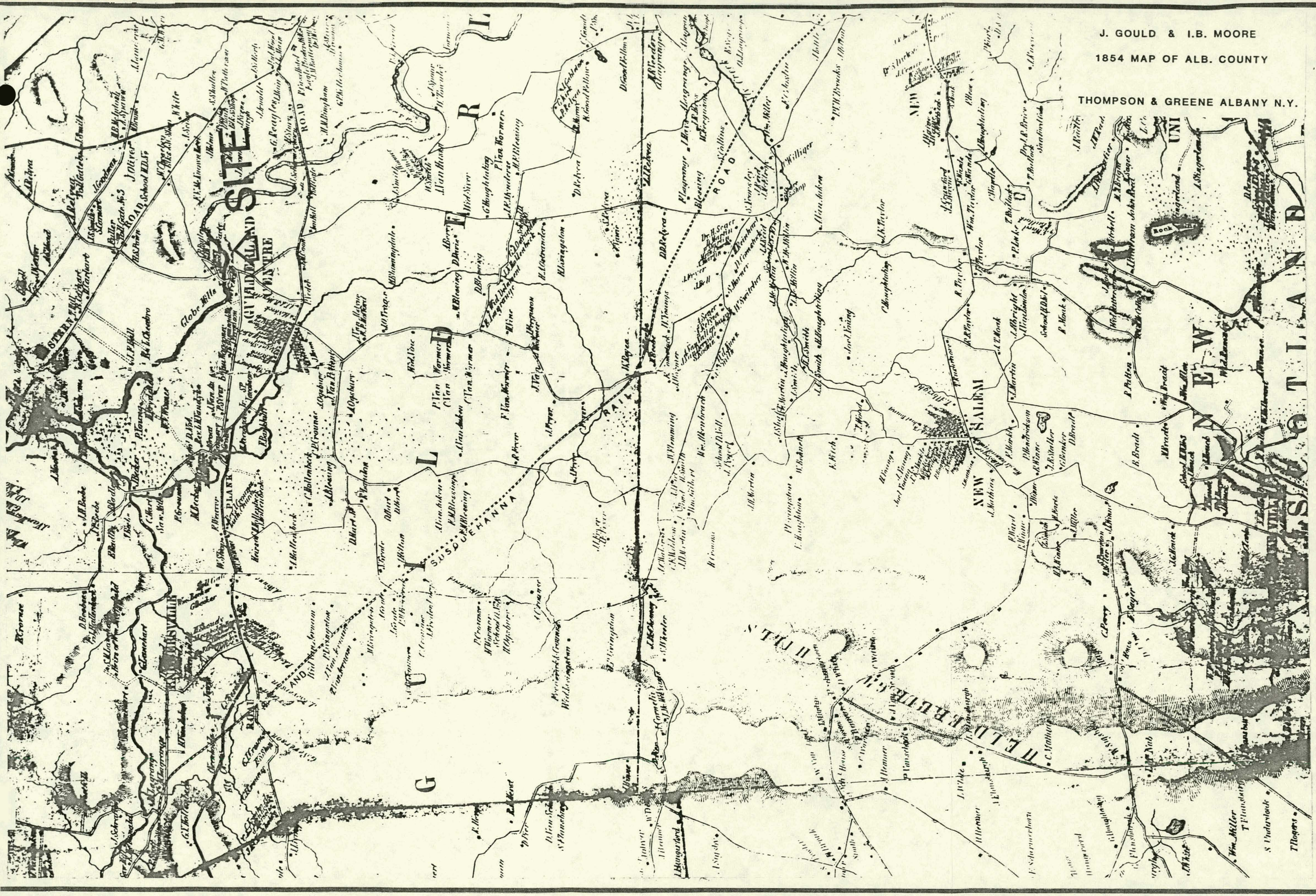
NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

J. GOULD & I.B. MOORE

1854 MAP OF ALB. COUNTY

THOMPSON & GREENE ALBANY N.Y.



GOULD & MOORE MAP 1854

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

COVERED BRIDGE

date unknown

52

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

SPAWN HOME NORTH FACE

SPAWN HOME
ENTRANCE DETAILS

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

NORMANSKILL HYDROELECTRIC FACILITY
FEASIBILITY ASSESSMENT-EW-78-F-07-1765

SPAWN BARN

LICENSING AND REGULATORY REQUIREMENTS

Jurisdiction

The proposed Normanskill Hydroelectric Facility falls under the aegis of the Federal Energy Regulatory Commission. Discussions with the New York State Public Service Commission and with the New York State Department of Environmental Conservation have determined that any regulation on their part would be subordinate to the Federal Energy Regulatory Commission.

Review Requirements

The New York State Public Service Commission, acting under Public Service Law Section 110[4] Section 66[12] would be required to approve any contractural agreement between the municipal owner of the Normanskill Hydroelectric facility and any purchaser of power [Ref.99].

The Federal Energy Regulatory Commission has determined that the proposed facility will be eligible for short-form licensing. A copy of this determination is on file [Ref. 95]. The FERC has also furnished a list of local, county, state and federal agencies which must participate in the review process prior to submission of an application for a short-form license. These agencies have been requested to estimate time required for their review processes to aid implementation in planning phases of this feasibility analysis.

A list of the nine agencies and the responses follow.

Agency	Reply as of 4/19/79
U.S. Environmental Protection Agency	no reply
U.S. Dept. of the Interior Fish and Wildlife Service	10 days

U.S. Dept. of the Interior Heritage and Conservatlon Service	no reply
U.S. Army Corps of Engineers	two years, if Section 404 Permit required; if not, uncertain.
U.S. Office of Parks & Recreation	30 days
NYS Dept. of Environmental Conservation	15-170 days; possibly concurrent FERC review.
NYS Fish & Wildlife Management Board	no review required
NYS Public Service Commission	no reply
Albany County Board of County Leglslators	no reply

Critical Energy Facility Program

Subsequent to discussions with the above agencies, the President issued Executive Order 12129 of April 05, 1979 [Ref. 105]. This Order directs the Office of Management and Budget to establish a system of coordination and deadlines for administrative decision-making by Federal agencies. The Program appears at this instance to be an attempt to expedite agency review, simplify and shorten the review process for new non-nuclear energy facilities. It is expected that this Order will significantly advance the projected facility on-line date shown in the draft PERT chart, Figure 69.

Environmental and Cultural Regulatory Requirements

The various environmental and cultural regulatory requirements are discussed in detail in Chapter 6.

ECONOMIC ANALYSIS

The Economic Analysis serves to determine the optimum values of those critical parameters which can be shown to be highly reactive or in maximizing the objective.

Several criteria can be set for the objective function. First, the net benefit is the value of savings or earnings by the site developer in pursuing a particular project. A second criteria is benefit to cost ratio. An extremely favorable ratio might be shown of a minor power project. Selection on this basis alone, however, might result in a very small net benefit and minimal production of power. Other criteria include rates of return and cash flow profiles.

It was initially assumed that a linear programming model could be developed to optimize certain critical variables such as design flow, machine sizing and type, etc. It was determined early in the marketing phase that the cost function unique to this project was discontinuous due to the different values placed upon the power generated. The most valuable use for power generated is in water supply pumping at the site. The second most valuable use for power generated is for power wheeled across utility lines to City owned facilities. The value in this case is equal to the value of power similarly supplied by the area utility less any wheeling charge extracted by the utility for the transmission service. The least valuable class of power generated is the surplus after the first two demands have been met. The value of surplus or "dump" power is set by the market requirements of Niagara Mohawk Power Corporation. A fourth and relatively minor value derives from the potential use of the generator during periods of non-generation due to low stream flow. In this mode of operation, the facility would operate as a synchronous condenser supplying power factor correction to the Niagara Mohawk Power Corporation grid. While it is recognized that this service may be of some value in maximizing power transmission capabilities of the utility grid, its economic value is as yet undeterminable. For this reason, a token value, thought to be much less than the actual value, has been included in the analysis.

Since the benefit function is discontinuous, optimization of net benefits by normal linear programming methodologies becomes a difficult problem. Consideration was given to developing the methodology using the constrained linear systems (CLS) approach, but this was deemed to be too inflexible and imprecise for the analysis.

The methodology subsequently developed and used was a two-step process. 78 alternatives representing a broad range of site uses, design flows, machine types, configurations costs and benefits were compared and ranked. A net cost comparison was made between all 78 alternatives on the basis of present worth. Following this determination of an optimum configuration of component variables, those costs common to all alternatives were included to define two projects. These optimized projects, were then subjected to the following Economic Feasibility Analysis. The methods of analysis and conventions used follow those of Grant & Ireson [Ref. 11]. The accounting stance assumed was that of the owner, the City of Watervliet, N. Y.

Selected Projects

Two alternatives were selected which represented the optimum configuration of many variables. These alternatives, Nos. 1.02 and 8.07, represent two distinct types of projects. The first, Project A, represents a rehabilitation type approach utilizing available civil and mechanical works to their fullest capacity. Project A, which consists of Alternative 1.02 plus other common components would develop 46% of potential hydroelectric capacity at the Normans Kill site. Project B is based upon Alternative 8.07. It represents a new construction approach utilizing only certain existing civil works and develops 68% of potential hydroelectric power. Total project costs for each project type follows. Technical details for each project are depicted on Figure 44 and Figures 41A and 41H. A more detailed description of the recommended project will follow in the Synopsis/Recommendations.

	Project A	Project B
1. Intake (from Fig. 44)	$ 53,700	$ 276,700
2. Penstock (from Fig. 44)	68,400	136,800
3. Powerhouse (" " ")	91,200	162,000
4. Switchgear Controls(From Fig. 44)	201,500	328,100
5. Machine (From " ")	257,500	235,600
6. Anc. Equipment (From " ")	70,300	70,300
7. Pump/Control Station Modification		
a. Removals	5,000	5,000
b. Superstructure Rehab.	30,000	30,000
c. Security Const.	4,000	4,000
d. Metals	3,000	3,000
e. Standby Power	30,000	30,000
f. Surge Control	19,125	19,125
g. Piping	62,000	62,000
h. Pump Rehab.	15,000	15,000
i. Telemetry	9,000	9,000
j. Motor Control	35,000	35,000
k. Elec. Rehab.	20,000	20,000
8. Mobil. & Temp. Services	136,600	61,275
9. Subtotal Construction Cost	1,111,325	1,502,900
10. Admin., Legal & Technical Cost	148,200	177,100
11. Interest during Construction	50,375	67,200
12. Total Project Cost	$1,309,900	$1,747,200

Determination of Discount Rate and Cost and Benefit Gradients

The discount rate to be used to represent the time value of money for economic studies is the subject of lengthy and involved debate. It involves questions of varying discount rates for public versus private projects, and whether the rate should reflect the nominal or the social opportunity cost of money. A detailed discussion and framework for such analysis can be found in the references cited. For purposes of our analysis, the following rationale is offered. The City of Watervliet's rate for municipal bonding is 6.31% based upon a geometric mean of the past five years' issuance of bonds. We feel that a strong case can be made here for using a discounting rate equal to the actual cost of money to the municipality. However, in conjunction with this rate, it seems appropriate to increment (or decrement) other costs and benefits used in the economic evaluation to more nearly represent the observed and predicted patterns of relative price changes. This convention follows closely the methodologies suggested by the cited

Reference Nos. 40 and 51. We realize that these observed and predicted values or cost gradients include some component of general inflation or general increase in the nominal cost of goods and services relative to the real (constant) value of the same goods and services. Recognizing then that the discount rate should reflect this general and nominal increase in the time value of money, the problem becomes one of selecting an appropriately higher discount rate. The discount rate suggested in the recent U.S. Department of Energy Program Opportunity Notice for Hydroelectric Demonstration is used in our analysis. It is assumed and understood that this rate of 8.0% includes an inflationary component over and above the recognized bare time yield of money [Ref. 104]. We are cognizant of the fact, however, of the varying opinions of economists in selecting an appropriate discount rate. We have included in the Sensitivity Analysis section of this phase, detailed data which can help the reader to visualize the relative effect of varying discount rates.

The observed nominal increases in cost for goods and services in the categories pertinent to this analysis are depicted below.

Calculated Cost Gradients
(Compounded Amount Factors, All Positive)

	Period in Years (1978 Base)					
	-30	-20	-10	-5	+10	+20
Consumer Price Index (CPI)	3.25%	3.75%	6.0%			
Wholesale Price Index (SPI)	3.25%	3.5%	5.75%			
Electrical Machinery	4.25%	1.75%	6.0%			
Labor (Watervliet Municipal)		5.75%	6.5%			
Electrical Power Wholesale U.S.)	5.25%	7.5%	16.0%			
Electrical Power (NMPC)			6.0%	9.0%		

Electrical Power Projections N.Y.S. Energy Office (by NMPC)	1.8%	0.0%
Natural Gas Cost Projection NYS Energy Office (by NMPC)	4.2%	

Following the convention of [Ref. 51], we have elected to use nominal changes in cost for our analysis. We belive that the cost gradients selected are conservative in range. It is noted that the gradients used are based upon the historical record and include some inflationary component. The determination of an inflationary component by using the U.S. Department of Commerce Consumer or Wholesale Price Index to correct the observed gradients is impractical. The CPI or WPI is a relative index based upon a representative sample of market place goods and services, whereas the inflationary cost increases for specific goods and services varies for different products. Use of a general national index of costs for a disaggregated sample of goods and services on a local or microeconomic level is inappropriate.

In summary, our approach is to use a discount rate which knowingly includes some factor for assumed long-term general inflation and to use nominal cost gradients based upon the best observed and most appropriate data available to the City of Watervliet, New York. As previously mentioned, because of the wide range of opinions among economists in determining these gradients, we have included sufficient data in the Sensitivity Analysis section to visualize the impact of making alternative choices.

Present Worth Analysis

The present worth of the baseline condition and Projects A and B have been calculated, representing cash outflows as negative numbers. The factors used in the analysis were:

a. 50-year analysis period.

b. 8.0% discount rate.

c. Capital costs incurred at first year.

d. Labor cost gradient 5.8% per annum.

e. Operation & maintenance cost gradient 4.0% per annum.

f. Electrical energy cost gradient 7.0% per annum.

Present Worth Analysis

	Baseline	Project A	Project B
P.W. Capital Cost	$- 407,000	$-1,309,900	$-1,747,200
P.W. Labor	-3,454,437	- 575,740	- 575,740
P.W. Power	- 71,636	- 616,863	- 139,293
P.W. O & M	- 187,513	- 997,130	-1,213,322
P.W. Energy Credits	0	+2,367,957	+2,857,466
P.W. Net Cost	$-4,120,586	$-1,131,676	$- 818,089

A further discussion of present worths follows under Benefit Cost Ratio and Cash Flow.

Benefit Cost Ratio

The optimum configuration program (OCP) aided in the selection of the best configuration among several possible alternative selections of hydroelectric generating equipment. Alternatives Nos. 1.02 and 8.07 were tentatively selected as optimum configurations for generation equipment. Two separate alternatives were selected because they were not comparable on the same economic basis. Alternative No. 1.02 involves the reuse of certain existing equipment which for subjective reasons may be unacceptable in spite of being less expensive. These configurations have been incorporated into projects which have been designated as Project A and Project B, respectively. The feasibility of Project A or Project B can be investigated by determining the benefit-cost ratio of the incremental investment compared to a baseline condition. Our baseline accounting stance is that of operating the existing water pumping station in its present configuration which currently utilizes some mechancial hydropower to operate water supply pumps. The comparison period is taken to be 50 years or the projected life of the equipment for Projects A and B. The existing facility requires some immediate investment to be able to continue in its present capacity for a comparable 50-year period.

The benefit-cost ratio analysis is depicted on Figure 56. A period of 50 years and compound annual cost increases for labor, energy, and operation and maintenance of 5.8%, 7.0%, and 4.0%, respectively are shown. This benefit-cost ratio is based upon the present worth over the entire service period. The first or benefit portion includes the benefits accruing to the City as reduction in total power cost due to power which can be produced in excess of that which will be used to operate the electric pumps. The value of this credit in the base year can be taken from Figure 30A and is the total of the credits shown for "city use", "excess", and "power factor" correction. The second benefit item is the reduction in labor costs resulting from automation of the pumping station which will operate on electric power in contrast to the labor intensive existing baseline situation. The present worth of the future benefits is computed for each year of the service period and summed for projects A and B. on Figure 56-line 5.

Items required to determine the present worth of additional costs from implementing the projects are computed and displayed as lines 6-11 on Figure 56. The first such item is capital cost. For analysis period less than 50 years, credit is taken for a present worth of a future residual value which is computed by assuming that the basic value of the comparable new facility increases at a rate equal to the average of the energy, labor, and operation and maintenance cost gradients (5.6%), but because of its age, it is simultaneously reduced on the ratio of its age to its 50-year life. This future residual value is then discounted to present worth using the stated discount rate (8.0%). The second cost items are power to operate the pumps during low streamflow periods when turbines cannot produce electricity. The baseline condition assumes purchase of power for pumping for approximately 14 days per year at the assumed rate of 5.3 cents per kilowatt hour in the base year. Under Projects A and B, pumping costs in the base year are calculated to be $45,460 (365 days at 98 kw at 5.3 cents per kwh) less the amount shown under "site use" power credits in Figure 30A. The third cost item is Operation and Maintenance, the present worths of which is computed by escalating to future values in each year of the service period using the gradients shown, discounting them back to present worth at the indicated discount rate and summing them as in the benefits section.

In accordance with Grant and Ireson [Ref. 11], benefit cost ratio on the incremental investment is calculated as the incremental increase in benefits from the base line to Projects A or B on line 5 divided by the corresponding incremental increase in costs on line 12. Labor costs are not included in line 12 costs since the substantial reduction in labor costs have been taken as one of the major benefits and we are interested in determining the ratio of incremental benefit to incremental cost increases.

We feel that it is illogical to consider the implementation of the hydroelectric power generating facility without simultaneously upgrading the city's pumping station at the site. Although it is not shown in Figure 56, investigation was made of the relative benefit cost ratio of the incremental portions of the projects to upgrade the pumping station with its resulting labor saving benefits. The benefit cost ratio of this increment relative to the baseline was 1.81. The incremental benefit cost ratio for the further investment to add hydroelectric power generation resulting in the full Project A or B was incrementally 3.56 and 3.40, respectively.

In all cases, a benefit cost ratio greater than one indicates that an investment will bring a return greater than the investment over the study period.

Cash Flow

In order to permit the analysis of anticipated future cash flow associated with the projects, a cash flow model was developed which computes the annual costs for any specified period. Capital costs are indicated as a single expense at year zero while labor, power and operation and maintenance costs are shown as annual costs increasing from a base year value at a compound annual rate in this example equal to 5.8%, 7.0% and 4.0%, respectively, as used in the benefit cost program. The net cash flow for any year is the sum of all previous columns using the convention that a negative value is a cash outflow. The last or cumulative present worth column shows the base year cumulative present worth of all years net cash flow through that given year, in this case using an 8% discount rate.

A projected 50-year cash flow for Projects A and B are included as Figures 58. A similar cash flow is shown for the corresponding baseline condition assuming that substantial investment is immediately required to enable it to operate for the 50 year period. It should be noted that the operation of the pumping station in each case is essential to the welfare of the City of Watervliet. It can be seen that the baseline condition shows a lesser capital expenditure and operation and maintenance cost, a much greater outflow for labor cost, and none of the large credits for power production available under Projects A or B. By comparing the cash flows for Projects A and B with the baseline cash flow, it can be seen that the increased investment in Projects A or B will be repaid by the tenth or thirteenth years, respectively when the cumulative present worth cash outflow for either project becomes less than the corresponding item under the baseline condition. The total present worth of the 50-year series for each column is summarized on the bottom line of each of the displays in Figure 58.

Delta Cash Flow

To facilitate making the comparison between the cash flow for the proposed project and that for the baseline condition, the Delta Cash Flow display of Figure 58 shows the net change in cash flow resulting from investing in Project A or B. Figure 58 shows these net changes for Projects A or B utilizing the same assumptions as were used in the preceding Cash Flow description. The convention used shows increases in cost as negative numbers and cost reductions as positive numbers. It can be seen again that the capital investment and added incremental operation and maintenance cost in Projects A and B is more than offset by gains in labor savings and power credits so that after 10 or 13 years respectively the investment has turned into a net benefit compared to the baseline condition.

Discounted Cash Flow

The computed benefit cost ratios for the proposed projects demonstrate that investment in the projects merits consideration. The owner must compare that potential investment with other possible expenditures to decide whether that project warrants his investment. The owner may have other less attractive projects for which he may be obligated to spend his available capital, and cash flow problems may prevent him from making the investment.

For those reasons, and to help the owner to evaluate the relative merits of an investment in Project A or B, we have analyzed the investment in another way by showing the calculated rate of return for the incremental project relative to the baseline condition. A variation on the Delta Cash Flow was used in Figure 57 in which the change in net cash flow for the study period was obtained, but using an itterative procedure, the internal rate of return was determined. This computed rate which, when used to represent the time value of the investor's money or interest rate for discounting future cash values to present worth, causes the project to break even. The rates so computed for Projects A and B are 18.91% and 16.24%, respectively. This means that an investment in the project will be recovered over the service period, using the stated assumptions, when the value of money to the investor is as high as the calculated rate of return. The bottom line in each display is present worth of the 50-year series when discounted using the computed internal rate of return. The total net discounted cash flow is zero dollars. The internal rate of return on an an incremental investment is one more measure which the owner can utilize in trying to decide among competing investments which one is most advantageous for him.

Subjective Considerations

Economic analysis indicates that both Project A and Project B merit implementation. However, consideration must be given to non-quantitative indicators such as environmental impact, cultural resource impact, licensing constraints and other intangibles. Rather than attaching economic values to allow analysis in a supposedly "analytical" fashion, a simple listing of pertinent subjective factors and their relative impact on both projects is presented. Some admittedly subjective judgments are included in the ratings.

Relative Impacts of Other Subjective Considerations

Relative impact scale:

- 0 = beneficial or easy
- 5 = minimal or normal
- 10 = adverse or difficult

	Project A	Project B
Environmental		
Reservoir related	5	5
Stream related (B is seen as having beneficial effects on dissolved oxygen levels)	5	1
Recreational impact	5	6
Other impacts(drinking water)	5	5
Cultural & Archaeological		
Historic site disruption	8	5
Licensing		
Approvable design	9	5
Review delays	9	5
Construction Related		
Lead time required	5	4
Disruption of exist. facilities	9	5
Weather (streamflow) sensitive	4	6
Energy Significance		
Development of site potential	2	6

Implementation		
Easement acquisition	6	6
Power purchase agreement with utility	2	7
Impact on utility revenues	6	5

Sensitivity Analysis

Extensive research was performed as part of the analysis to determine the economic assumptions which could best represent the owner's true point of economic view. After considerable effort we concluded that it was impossible to select economic rates which were acceptable to a consensus of authorities. We therefore have presented the various computational output material using consistent assumptions which we felt were most reasonable from the accounting stance of the City of Watervliet. Expecting that each reviewer will wish to impose his own assumptions on the economic analysis, we have computed and displayed a series of data matrices showing interrelationships among several of the economic variables for the proposed and recommended Project B. This data has been plotted as an indicator of the response of benefits versus several of the most important and controversial variables. Each reviewer can therefore assess the sensitivity of a particular benefit to a particular change or error in economic variables. The most important and controversial factors were those pertaining to cost escalation gradients for labor and energy, particularly in relation to the choice of a discount rate and period of years for the analysis. Therefore, included as Figures 59-67 are displays showing the shape of the response surfaces for both the present worth of future net benefits and the benefit-cost ratio computed for the incremental investment in Project B relative to the baseline condition. The sensitivity of the value of the resulting benefits to possible errors in capital cost are likewise shown. Except where a range of values for certain of the economic variables have been substituted to investigate sensitivity to error, the computation in this and previous sections are based on the following summary of values:

1. Capital Costs - See Benefit-Cost Ratio (Figure 56) and Present Worth Analysis

2. Present Worth of Future Residual Facility Value is equal to the capital cost escalated, to facilitate automatic computation, at an annual rate equal to the average of labor, energy, and O & M escalation gradients (5.6% at chosen values), prorated to its remaining life, and discounted to present worth using the discount rate.

3. Energy Rates - See Figure 30A, "Annual Power Cost and Credit Summary".

4. Base Year Power Costs - See Benefit-Cost Ratio (Fig. 56). and Present Worth Analysis

5. Base Year Power Credit- See Benefit-Cost Ratio (Fig. 56). and Present Worth Analysis

6. Base Year O & M Cost - See Benefit-Cost Ratio (Fig. 56). and Present Worth Analysis

7. Base Year Labor Costs for the baseline or Project B condition are based on five or one man, respectively, at $18,629 per year.

8. Energy Values Increase at 7.0% per Year Compounded.

9. Labor Values Increase at 5.8% per Year Compounded.

10. O & M Values Increase at 4.0% per Year Compounded.

11. Discount Rate equals 8.0% per Year Compounded.

12. Analysis Period is 50 Years.

<u>Economic Criteria for Incremental Projects</u>

In completing this feasibility assessment, several aspects of site development of possible economic significance became apparent. These aspects have been given a cursory examination as Incremental Projects. The criteria used for this preliminary evaluation was benefit/cost ratio based upon a ratio of present worth net benefits to cost. Gradient factors used are those established in previous sections. In addition, value gradients for natural gas,unfinished water, municipal ice rink rental and coal are 4.2%, 1.0%, 2.0% and 4.0%, respectively. A 50-year analysis period is used with a 8.0% discount rate. Analysis of Incremental Projects follows:

Incremental Project I - Heating Systems Conversions to Electric

Assume: Conversion of dual fuel (gas/electric) space heating systems at certain municipal buildings to electric to utilize surplus electric power produced.

Facility	Current Annual Natural Gas Use (CCF)	Annual Cost
Senior Citizens Center	4,942	$ 1,180
City Hall	17,642	4,410
City Garage	11,774	2,940
Water Filtration Plant	15,675	3,920
Civic Center	1,202	300
Firehouse	13,628	3,400
	64,664 CCF	$16,150

Benefits:	1.	Natural Gas Savings (60% reduction in use)	$ 9,690
	2.	Disbenefit (Loss of Dump Power) at 0.9¢ KWH	-1,388
	3.	Net Benefit (Year 1)	$ 8,302
	4.	PW-B	$166,079

Costs:	1.	Capital Cost	$ 20,000
	2.	O & M Cost	$ 1,000
	3.	Power Wheeling Charge @ 0.4¢ KWH	$ 616
	4.	Net Cost (Year 1)	$ 21,616
	5.	PW-C	$ 42,060

$$B/C = \frac{166,079}{42,060} = 3.9$$

Incremental Project 2 - Extending Ice Rink Season

Assume: Extension of ice rink season one month utilizing surplus electric power to maintain ice.

Benefits:	1.	Sale of Rink Time 108 hrs. @$30./hr.	$ 3,240
	2.	Disbenefit-Loss of Dump Power @ 0.9¢ KWH	$ -1,215
	3.	Net Benefit (Year 1)	$ 2,025
	4.	PW-B	$ 3,562

Costs:	1.	Labor at Rink	$ 486
	2.	O & M	$ 200
	3.	Power Wheeling Charge @ 0.4¢ KWH	$ 540
	4.	Net Cost	$ 1,226
	5.	PW-C	$ 19,429

$$B/C = \frac{3,562}{19,429} = 0.18$$

Incremental Project 3 - Coal Heat Conversion

Assume: Conversion of coal fired space heat at French's Mills Pump/Control Station to electric heat.

Benefits:	1.	Coal Cost Savings	$ 1,440
	2.	Disbenefit-Loss of Dump Power @0.9¢ KWH -	$ - 461
	3.	Net Benefit (Year 1)	$ 979
	4.	PW-B	$ 13,419
Costs:	1.	Capital Cost	$ 500
	2.	PW-C	$ 500

$$B/C = \frac{13,419}{500} = 26.8$$

Incremental Project 4 - Bascule Gate

Assume: Installation of Bascule Gate atop dam to increase available head for power and increase water supply yield.

a. Power

Benefits:	1.	Increased hydroelectric production value	$ 14,789
	2.	PW-B	$ 588,500
Costs :	1.	Capital Costs	$2,255,000
	2.	PW-C	$2,255,000

$$B/C = \frac{588,500}{2,255,000} = 0.26$$

b. Water Yield

Benefits:	1.	Addition 10 mgd Yield value @$0.10/1,000 gal.	$ 360,000
	2.	PW-B	$5,012,000
Costs :	1.	Capital Cost	$2,255,000
	2.	PW-C	$2,255,000

$$B/C = \frac{5,012,000}{2,255,000} = 2.0$$

Conclusions

Based upon the economic criteria preceding and other subjective considerations, the recommended course of action is implementation of Project B. Within the range of incremental projects, only Incremental Projects 1 and 3 are recommended with their adoption delayed until completion of the hydroelectric project.

ECONOMIC COMPARISON OF PROJECTS A&B TO BASELINE ALTERNATIVE

BENEFIT/COST RATIO

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
BENEFIT / COST RATIO PROGRAM (BCP)
50 YEAR ANALYSIS PERIOD BASED UPON 8.000 PERCENT DISCOUNT RATE

ITEM		BASELINE	PROJECT A	PROJECT B
1. BASE YEAR ANNUAL POWER BENEFIT	$	0	59500	71800
2. P.W. POWER @ 7.0% CMPD. GRADIENT	$	0	2368000	2857500
3. BASE YEAR ANNUAL LABOR BENEFIT	$	0	93100	93100
4. P.W. LABOR @ 5.8% CMPD. GRADIENT	$	0	2877300	2877300
5. P.W. TOTAL POWER & LABOR BENEFIT	$	0	5245300	5734800
6. CAPITAL COST	$	407000	1309900	1747200
7. P.W. OF CAP. COST LESS RESID. VAL.	$	407000	1309900	1747200
8. BASE YEAR PUMPING STA. POWER COST	$	1800	15500	3500
9. P.W. POWER COST @ 7.0% CMPD. GRAD.	$	71600	616900	139300
10. BASE YEAR ANNUAL O & M COST	$	8500	45200	55000
11. P.W. O & M COST @ 4.0% CMPD. GRAD.	$	187500	997100	1213300
12. P.W. OF COSTS [7, 9 & 11]	$	666100	2923900	3099800
13. B/C RATIO RELATIVE TO BASELINE		.00	2.32	2.36

ECONOMIC COMPARISON OF PROJECTS A&B

TO BASELINE ALTERNATIVE

INTERNAL RATE OF RETURN

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
DISCOUNTED CASH FLOW PROGRAM (CFP2)
PROJECT A COMPARED TO BASELINE ALTERNATIVE
50 YEAR DISCOUNTED Δ NET CASH FLOW (ΔDNCF)
COMPUTED INTERNAL RATE OF RETURN EQUAL TO 18.91419 PERCENT

YR.	Δ CAPITAL +	Δ LABOR +	Δ POWER +	Δ O & M +	Δ PWR.CR. =	Δ NET CF	ΔDNCF
0.	¯902900					¯902900	¯902900
1.	0	98547	¯14659	¯38168	63665	109385	91986
2.	0	104263	¯15685	¯39695	68122	117005	82744
3.	0	110310	¯16783	¯41283	72890	125134	74417
4.	0	116708	¯17958	¯42934	77992	133808	66919
5.	0	123478	¯19215	¯44651	83452	143064	60168
6.	0	130639	¯20560	¯46437	89293	152935	54088
7.	0	138216	¯21999	¯48295	95544	163466	48617
8.	0	146233	¯23539	¯50226	102232	174700	43694
9.	0	154714	¯25187	¯52236	109388	186679	39264
10.	0	163688	¯26950	¯54325	117046	199459	35279
11.	0	173182	¯28836	¯56498	125239	213087	31695
12.	0	183226	¯30855	¯58758	134005	227618	28471
13.	0	193853	¯33015	¯61108	143386	243116	25573
14.	0	205097	¯35326	¯63553	153423	259641	22967
15.	0	216992	¯37799	¯66095	164162	277260	20624
16.	0	229578	¯40445	¯68738	175654	296049	18519
17.	0	242894	¯43276	¯71488	187950	316080	16627
18.	0	256981	¯46305	¯74347	201106	337435	14927
19.	0	271886	¯49546	¯77321	215183	360202	13400
20.	0	287656	¯53015	¯80414	230246	384473	12028
21.	0	304340	¯56726	¯83631	246363	410346	10796
22.	0	321991	¯60697	¯86976	263609	437927	9689
23.	0	340667	¯64945	¯90455	282062	467329	8695
24.	0	360426	¯69491	¯94073	301806	498668	7802
25.	0	381330	¯74356	¯97836	322932	532070	7000
26.	0	403447	¯79561	¯101750	345537	567673	6281
27.	0	426847	¯85130	¯105820	369725	605622	5635
28.	0	451604	¯91089	¯110052	395606	646069	5055
29.	0	477798	¯97465	¯114455	423298	689176	4535
30.	0	505510	¯104288	¯119033	452929	735118	4068
31.	0	534829	¯111588	¯123794	484634	784081	3649
32.	0	565849	¯119399	¯128746	518559	836263	3272
33.	0	598669	¯127757	¯133896	554858	891874	2935
34.	0	633392	¯136700	¯139251	593698	951139	2632
35.	0	670128	¯146269	¯144821	635257	1014295	2360
36.	0	708996	¯156508	¯150614	679725	1081599	2117
37.	0	750117	¯167464	¯156639	727305	1153319	1898
38.	0	793624	¯179186	¯162904	778217	1229751	1702
39.	0	839654	¯191729	¯169421	832692	1311196	1526
40.	0	888354	¯205150	¯176197	890980	1397987	1368
41.	0	939879	¯219511	¯183245	953349	1490472	1227
42.	0	994392	¯234876	¯190575	1020083	1589024	1100
43.	0	1052067	¯251318	¯198198	1091489	1694040	986
44.	0	1113087	¯268910	¯206126	1167893	1805944	884
45.	0	1177646	¯287734	¯214371	1249646	1925187	792
6.	0	1245949	¯307875	¯222946	1337121	2052249	710
7.	0	1318214	¯329426	¯231864	1430720	2187644	637
48.	0	1394670	¯352486	¯241138	1530870	2331916	571
49.	0	1475561	¯377160	¯250784	1638031	2485648	512
50.	0	1561144	¯403561	¯260815	1752693	2649461	459
PW	¯902900	749275	¯122411	¯255602	531638	0	0

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
DISCOUNTED CASH FLOW PROGRAM (CFP2)
PROJECT B COMPARED TO BASELINE ALTERNATIVE
50 YEAR DISCOUNTED Δ NET CASH FLOW (ΔDNCF)
COMPUTED INTERNAL RATE OF RETURN EQUAL TO 16.24351 PERCENT

YR.	Δ CAPITAL +	Δ LABOR +	Δ POWER +	Δ O & M +	Δ PWR.CR. =	Δ NET CF	ΔDNCF
0.	¯1340200					¯1340200	¯1340200
1.	0	98547	¯1819	¯48360	76826	125194	107701
2.	0	104263	¯1946	¯50294	82204	134227	99335
3.	0	110310	¯2083	¯52306	87958	143879	91599
4.	0	116708	¯2228	¯54398	94115	154197	84450
5.	0	123478	¯2384	¯56574	100703	165223	77844
6.	0	130639	¯2551	¯58837	107752	177003	71741
7.	0	138216	¯2730	¯61191	115295	189590	66105
8.	0	146233	¯2921	¯63638	123366	203040	60902
9.	0	154714	¯3125	¯66184	132001	217406	56099
10.	0	163688	¯3344	¯68831	141241	232754	51667
11.	0	173182	¯3578	¯71585	151128	249147	47577
12.	0	183226	¯3829	¯74448	161707	266656	43805
13.	0	193853	¯4097	¯77426	173027	285357	40327
14.	0	205097	¯4384	¯80523	185139	305329	37120
15.	0	216992	¯4690	¯83744	198098	326656	34163
16.	0	229578	¯5019	¯87094	211965	349430	31438
17.	0	242894	¯5370	¯90577	226803	373750	28928
18.	0	256981	¯5746	¯94200	242679	399714	26614
19.	0	271886	¯6148	¯97968	259667	427437	24483
20.	0	287656	¯6578	¯101887	277843	457034	22520
21.	0	304340	¯7039	¯105963	297292	488630	20713
22.	0	321991	¯7532	¯110201	318103	522361	19048
23.	0	340667	¯8059	¯114609	340370	558369	17516
24.	0	360426	¯8623	¯119194	364196	596805	16106
25.	0	381330	¯9227	¯123961	389690	637832	14808
26.	0	403447	¯9872	¯128920	416968	681623	13613
27.	0	426847	¯10564	¯134077	446156	728362	12514
28.	0	451604	¯11303	¯139440	477387	778248	11503
29.	0	477798	¯12094	¯145017	510804	831491	10572
30.	0	505510	¯12941	¯150818	546560	888311	9716
31.	0	534829	¯13847	¯156851	584819	948950	8929
32.	0	565849	¯14816	¯163125	625756	1013664	8205
33.	0	598669	¯15853	¯169650	669559	1082725	7540
34.	0	633392	¯16963	¯176436	716429	1156422	6928
35.	0	670128	¯18150	¯183493	766579	1235064	6365
36.	0	708996	¯19421	¯190833	820239	1318981	5847
37.	0	750117	¯20780	¯198466	877656	1408527	5372
38.	0	793624	¯22235	¯206405	939092	1504076	4935
39.	0	839654	¯23791	¯214661	1004828	1606030	4533
40.	0	888354	¯25457	¯223247	1075166	1714816	4164
41.	0	939879	¯27239	¯232177	1150428	1830891	3824
42.	0	994392	¯29145	¯241464	1230958	1954741	3512
43.	0	1052067	¯31185	¯251123	1317125	2086884	3226
44.	0	1113087	¯33368	¯261168	1409323	2227874	2963
45.	0	1177646	¯35704	¯271615	1507976	2378303	2721
6.	0	1245949	¯38203	¯282479	1613534	2538801	2498
7.	0	1318214	¯40878	¯293778	1726482	2710040	2294
48.	0	1394670	¯43739	¯305530	1847335	2892736	2107
49.	0	1475561	¯46801	¯317751	1976649	3087658	1934
50.	0	1561144	¯50077	¯330461	2115014	3295620	1776
PW	¯1340200	935098	¯19366	¯393470	817938	0	0

CASH FLOWS:

BASELINE

PROJECT A

PROJECT B

PROJECT A minus BASELINE

PROJECT B minus BASELINE

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
CASH FLOW PROGRAM (CFP1)
BASELINE
50 YEAR ANALYSIS PERIOD ASSUMING 8.000 PERCENT DISCOUNT RATE

R.	CAPITAL	+ LABOR	+ POWER	+ O & M	+ PWR.CR.	= NET	CUM. PW
0.	¯407000					¯407000	¯407000
1.	0	¯118257	¯1926	¯8840	0	¯129023	¯526466
2.	0	¯125116	¯2061	¯9194	0	¯136371	¯643382
3.	0	¯132373	¯2205	¯9561	0	¯144139	¯757804
4.	0	¯140050	¯2359	¯9944	0	¯152353	¯869788
5.	0	¯148173	¯2525	¯10342	0	¯161040	¯979389
6.	0	¯156767	¯2701	¯10755	0	¯170223	¯1086659
7.	0	¯165860	¯2890	¯11185	0	¯179935	¯1191649
8.	0	¯175479	¯3093	¯11633	0	¯190205	¯1294411
9.	0	¯185657	¯3309	¯12098	0	¯201064	¯1394993
10.	0	¯196425	¯3541	¯12582	0	¯212548	¯1493444
11.	0	¯207818	¯3789	¯13085	0	¯224692	¯1589810
12.	0	¯219871	¯4054	¯13609	0	¯237534	¯1684138
13.	0	¯232624	¯4338	¯14153	0	¯251115	¯1776473
14.	0	¯246116	¯4641	¯14719	0	¯265476	¯1866857
15.	0	¯260391	¯4966	¯15308	0	¯280665	¯1955334
16.	0	¯275494	¯5314	¯15920	0	¯296728	¯2041946
17.	0	¯291472	¯5686	¯16557	0	¯313715	¯2126734
18.	0	¯308378	¯6084	¯17219	0	¯331681	¯2209737
19.	0	¯326263	¯6510	¯17908	0	¯350681	¯2290994
20.	0	¯345187	¯6965	¯18625	0	¯370777	¯2370543
21.	0	¯365208	¯7453	¯19370	0	¯392031	¯2448422
22.	0	¯386390	¯7975	¯20144	0	¯414509	¯2524667
23.	0	¯408800	¯8533	¯20950	0	¯438283	¯2599314
24.	0	¯432511	¯9130	¯21788	0	¯463429	¯2672396
25.	0	¯457596	¯9769	¯22660	0	¯490025	¯2743949
26.	0	¯484137	¯10453	¯23566	0	¯518156	¯2814004
27.	0	¯512217	¯11185	¯24509	0	¯547911	¯2882595
28.	0	¯541925	¯11968	¯25489	0	¯579382	¯2949754
29.	0	¯573357	¯12806	¯26509	0	¯612672	¯3015510
30.	0	¯606612	¯13702	¯27569	0	¯647883	¯3079895
31.	0	¯641795	¯14661	¯28672	0	¯685128	¯3142938
32.	0	¯679019	¯15687	¯29818	0	¯724524	¯3204667
33.	0	¯718402	¯16786	¯31011	0	¯766199	¯3265112
34.	0	¯760070	¯17961	¯32252	0	¯810283	¯3324299
35.	0	¯804154	¯19218	¯33542	0	¯856914	¯3382256
36.	0	¯850795	¯20563	¯34883	0	¯906241	¯3439009
37.	0	¯900141	¯22003	¯36279	0	¯958423	¯3494584
38.	0	¯952349	¯23543	¯37730	0	¯1013622	¯3549006
39.	0	¯1007585	¯25191	¯39239	0	¯1072015	¯3602300
40.	0	¯1066025	¯26954	¯40809	0	¯1133788	¯3654489
41.	0	¯1127855	¯28841	¯42441	0	¯1199137	¯3705598
42.	0	¯1193270	¯30860	¯44139	0	¯1268269	¯3755649
43.	0	¯1262480	¯33020	¯45904	0	¯1341404	¯3804665
44.	0	¯1335704	¯35331	¯47740	0	¯1418775	¯3852668
45.	0	¯1413175	¯37804	¯49650	0	¯1500629	¯3899679
6.	0	¯1495139	¯40451	¯51636	0	¯1587226	¯3945720
7.	0	¯1581857	¯43282	¯53701	0	¯1678840	¯3990812
48.	0	¯1673605	¯46312	¯55849	0	¯1775766	¯4034973
49.	0	¯1770674	¯49554	¯58083	0	¯1878311	¯4078225
50.	0	¯1873373	¯53023	¯60407	0	¯1986803	¯4120586
PW	¯407000	¯3454437	¯71636	¯187513	0	¯4120586	

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
CASH FLOW PROGRAM (CFP1)
PROJECT A
50 YEAR ANALYSIS PERIOD ASSUMING 8.000 PERCENT DISCOUNT RATE

R.	CAPITAL	+ LABOR	+ POWER	+ O & M	+ PWR.CR.	= NET	CUM. PW
0.	¯1309900					¯1309900	¯1309900
1.	0	¯19709	¯16585	¯47008	63665	¯19637	¯1328082
2.	0	¯20853	¯17746	¯48888	68122	¯19365	¯1344685
3.	0	¯22062	¯18988	¯50844	72890	¯19004	¯1359771
4.	0	¯23342	¯20317	¯52878	77992	¯18545	¯1373402
5.	0	¯24696	¯21740	¯54993	83452	¯17977	¯1385637
6.	0	¯26128	¯23261	¯57192	89293	¯17288	¯1396531
7.	0	¯27643	¯24890	¯59480	95544	¯16469	¯1406141
8.	0	¯29247	¯26632	¯61859	102232	¯15506	¯1414518
9.	0	¯30943	¯28496	¯64334	109388	¯14385	¯1421714
10.	0	¯32738	¯30491	¯66907	117046	¯13090	¯1427777
11.	0	¯34636	¯32625	¯69583	125239	¯11605	¯1432754
12.	0	¯36645	¯34909	¯72367	134005	¯9916	¯1436692
13.	0	¯38771	¯37353	¯75261	143386	¯7999	¯1439633
14.	0	¯41019	¯39967	¯78272	153423	¯5835	¯1441620
15.	0	¯43398	¯42765	¯81403	164162	¯3404	¯1442693
16.	0	¯45916	¯45759	¯84659	175654	¯680	¯1442892
17.	0	¯48579	¯48962	¯88045	187950	2364	¯1442253
18.	0	¯51396	¯52389	¯91567	201106	5754	¯1440813
19.	0	¯54377	¯56056	¯95230	215183	9520	¯1438607
20.	0	¯57531	¯59980	¯99039	230246	13696	¯1435668
21.	0	¯60868	¯64179	¯103000	246363	18316	¯1432030
22.	0	¯64398	¯68671	¯107120	263609	23420	¯1427722
23.	0	¯68133	¯73478	¯111405	282062	29046	¯1422775
24.	0	¯72085	¯78622	¯115861	301806	35238	¯1417218
25.	0	¯76266	¯84125	¯120496	322932	42045	¯1411079
26.	0	¯80689	¯90014	¯125316	345537	49518	¯1404384
27.	0	¯85369	¯96315	¯130328	369725	57713	¯1397159
28.	0	¯90321	¯103057	¯135541	395606	66687	¯1389429
29.	0	¯95560	¯110271	¯140963	423298	76504	¯1381218
30.	0	¯101102	¯117990	¯146602	452929	87235	¯1372549
31.	0	¯106966	¯126249	¯152466	484634	98953	¯1363443
32.	0	¯113170	¯135087	¯158564	518559	111738	¯1353923
33.	0	¯119734	¯144543	¯164907	554858	125674	¯1344009
34.	0	¯126678	¯154661	¯171503	593698	140856	¯1333720
35.	0	¯134026	¯165487	¯178363	635257	157381	¯1323076
36.	0	¯141799	¯177071	¯185498	679725	175357	¯1312094
37.	0	¯150023	¯189466	¯192918	727305	194898	¯1300793
38.	0	¯158725	¯202729	¯200634	778217	216129	¯1289189
39.	0	¯167931	¯216920	¯208660	832692	239181	¯1277298
40.	0	¯177671	¯232104	¯217006	890980	264199	¯1265137
41.	0	¯187976	¯248351	¯225686	953349	291336	¯1252720
42.	0	¯198878	¯265736	¯234714	1020083	320755	¯1240062
43.	0	¯210413	¯284337	¯244102	1091489	352637	¯1227176
44.	0	¯222617	¯304241	¯253866	1167893	387169	¯1214076
45.	0	¯235529	¯325538	¯264021	1249646	424558	¯1200776
46.	0	¯249190	¯348326	¯274582	1337121	465023	¯1187287
47.	0	¯263643	¯372708	¯285565	1430720	508804	¯1173621
48.	0	¯278934	¯398798	¯296988	1530870	556150	¯1159790
49.	0	¯295112	¯426714	¯308867	1638031	607338	¯1145805
50.	0	¯312229	¯456584	¯321222	1752693	662658	¯1131676
PW	¯1309900	¯575740	¯616863	¯997130	2367957	¯1131676	

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
CASH FLOW PROGRAM (CFP1)
PROJECT B
50 YEAR ANALYSIS PERIOD ASSUMING 8.000 PERCENT DISCOUNT RATE

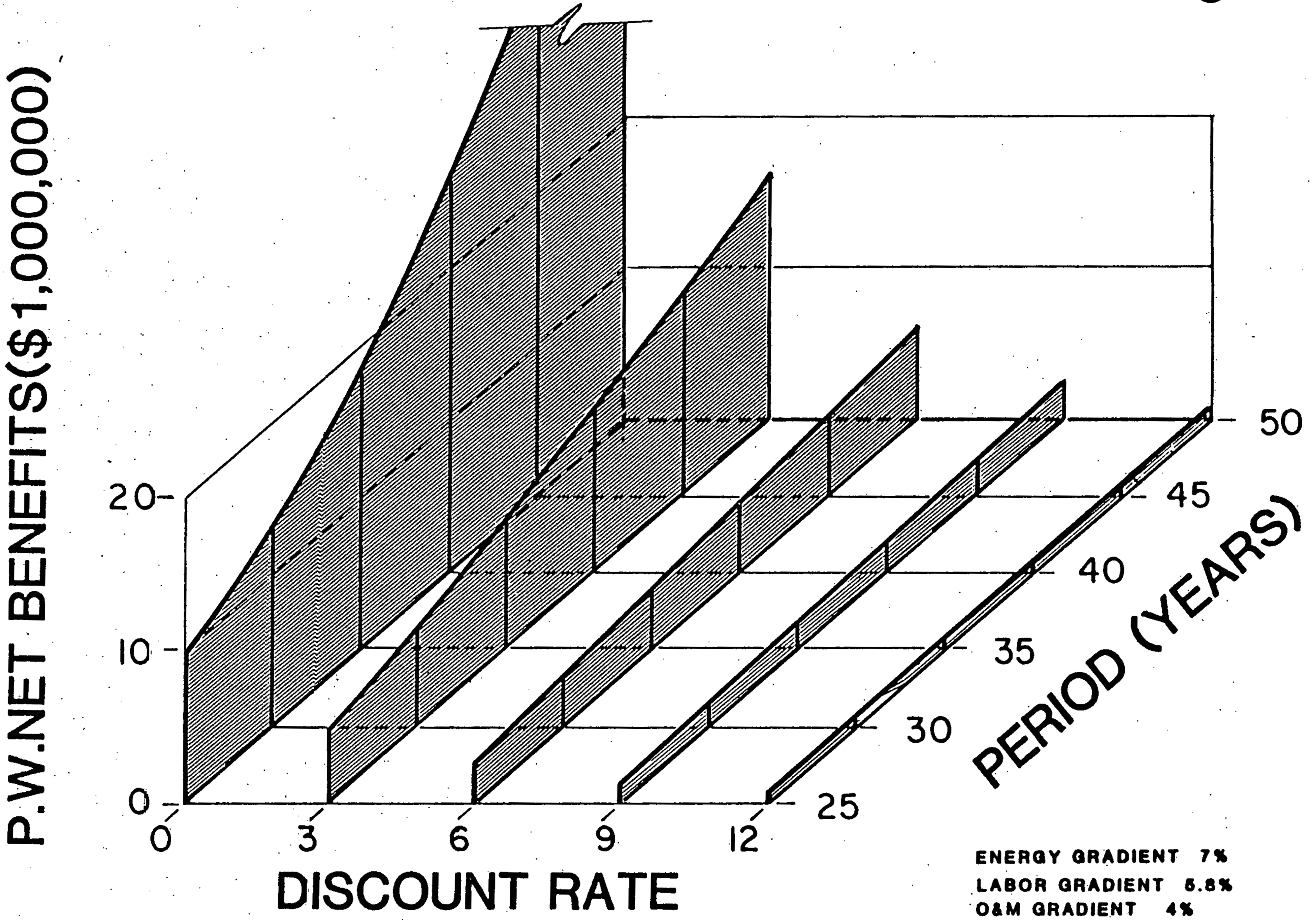
YR.	CAPITAL	+ LABOR	+ POWER	+ O & M	+ PWR.CR.	= NET	CUM. PW
0.	¯1747200					¯1747200	¯1747200
1.	0	¯19709	¯3745	¯57200	76826	¯3828	¯1750744
2.	0	¯20853	¯4007	¯59488	82204	¯2144	¯1752583
3.	0	¯22062	¯4288	¯61868	87958	¯260	¯1752789
4.	0	¯23342	¯4588	¯64342	94115	1843	¯1751434
5.	0	¯24696	¯4909	¯66916	100703	4182	¯1748588
6.	0	¯26128	¯5253	¯69593	107752	6778	¯1744317
7.	0	¯27643	¯5620	¯72376	115295	9656	¯1738683
8.	0	¯29247	¯6014	¯75271	123366	12834	¯1731749
9.	0	¯30943	¯6435	¯78282	132001	16341	¯1723574
10.	0	¯32738	¯6885	¯81413	141241	20205	¯1714215
11.	0	¯34636	¯7367	¯84670	151128	24455	¯1703727
12.	0	¯36645	¯7883	¯88057	161707	29122	¯1692162
13.	0	¯38771	¯8434	¯91579	173027	34243	¯1679571
14.	0	¯41019	¯9025	¯95242	185139	39853	¯1666003
15.	0	¯43398	¯9657	¯99052	198098	45991	¯1651505
16.	0	¯45916	¯10333	¯103014	211965	52702	¯1636121
17.	0	¯48579	¯11056	¯107135	226803	60033	¯1619896
18.	0	¯51396	¯11830	¯111420	242679	68033	¯1602871
19.	0	¯54377	¯12658	¯115877	259667	76755	¯1585086
20.	0	¯57531	¯13544	¯120512	277843	86256	¯1566580
21.	0	¯60868	¯14492	¯125332	297292	96600	¯1547390
22.	0	¯64398	¯15506	¯130346	318103	107853	¯1527551
23.	0	¯68133	¯16592	¯135559	340370	120086	¯1507099
24.	0	¯72085	¯17753	¯140982	364196	133376	¯1486066
25.	0	¯76266	¯18996	¯146621	389690	147807	¯1464483
26.	0	¯80689	¯20326	¯152486	416968	163467	¯1442382
27.	0	¯85369	¯21749	¯158585	446156	180453	¯1419792
28.	0	¯90321	¯23271	¯164929	477387	198866	¯1396740
29.	0	¯95560	¯24900	¯171526	510804	218818	¯1373255
30.	0	¯101102	¯26643	¯178387	546560	240428	¯1349362
31.	0	¯106966	¯28508	¯185522	584819	263823	¯1325086
32.	0	¯113170	¯30503	¯192943	625756	289140	¯1300451
33.	0	¯119734	¯32639	¯200661	669559	316525	¯1275481
34.	0	¯126678	¯34923	¯208687	716429	346141	¯1250197
35.	0	¯134026	¯37368	¯217035	766579	378150	¯1224621
36.	0	¯141799	¯39984	¯225716	820239	412740	¯1198773
37.	0	¯150023	¯42783	¯234745	877656	450105	¯1172674
38.	0	¯158725	¯45777	¯244135	939092	490455	¯1146341
39.	0	¯167931	¯48982	¯253900	1004828	534015	¯1119793
40.	0	¯177671	¯52411	¯264056	1075166	581028	¯1093048
41.	0	¯187976	¯56079	¯274618	1150428	631755	¯1066122
42.	0	¯198878	¯60005	¯285603	1230958	686472	¯1039031
43.	0	¯210413	¯64205	¯297027	1317125	745480	¯1011790
44.	0	¯222617	¯68700	¯308908	1409323	809098	¯984415
45.	0	¯235529	¯73509	¯321265	1507976	877673	¯956920
46.	0	¯249190	¯78654	¯334115	1613534	951575	¯929317
47.	0	¯263643	¯84160	¯347480	1726482	1031199	¯901621
48.	0	¯278934	¯90051	¯361379	1847335	1116971	¯873842
49.	0	¯295112	¯96355	¯375834	1976649	1209348	¯845995
50.	0	¯312229	¯103100	¯390868	2115014	1308817	¯818089
PW	¯1747200	¯575740	¯139293	¯1213322	2857466	¯818089	

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
DELTA CASH FLOW PROGRAM (ΔCFP1)
PROJECT A LESS BASELINE
50 YEAR ANALYSIS PERIOD ASSUMING 8.000 PERCENT DISCOUNT RATE

R.	CAPITAL	+ LABOR	+ POWER	+ O & M	+ PWR.CR.	= NET	CUM. PW
0.	¯902900					¯902900	¯902900
1.	0	98548	¯14659	¯38168	63665	109386	¯801617
2.	0	104263	¯15685	¯39694	68122	117006	¯701303
3.	0	110311	¯16783	¯41283	72890	125135	¯601967
4.	0	116708	¯17958	¯42934	77992	133808	¯503614
5.	0	123477	¯19215	¯44651	83452	143063	¯406248
6.	0	130639	¯20560	¯46437	89293	152935	¯309873
7.	0	138217	¯22000	¯48295	95544	163466	¯214492
8.	0	146232	¯23539	¯50226	102232	174699	¯120107
9.	0	154714	¯25187	¯52236	109388	186679	¯26721
10.	0	163687	¯26950	¯54325	117046	199458	65666
11.	0	173182	¯28836	¯56498	125239	213087	157056
12.	0	183226	¯30855	¯58758	134005	227618	247446
13.	0	193853	¯33015	¯61108	143386	243116	336839
14.	0	205097	¯35326	¯63553	153423	259641	425237
15.	0	216993	¯37799	¯66095	164162	277261	512641
16.	0	229578	¯40445	¯68739	175654	296048	599055
17.	0	242893	¯43276	¯71488	187950	316079	684481
18.	0	256982	¯46305	¯74348	201106	337435	768924
19.	0	271886	¯49546	¯77322	215183	360201	852387
20.	0	287656	¯53015	¯80414	230246	384473	934875
21.	0	304340	¯56726	¯83630	246363	410347	1016392
22.	0	321992	¯60696	¯86976	263609	437929	1096945
23.	0	340667	¯64945	¯90455	282062	467329	1176539
24.	0	360426	¯69492	¯94073	301806	498667	1255178
25.	0	381330	¯74356	¯97836	322932	532070	1332870
26.	0	403448	¯79561	¯101750	345537	567674	1409620
27.	0	426848	¯85130	¯105819	369725	605624	1485437
28.	0	451604	¯91089	¯110052	395606	646069	1560325
29.	0	477797	¯97465	¯114454	423298	689176	1634292
30.	0	505510	¯104288	¯119033	452929	735118	1707346
31.	0	534829	¯111588	¯123794	484634	784081	1779494
32.	0	565849	¯119400	¯128746	518559	836262	1850744
33.	0	598668	¯127757	¯133896	554858	891873	1921103
34.	0	633392	¯136700	¯139251	593698	951139	1990579
35.	0	670128	¯146269	¯144821	635257	1014295	2059181
36.	0	708996	¯156508	¯150615	679725	1081598	2126915
37.	0	750118	¯167463	¯156639	727305	1153321	2193791
38.	0	793624	¯179186	¯162904	778217	1229751	2259817
39.	0	839654	¯191729	¯169421	832692	1311196	2325001
40.	0	888354	¯205150	¯176197	890980	1397987	2389352
41.	0	939879	¯219510	¯183245	953349	1490473	2452878
42.	0	994392	¯234876	¯190575	1020083	1589024	2515587
43.	0	1052067	¯251317	¯198198	1091489	1694041	2577489
44.	0	1113087	¯268910	¯206126	1167893	1805944	2638591
45.	0	1177646	¯287734	¯214371	1249646	1925187	2698903
46.	0	1245949	¯307875	¯222946	1337121	2052249	2758433
47.	0	1318214	¯329426	¯231864	1430720	2187644	2817191
48.	0	1394671	¯352486	¯241139	1530870	2331916	2875183
49.	0	1475562	¯377160	¯250784	1638031	2485649	2932420
50.	0	1561144	¯403561	¯260815	1752693	2649461	2988910
PW	¯902900	2878698	¯545227	¯809617	2367956	2988910	

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
DELTA CASH FLOW PROGRAM (ΔCFP1)
PROJECT B LESS BASELINE
50 YEAR ANALYSIS PERIOD ASSUMING 8.000 PERCENT DISCOUNT RATE

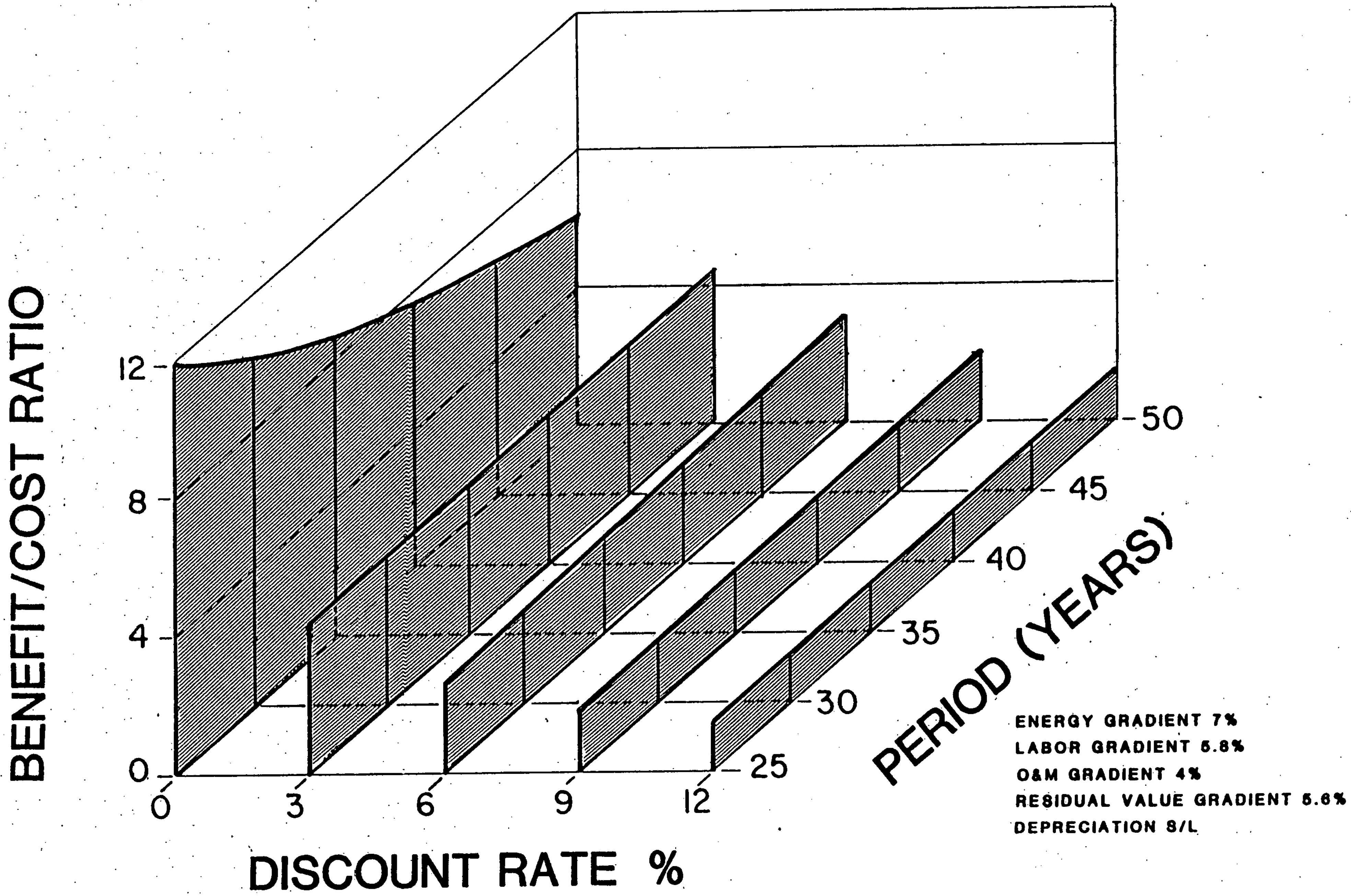
YR.	CAPITAL	+ LABOR	+ POWER	+ O & M	+ PWR.CR.	= NET	CUM. PW
0.	¯1340200					¯1340200	¯1340200
1.	0	98548	¯1819	¯48360	76826	125195	¯1224279
2.	0	104263	¯1946	¯50294	82204	134227	¯1109201
3.	0	110311	¯2083	¯52307	87958	143879	¯994985
4.	0	116708	¯2229	¯54398	94115	154196	¯881646
5.	0	123477	¯2384	¯56574	100703	165222	¯769199
6.	0	130639	¯2552	¯58838	107752	177001	¯657658
7.	0	138217	¯2730	¯61191	115295	189591	¯547034
8.	0	146232	¯2921	¯63638	123366	203039	¯437338
9.	0	154714	¯3126	¯66184	132001	217405	¯328581
10.	0	163687	¯3344	¯68831	141241	232753	¯220772
11.	0	173182	¯3578	¯71585	151128	249147	¯113917
12.	0	183226	¯3829	¯74448	161707	266656	¯8024
13.	0	193853	¯4096	¯77426	173027	285358	96901
14.	0	205097	¯4384	¯80523	185139	305329	200854
15.	0	216993	¯4691	¯83744	198098	326656	303830
16.	0	229578	¯5019	¯87094	211965	349430	405825
17.	0	242893	¯5370	¯90578	226803	373748	506837
18.	0	256982	¯5746	¯94201	242679	399714	606865
19.	0	271886	¯6148	¯97969	259667	427436	705908
20.	0	287656	¯6579	¯101887	277843	457033	803963
21.	0	304340	¯7039	¯105962	297292	488631	901032
22.	0	321992	¯7531	¯110202	318103	522362	997116
23.	0	340667	¯8059	¯114609	340370	558369	1092215
24.	0	360426	¯8623	¯119194	364196	596805	1186331
25.	0	381330	¯9227	¯123961	389690	637832	1279465
26.	0	403448	¯9873	¯128920	416968	681623	1371622
27.	0	426848	¯10564	¯134076	446156	728364	1462804
28.	0	451604	¯11303	¯139440	477387	778248	1553013
29.	0	477797	¯12094	¯145017	510804	831490	1642255
30.	0	505510	¯12941	¯150818	546560	888311	1730533
31.	0	534829	¯13847	¯156850	584819	948951	1817852
32.	0	565849	¯14816	¯163125	625756	1013664	1904216
33.	0	598668	¯15853	¯169650	669559	1082724	1989631
34.	0	633392	¯16962	¯176435	716429	1156424	2074102
35.	0	670128	¯18150	¯183493	766579	1235064	2157635
36.	0	708996	¯19421	¯190833	820239	1318981	2240236
37.	0	750118	¯20780	¯198466	877656	1408528	2321910
38.	0	793624	¯22234	¯206405	939092	1504077	2402665
39.	0	839654	¯23791	¯214661	1004828	1606030	2482506
40.	0	888354	¯25457	¯223247	1075166	1714816	2561441
41.	0	939879	¯27238	¯232177	1150428	1830892	2639476
42.	0	994392	¯29145	¯241464	1230958	1954741	2716618
43.	0	1052067	¯31185	¯251123	1317125	2086884	2792874
44.	0	1113087	¯33369	¯261168	1409323	2227873	2868252
45.	0	1177646	¯35705	¯271615	1507976	2378302	2942760
46.	0	1245949	¯38203	¯282479	1613534	2538801	3016403
47.	0	1318214	¯40878	¯293779	1726482	2710039	3089191
48.	0	1394671	¯43739	¯305530	1847335	2892737	3161131
49.	0	1475562	¯46801	¯317751	1976649	3087659	3232230
50.	0	1561144	¯50077	¯330461	2115014	3295620	3302497
PW	¯1340200	2878698	¯67657	¯1025809	2857465	3302497	



ENERGY GRADIENT 7%
LABOR GRADIENT 5.8%
O&M GRADIENT 4%
RESIDUAL VALUE GRADIENT 5.6%
DEPRECIATION S/L

NORMANSKILL HYDROELECTRIC FACILITY
FEASIBILITY ASSESSMENT-EW-78-F-07-1765

SENSITIVITY
BENEFITSvsDISCOUNTvsPERIOD

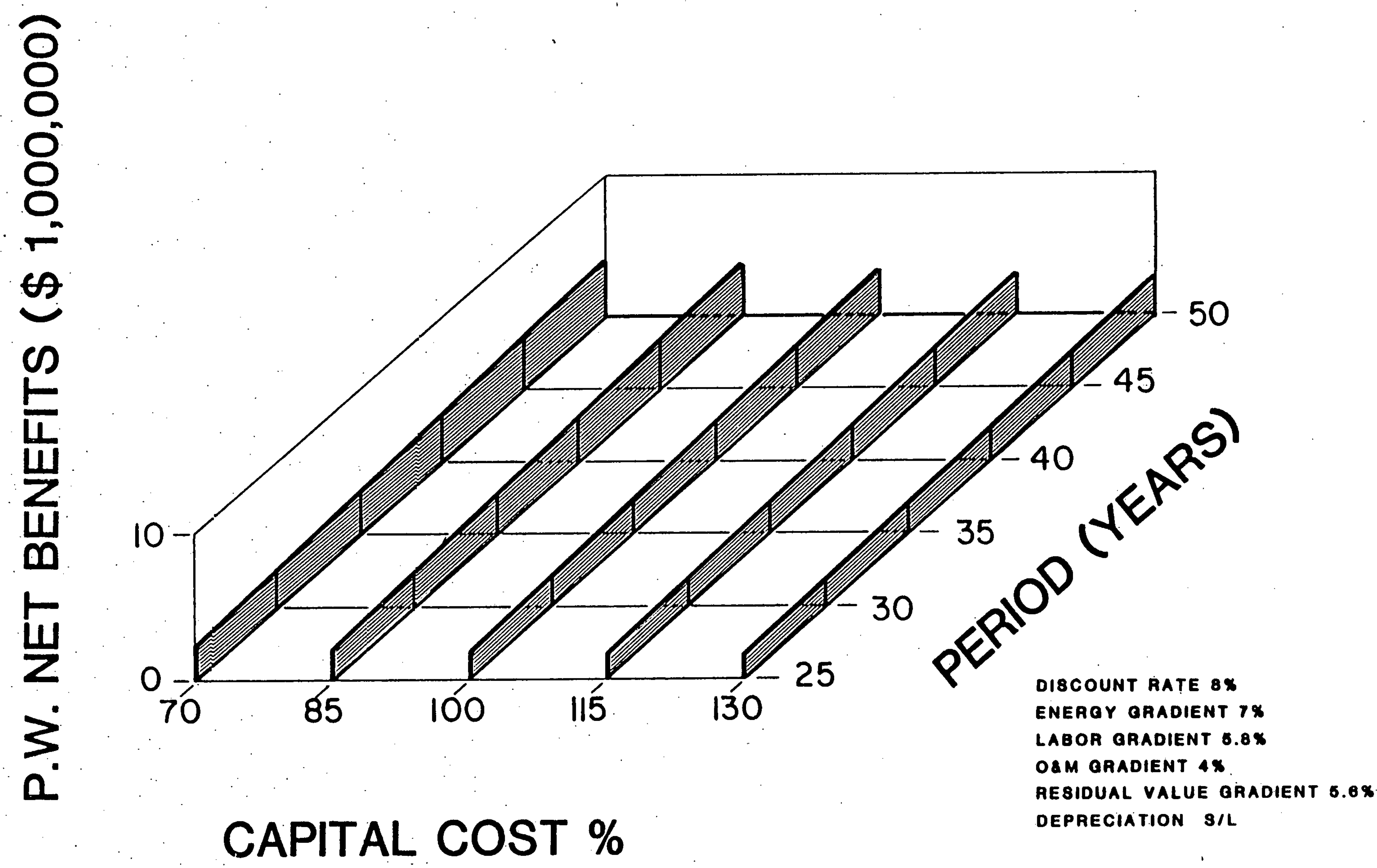


NORMANSKILL HYDROELECTRIC FACILITY
FEASIBILITY ASSESSMENT-EW-78-F-07-1765

SENSITIVITY
B/C RATIOvsDISCOUNTvsPERIOD

DATA MATRIX FOR FIGURES 59 & 60

ANALYSIS PERIOD (YEARS)	DISCOUNT RATE (%/YEAR)	LABOR GRADIENT (%/YEAR)	ENERGY GRADIENT (%/YEAR)	CAPITAL COST FACTOR	P.W. NET BENEFITS ($/1000)	BENEFIT TO COST RATIO
25	.00	5.80	7.00	1.00	9263	11.86
25	3.00	5.80	7.00	1.00	4936	4.33
25	6.00	5.80	7.00	1.00	2610	2.54
25	9.00	5.80	7.00	1.00	1302	1.75
25	12.00	5.80	7.00	1.00	532	1.31
30	.00	5.80	7.00	1.00	13304	10.02
30	3.00	5.80	7.00	1.00	6522	4.38
30	6.00	5.80	7.00	1.00	3240	2.64
30	9.00	5.80	7.00	1.00	1555	1.82
30	12.00	5.80	7.00	1.00	633	1.35
35	.00	5.80	7.00	1.00	18699	8.64
35	3.00	5.80	7.00	1.00	8395	4.43
35	6.00	5.80	7.00	1.00	3905	2.75
35	9.00	5.80	7.00	1.00	1795	1.88
35	12.00	5.80	7.00	1.00	721	1.38
40	.00	5.80	7.00	1.00	25914	7.60
40	3.00	5.80	7.00	1.00	10608	4.47
40	6.00	5.80	7.00	1.00	4605	2.86
40	9.00	5.80	7.00	1.00	2023	1.95
40	12.00	5.80	7.00	1.00	797	1.42
45	.00	5.80	7.00	1.00	35579	6.78
45	3.00	5.80	7.00	1.00	13224	4.51
45	6.00	5.80	7.00	1.00	5340	2.97
45	9.00	5.80	7.00	1.00	2236	2.01
45	12.00	5.80	7.00	1.00	861	1.44
50	.00	5.80	7.00	1.00	48548	6.13
50	3.00	5.80	7.00	1.00	16317	4.54
50	6.00	5.80	7.00	1.00	6109	3.08
50	9.00	5.80	7.00	1.00	2435	2.07
50	12.00	5.80	7.00	1.00	915	1.47

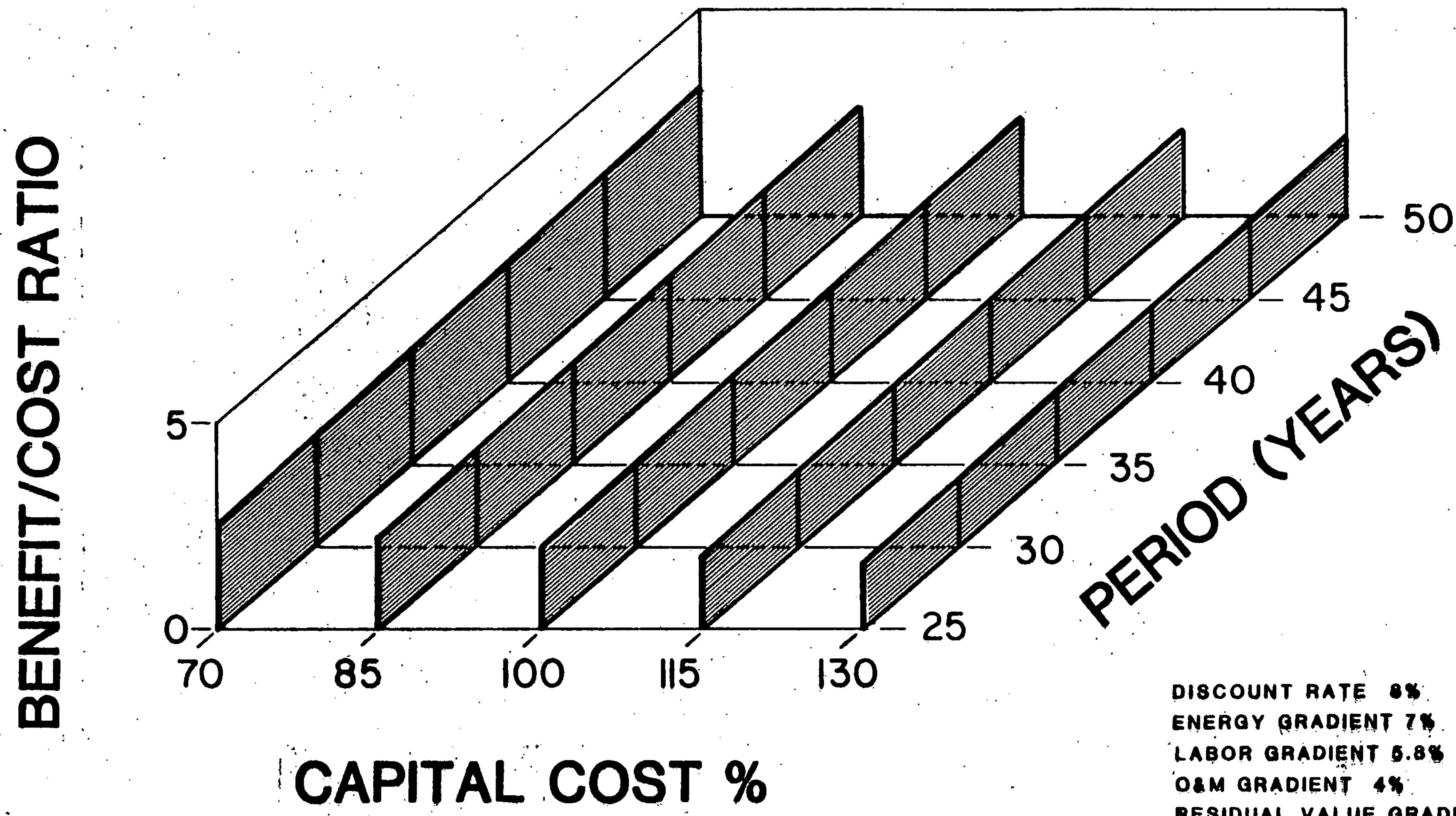


NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

SENSITIVITY

NET BENEFITS vs CAP. COST vs PERIOD

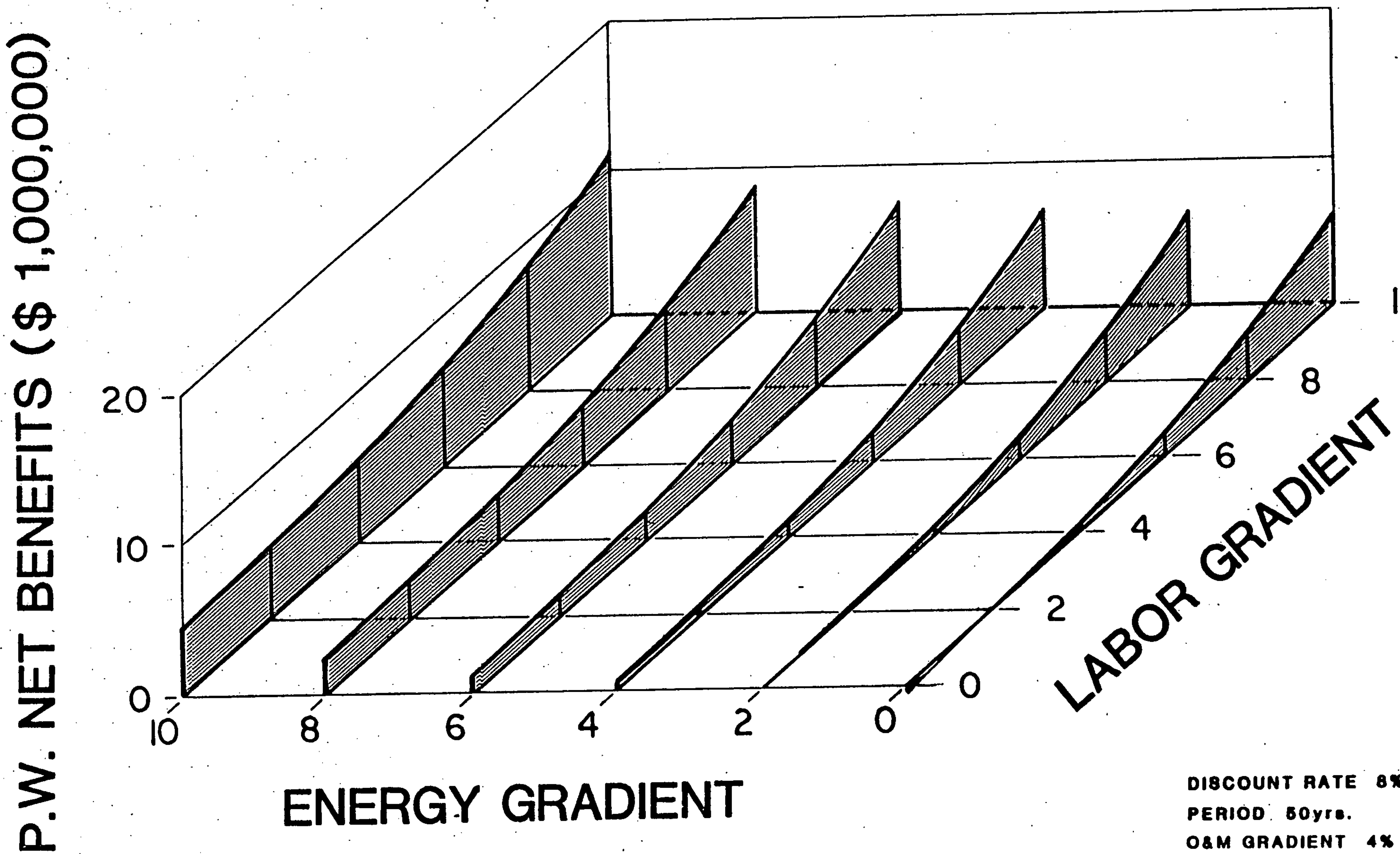


DISCOUNT RATE 8%
ENERGY GRADIENT 7%
LABOR GRADIENT 5.8%
O&M GRADIENT 4%
RESIDUAL VALUE GRADIENT 5.6%
DEPRECIATION S/L

SENSITIVITY
B/C RATIO vs CAP. COST vs PERIOD

DATA MATRIX FOR FIGURES 62 & 63

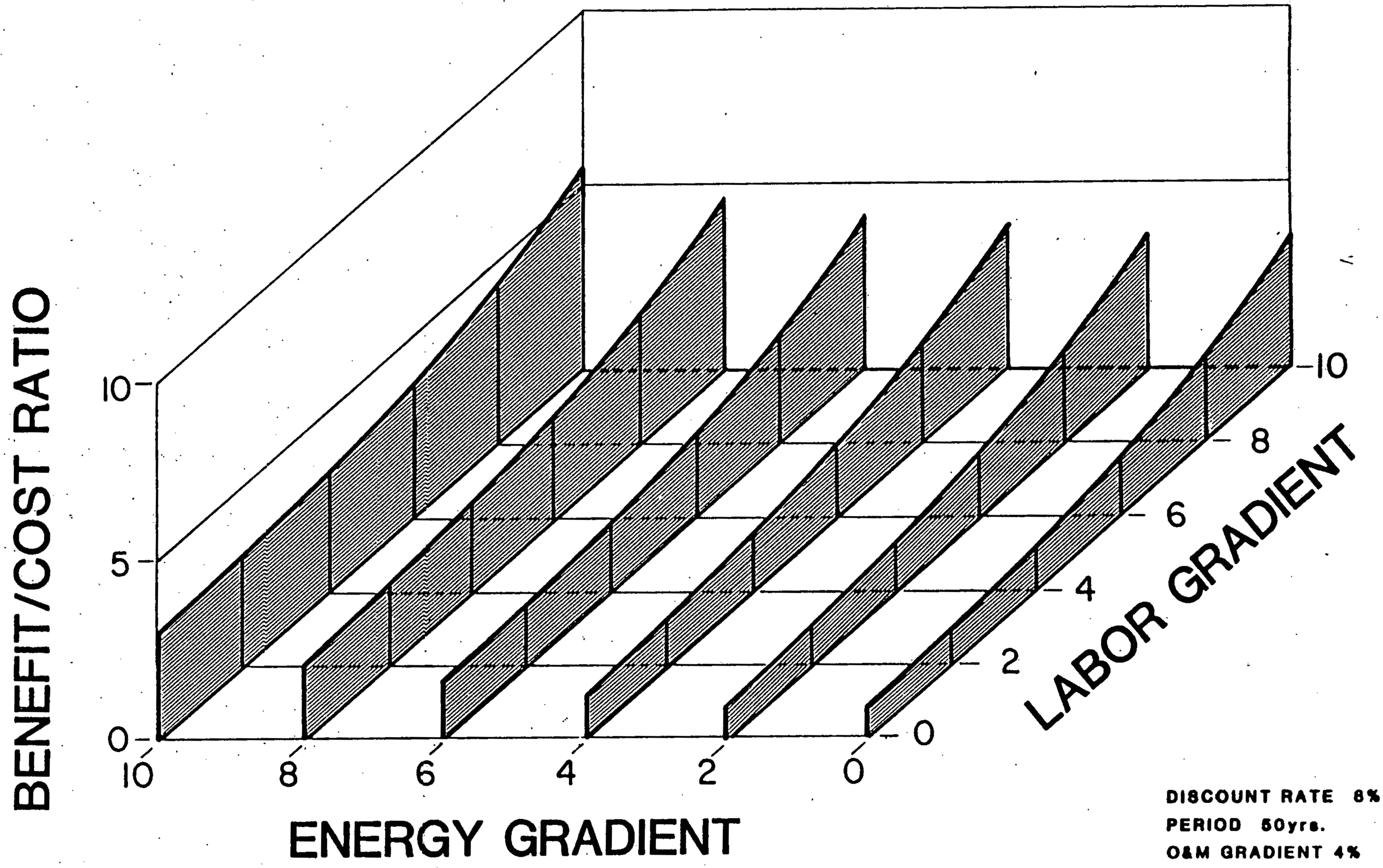
ANALYSIS PERIOD (YEARS)	DISCOUNT RATE (%/YEAR)	LABOR GRADIENT (%/YEAR)	ENERGY GRADIENT (%/YEAR)	CAPITAL COST FACTOR	P.W. NET BENEFITS ($/1000)	BENEFIT TO COST RATIO
25	8.00	5.80	7.00	.70	2036	2.50
25	8.00	5.80	7.00	.85	1849	2.20
25	8.00	5.80	7.00	1.00	1662	1.96
25	8.00	5.80	7.00	1.15	1474	1.77
25	8.00	5.80	7.00	1.30	1287	1.61
30	8.00	5.80	7.00	.70	2421	2.60
30	8.00	5.80	7.00	.85	2212	2.28
30	8.00	5.80	7.00	1.00	2004	2.04
30	8.00	5.80	7.00	1.15	1795	1.84
30	8.00	5.80	7.00	1.30	1586	1.68
35	8.00	5.80	7.00	.70	2793	2.70
35	8.00	5.80	7.00	.85	2567	2.37
35	8.00	5.80	7.00	1.00	2341	2.12
35	8.00	5.80	7.00	1.15	2114	1.91
35	8.00	5.80	7.00	1.30	1888	1.74
40	8.00	5.80	7.00	.70	3152	2.80
40	8.00	5.80	7.00	.85	2911	2.46
40	8.00	5.80	7.00	1.00	2671	2.20
40	8.00	5.80	7.00	1.15	2430	1.98
40	8.00	5.80	7.00	1.30	2189	1.81
45	8.00	5.80	7.00	.70	3497	2.90
45	8.00	5.80	7.00	.85	3244	2.55
45	8.00	5.80	7.00	1.00	2992	2.28
45	8.00	5.80	7.00	1.15	2739	2.06
45	8.00	5.80	7.00	1.30	2486	1.87
50	8.00	5.80	7.00	.70	3827	3.00
50	8.00	5.80	7.00	.85	3565	2.64
50	8.00	5.80	7.00	1.00	3302	2.36
50	8.00	5.80	7.00	1.15	3040	2.13
50	8.00	5.80	7.00	1.30	2778	1.94



DISCOUNT RATE 8%
PERIOD 50yrs.
O&M GRADIENT 4%

SENSITIVITY

BENEFITS vs ENERGY vs LABOR



NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

SENSITIVITY

B/C RATIOvsENERGYvsLABOR

DATA MATRIX FOR FIGURES 65 & 66

ANALYSIS PERIOD (YEARS)	DISCOUNT RATE (%/YEAR)	LABOR GRADIENT (%/YEAR)	ENERGY GRADIENT (%/YEAR)	CAPITAL COST FACTOR	P.W. NET BENEFITS ($/1000)	BENEFIT TO COST RATIO
50	8.00	.00	.00	1.00	¯369	.85
50	8.00	2.00	.00	1.00	¯16	.99
50	8.00	4.00	.00	1.00	546	1.23
50	8.00	6.00	.00	1.00	1489	1.62
50	8.00	8.00	.00	1.00	3149	2.32
50	8.00	10.00	.00	1.00	6191	3.59
50	8.00	.00	2.00	1.00	¯103	.96
50	8.00	2.00	2.00	1.00	250	1.10
50	8.00	4.00	2.00	1.00	812	1.34
50	8.00	6.00	2.00	1.00	1755	1.73
50	8.00	8.00	2.00	1.00	3415	2.43
50	8.00	10.00	2.00	1.00	6457	3.70
50	8.00	.00	4.00	1.00	320	1.13
50	8.00	2.00	4.00	1.00	673	1.28
50	8.00	4.00	4.00	1.00	1235	1.51
50	8.00	6.00	4.00	1.00	2178	1.91
50	8.00	8.00	4.00	1.00	3838	2.60
50	8.00	10.00	4.00	1.00	6880	3.86
50	8.00	.00	6.00	1.00	1030	1.43
50	8.00	2.00	6.00	1.00	1383	1.57
50	8.00	4.00	6.00	1.00	1945	1.80
50	8.00	6.00	6.00	1.00	2888	2.19
50	8.00	8.00	6.00	1.00	4547	2.88
50	8.00	10.00	6.00	1.00	7590	4.14
50	8.00	.00	8.00	1.00	2278	1.93
50	8.00	2.00	8.00	1.00	2632	2.07
50	8.00	4.00	8.00	1.00	3194	2.30
50	8.00	6.00	8.00	1.00	4137	2.69
50	8.00	8.00	8.00	1.00	5796	3.36
50	8.00	10.00	8.00	1.00	8838	4.61
50	8.00	.00	10.00	1.00	4568	2.82
50	8.00	2.00	10.00	1.00	4921	2.96
50	8.00	4.00	10.00	1.00	5483	3.19
50	8.00	6.00	10.00	1.00	6426	3.56
50	8.00	8.00	10.00	1.00	8086	4.23
50	8.00	10.00	10.00	1.00	11128	5.44

IMPLEMENTATION PLAN

It has been determined as a matter of policy by the site owner, the City of Watervliet, New York, that a decision on pursuing the Normanskill Hydroelectric Facility Project will be made only after several public hearings held for the benefit of the city taxpayers. A referendum for such a project will not be required. It is expected that such public hearings will involve discussion of two configuration alternatives. One would be the alternative judged the optimum most feasible resulting in maximum benefits over the life of the project. The second would be a "no project" alternative representing the maintenance of the existing facility alternative with its attendant ramifications for increased energy costs to the city. Acting under municipal law statutes of the State of New York, the only legal requirements for implementation of a selected project would be a majority vote of the two City Councilmen and the Mayor.

PERT

A PERT (Program Evaluation Review Technique) preliminary activity chart has been prepared and is shown as Figure 69. This technique will be used throughout the design, licensing and construction of the proposed Normanskill Hydroelectric Facility as a means of identifying and eliminating undue time delay. The PERT program to be used will operate on the estimated time completion basis using the standard distribution [Ref. 33] calculated from several estimates varying from most optimistic to most pessimistic. The figure illustrated here is diagrammatic in nature and is not intended to represent all activities and nodes. It is anticipated that during the process of design and licensing construction, the more specific activities will be identified and logged. As can be seen from an examination of Figure 69, the most identifiable and least accurate estimate of time delay is in the licensing process. The decision has been made in the preliminary PERT analysis for application of a Federal Energy Regulatory Commission permit prior to license as permitted under the present draft regulations [Ref. 83]. It is hoped that through this process, any initial conceptual problems with the license application will be identified at an early stage and will serve to expedite the formal license review. As shown on Figure 69,, the earliest (most optimistic) power on-line date is March 1982. It is emphasized that this is based upon the preliminary estimate only. (Note: Immediately prior to issuance of this report, Executive Order 12129 was issued. See Chapter 7 of this report for particulars).

Financing

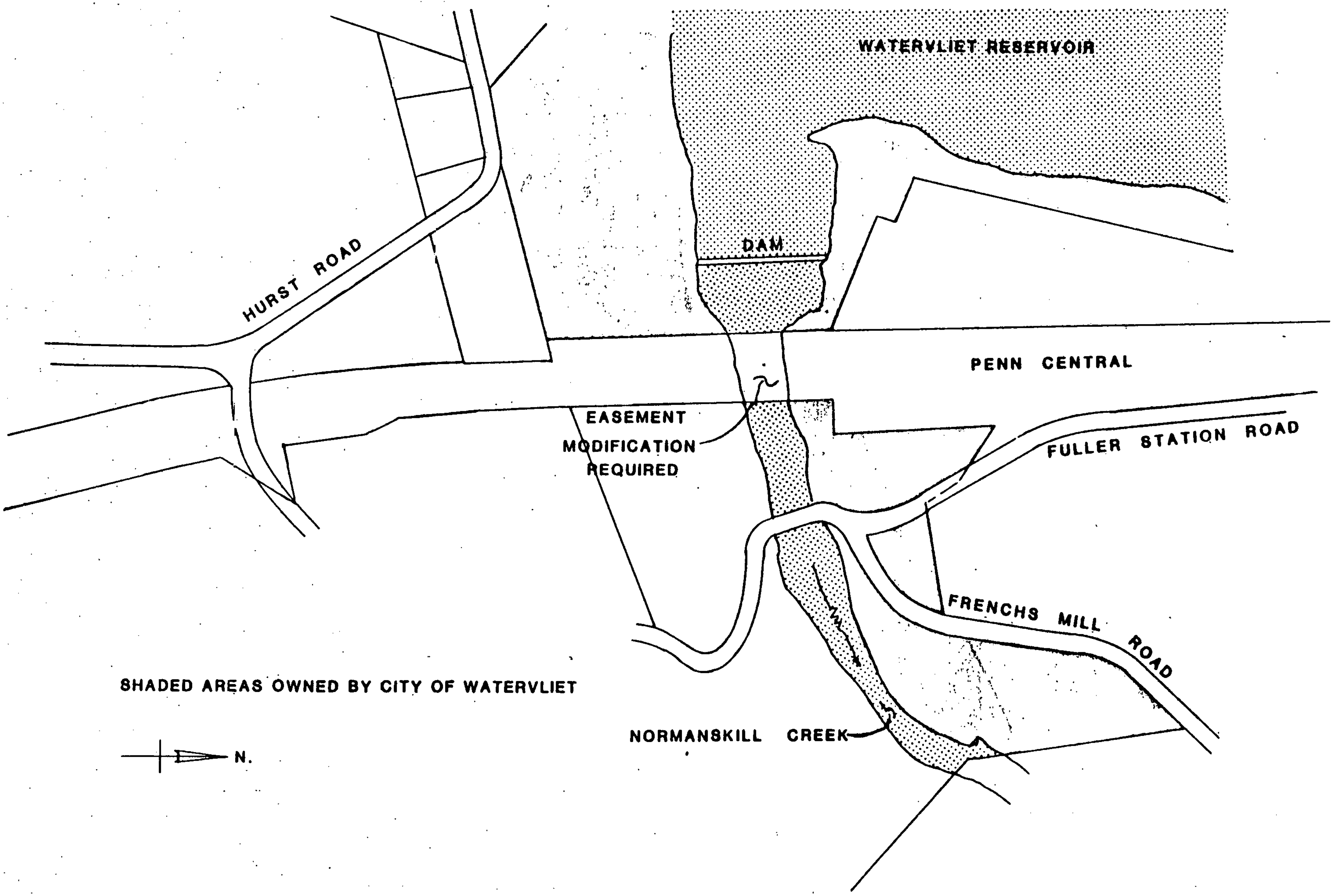
Various vehicles were investigated to determine their desirability with regard to the financing of the construction phase of the hydroelectric project. Municipal bonding, Industrial Development Authority bonding, Environmental Facility Corporation bonding, and private financing (lease) were reviewed for this purpose. Municipal bonding appears to be the most attractive avenue for consideration. This form of bonding could either be through the General or Water Fund. Each requires the same course of action. The City Council would pass a resolution citing the reasons for borrowing and the amount sought. Pending approval of a commercial bank, bond anticipation notes would be issued to the city. For the first year only interest would have to be paid on these notes. If desired, the notes could be extended and renewed for an additional two years. As the bond market dictates, a bond sale would be held, for the issuance of municipal bonds. Water fund bonding has no effect upon the general borrowing power of the city, while general bonding does. The water bonds could extend for a period of 40 years, while general bonds usually hold a 20-year maturity.

City and County Industrial Development Authority (I.D.A.) bonding were eliminated from consideration due to the fact that for a project of this type, they could not legally be a bonding agent without action by the New York State Legislature to modify the I.D.A.'s charters.

Similarly, The N.Y.S. Environmental Facilities Corporation was found to be unavailable for financing purposes. This public benefit corporation is commissioned to grant funding for sewer projects only and cannot offer their services for this type of project.

Private financing was discussed with Niagara-Mohawk Power Corporation and, as mentioned in the Marketing section, Niagara-Mohawk Power Corporation would rather purchase the facility rather than lease it. The Power Authority of the State of New York (PASNY) also showed no interest in leasing the facility.

Whether the city finances the project through municipal bonding or federal loans are granted, the decisions and legal responsibility will be that of the City Council.



NORMANSKILL HYDROELECTRIC FACILITY

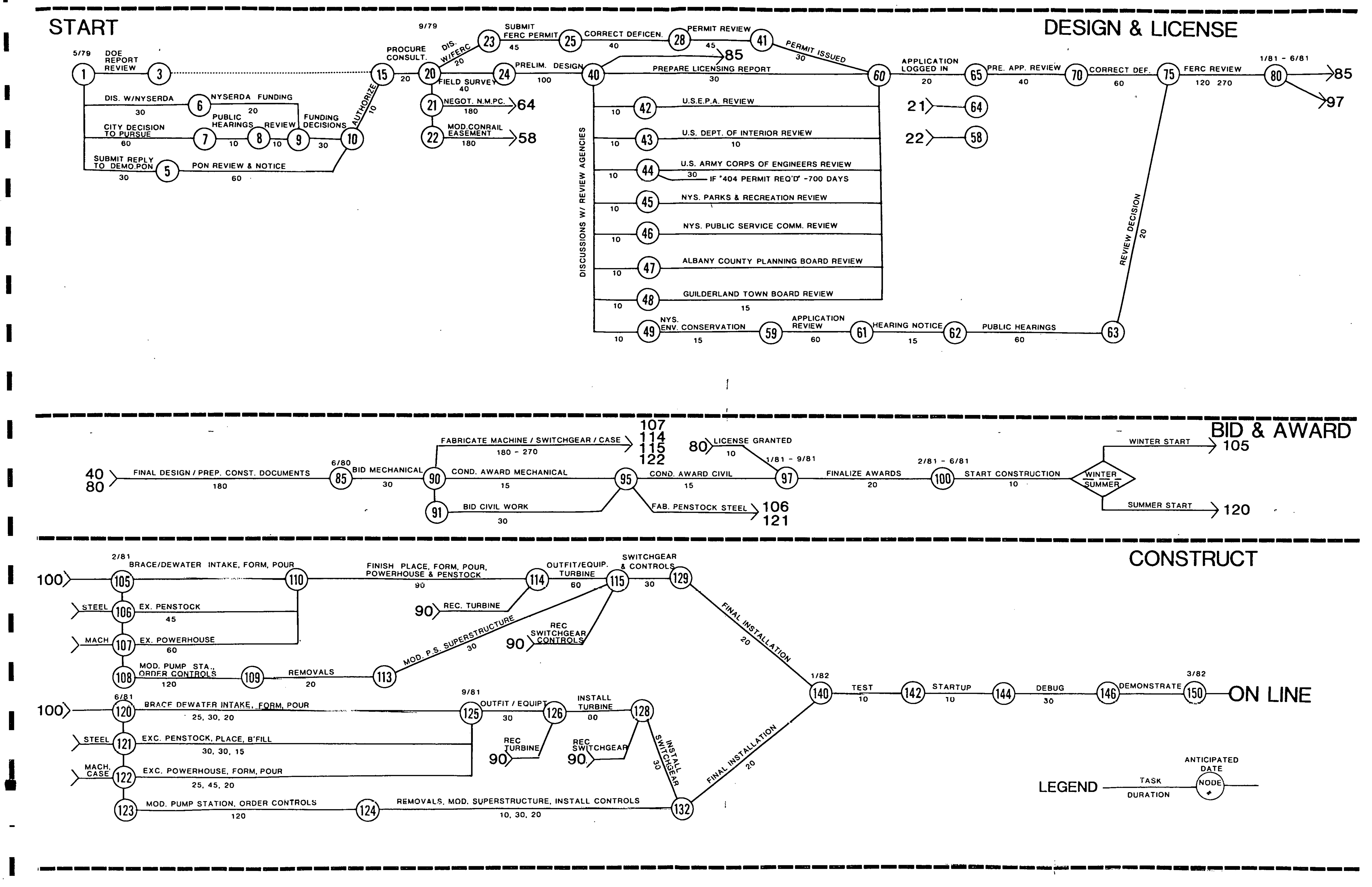
FEASIBILITY ASSESSMENT-EW-78-F-07-1765

PROPERTY MAP

PERT CHART

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



SYNOPSIS AND RECOMMENDATIONS

Recommended Project

The recommended project for implementation is Project B. This project is considered to maximize potential hydroelectric generating capacity at the existing Normans Kill site. This project would produce 68% of potential hydroelectric capacity at the site. In this project, a new intake would be constructed at Bay 5 of the existing reinforced concrete dam. The intake (Figures 71, 71A) would consist of a reinforced concrete appendage to the upstream face of the dam with the outer walls of the intake resting upon buttresses 5 and 6. The intake platform would be situated at Elevation 264, above design flood high water. Access to the intake platform would be via an internal stairway within the intake and the existing catwalk and stairway at the south abutment of the dam. The intake would consist of a stop log recess with a coarse grating consisting of reinforced concrete columns approximately two feet on center. Following the stop log recess, an intake sluice approximately eight feet square will be situated to control flow to the bar rack and penstock. A bar rack approximately 100 square feet in area will consist of A242 steel bars approximately two inches on center with a net to gross area ratio of 0.65. Velocity through the bar rack will be limited to two feet per second to minimize problems of frazil ice. The bar rack will be manually cleanable from the intake platform with provision made for a trash sluiceway at Elevation 257. Following the intake rack, a concrete transition to the welded steel penstock will be made exiting the dam with an invert elevation of approximately 212. Due to the minimal existing spillway capacity during standard project design flood and because of the fact that the proposed intake would block or eliminate approximately 18 feet of weir crest, an overflow siphon will be constructed integral with the intake on either side of it. The siphons will have a flow capacity equal to the capacity of the existing 18 foot section of crest. The sluice gate will be motor operated controllable from the powerhouse. Necessary railings and personnel safeguards will also be provided.

The penstock under Project B consists of a 72 inch welded steel conduit encased in concrete below the existing streambed. After embedment of the penstock beneath the streambed, the existing streambed rock would be replaced to its original state presenting a aesthetic appearance similar to that now existing. It is anticipated that construction of this penstock would involve blasting and removal of the streambed rock during low or no-flow periods during the construction season.

The powerhouse under Project B will consist of an underground vault constructed beneath the streambed (Figures 72, 73, 73A). The powerhouse will be constructed of reinforced concrete and will house a horiziontal axial flow tubular type turbine. The powerhouse will connect to an entry/access riser located adjacent to French's Mill Road. The connection to this access structure will be through an eight foot square reinforced concrete tunnel. Certain operating controls and local control panels for the turbine/generator will be located in this access structure. Switch gear associated with Project B (see Figure 75) will include generator protection relaying, an automatic synchronizing device, phase differential protective relays, overcurrent relaying, and overhead line protection relays. Switch gear from the generator to connection with the 2,400 volt bus will be located at the access structure above high water level. The switch gear will also include an above ground 2400 volt overhead transmission line to the existing pump/control station where the necessary motor starters, step-up transformers and utility tie will be located.

The axial flow tubular machine suggested for Project B will operate at a maximum design flow of 200 cfs, a gross head of 64.4 feet, and a corresponding net head of 60.9 feet at design flow. The runner will have an approximate diameter of 35 inches and will be a five blade type. Setting of the turbine will be approximately four feet below design tail water. The turbine will operate with a specific speed of approximately 120 and will be connected through a speed increaser to a 1,000 KVA generator. The generator will be a three-phase synchronous and operated at 2,400 volts AC. The turbine will be equipped with an inlet butterfly valve upstream from the runner and the runner will be of the adjustable blade type. The composite efficiency of the machine will exceed 81.0%. Ancillary equipment included in Project B will consist of a turbine control panel. Necessary control information to and from the local control panel will be transmitted to the facility computer to be located at the existing pumping/control station via a fiber optic digital telemetry line. Additional ancillary equipment located at the powerhouse will include a breathable gas fire extinguishing protection system and station battery (for operation under black-start conditions). A control schematic indicating relationships of the various turbine control, safety and monitoring devices and the relationships with the facility control system is shown on Figure 76. The controls necessary to operate the turbine will include voltage and amperage and power factor meters, watt hour meters, and ground flow controls. Sensing systems capable of sensing reservoir elevation as well as indications of stream flow, rainfall, and ground moisture from two locations in the watershed will serve as input to a 32K core digital computer located at the pumping/control station. This computer will be programmed to operate the hydroelectric and pumping station facility in an unattended mode with minimal supervision from a host computer to be located at the Watervliet Water Filtration Plant in the City of Watervliet. Costs for this host supervisory computer are not included in the hydroelectric project. The on-site computer would include off-line disc storage, cathode ray tube input/output as well as a priority interrupt control structure. The computer will interface through communications modums to the remote watershed sensors as well as to the host computer.

The recommended mode of operation for the composed Project B Normanskill Hydroelectric Facility will be fully automatic. Two automatic options will be allowed. The first automatic control option will permit the local turbine/generator control panel to automatically vary turbine load based upon reservoir level with a preset control deadband. The second automatic control option will permit the local turbine/generator control panel to automatically vary load in proportion to a load set point signal determined by a load decision routine operating in the on-site digital computer. This load decision routine serves as the keystone element in a control algorithm for the Normanskill Hydroelectric facility. It has been determined in the hydrologic phase of this feasibility assessment that optimum operation of the hydroelectric facility (that is, operation maximizing hydroelectric output in relation to the market benefit function while at the same time minimizing disruptions of reservoir level) will operate most efficiently if short-term predictions of reservoir inflows can be obtained. This relationship is due in part to the large size of the watershed in relation to the rather limited reservoir capacity. Anticipation of inflow conditions and moderate drawdown in anticipation of inflow will serve to capture runoffs from storm events which would otherwise be lost. While at certain times of the year it might be feasible to operate the hydroelectric generation equipment in an automatic mode with the reservoir level as the sole criteria for load decision, it is expected that for a large portion of the year this mode of operation will be inadequate. It is anticipated that the reservoir level deadband necessary to achieve stable turbine operation may itself be of a magnitude similar to the maximum allowable three feet drawdown. For this reason, it is anticipated that for most of the operating year an operating model based upon the particular hydrologic characteristics of the watershed will serve as the load decision input to the turbine control. This control model will regulate the generator load point in relation to a calculated reservoir inflow using the storage characteristics of the reservoir as buffer. Data relating to the expected energy consumption patterns of the City will be programmed into the model as well as decision rules based upon the negotiated power accounting rules between the City and Niagara Mohawk Power Corporation. The control model will decide, for example, on the basis of City power consumption whether to ration the expected inflows by operating at low load points so as to extend operation of water pumping units under City produced power or to generate at full load to offset anticipated in-city power consumption. The routine will use as its source data for prediction of the streamflow into the reservoir, current data received from the remote sensing stations as well as long-term historical data. The long-term historical data base used to initialize the control model will be that of this feasibility assessment. The means used for correlating rainfall and ground moisture to streamflow will be a multivariate analysis technique relating the observed coefficients to measured streamflow responses. However, as an aid in determining and updating the appropriate changes in system characteristics and parameters, a technique known as a Kalman filter will be used [Ref. 52]. This control method estimates the state, in this case the streamflow, by updating the estimation of the state at the previous time frame, using a weighted component of all observed variables at the current state. This technique lends itself quite readily to prediction of short-term phenomena such as are observed in the response of a small reservoir to a large watershed. The Kalman filter technique has the added advantage of improving its own accuracy through feedback, requiring minimal computational capacity.

Economic Criteria

The proposed project has a present worth net cost of $3,099,800. The benefit cost ratio is 2.36. The corresponding internal rate of return is 16.24%. Cash flows for Project B are depicted on Figure 58. Since the cash flows depicted use the convention of capital cost shown as a lump sum disbursement rather than amortized, a schedule of receipts and disbursements has been prepared and is shown on Figure 77. This schedule represents a cash flow summary for a 50-year period for Project B. This schedule depicts the capital cost amortized over 25 years utilizing the expected City of Watervliet municipal bonding rate of 6.3%. Furthermore, the amortization cash flow is calculated using the "50% Rule" as mandated by the New York State Division of Audit & Control for municipal bonding.

Further Criteria

It is a matter of historical precedent that electric generation construction costs are sometimes examined on a basis of cost per kilowatt installed. We would suggest that for a project such as Project B, operating over a wide range of load factor, that this yardstick is not relevant. However, based upon a total capital cost of $1,747,000 and with an installed net electric generating capacity of 842 kilowatts, the net cost per installed kilowatt is $2,075.

Similarly, a unit cost per kilowatt hour produced is sometimes used as a guideline. In this particular case, with a unique benefit cost structure, unique considerations, labor-saving, etc., it is not felt this unit pricing guideline is an accurate indication of project feasibility. However, the first year operating cost (which would be expected to be the highest operating cost due to the 50% amortization rule on capital cost) would be approximately $0.041 per kilowatt hour. Other values for this unit price calculated for various years of the expected life of the facility are as follows:

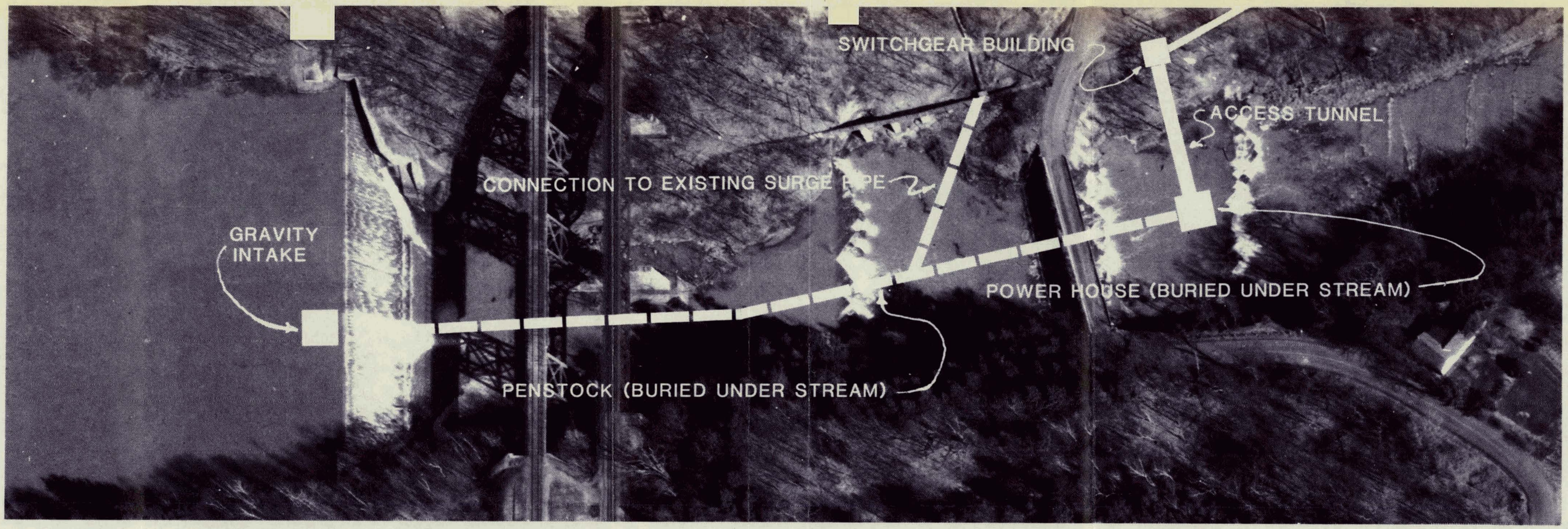
Year	Cost per Kilowatt Hour
Year 1	$ 0.041
Year 10	0.023
Year 20	0.014
Year 30	+0.103
Year 40	+0.228
Year 50	+0.484

It is estimated that the proposed hydroelectric generating facility at the French's Mills site, City of Watervliet Reservoir will replace approximately 6,000 barrels of foreign oil per year. This is based upon the assumption that the marginal power produced by the local utility is foreign oil produced and assumes a 30% conversion efficiency with an oil energy equivalent of 5.8×10^6 BTU per barrel [Ref. 81].

Conclusions

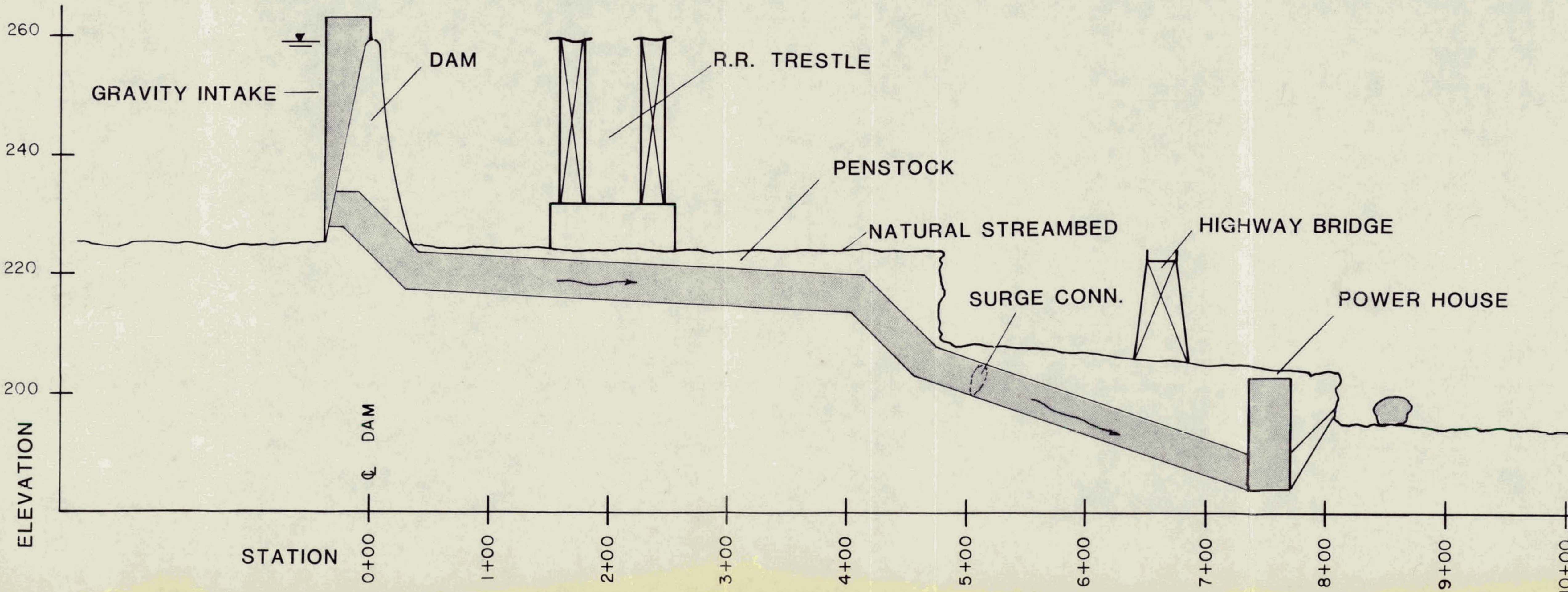
Based upon technical, environmental and economic feasibility, the site owner, the City of Watervliet, New York, should pursue implementation of selected Project B for hydroelectric generation at the Watervliet Reservoir at French's Mills.

SELECTED OPTION No. 8.07



PLAN

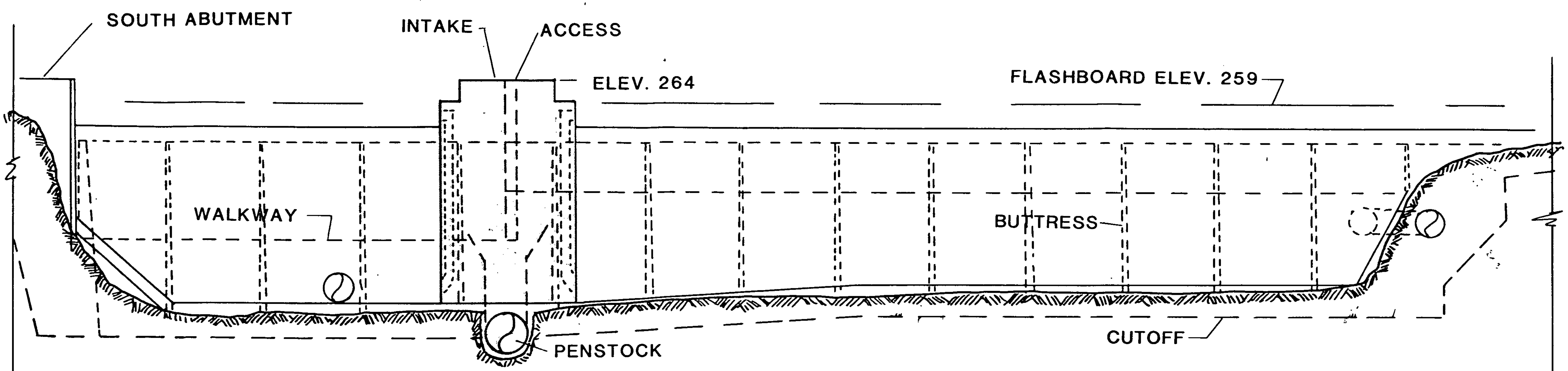
(SEE FIGURE 41H)



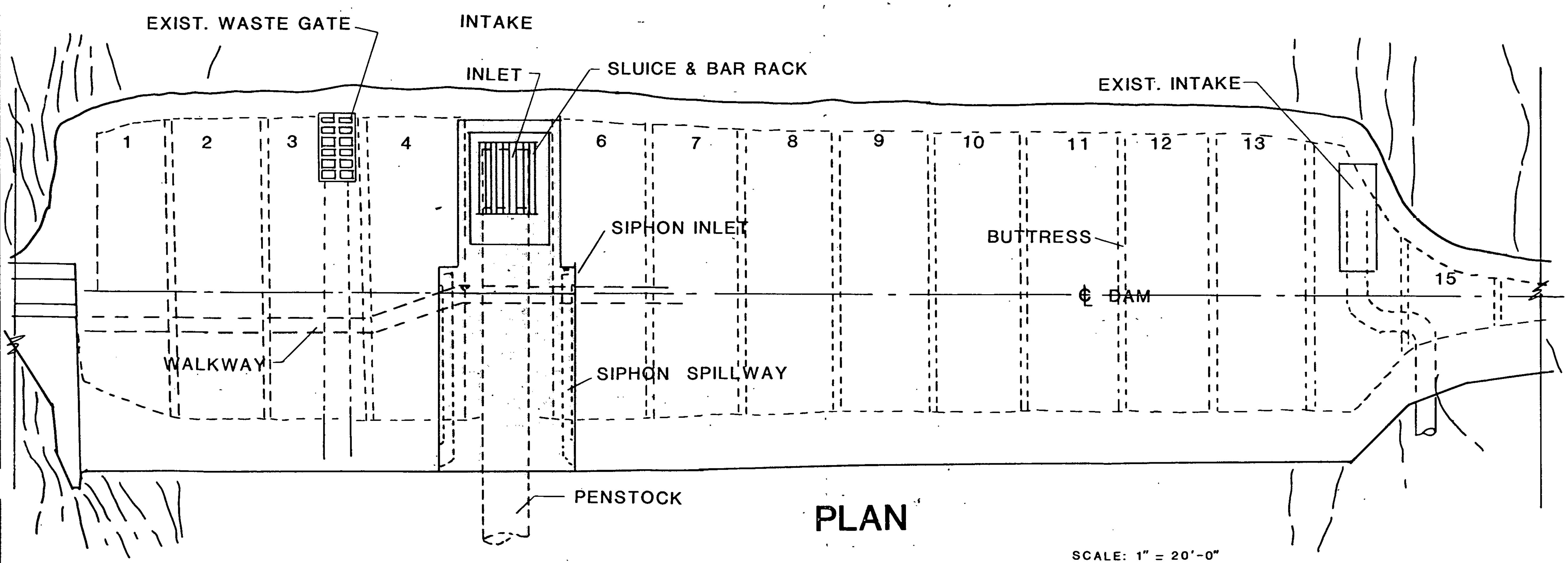
PROFILE

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



ELEVATION

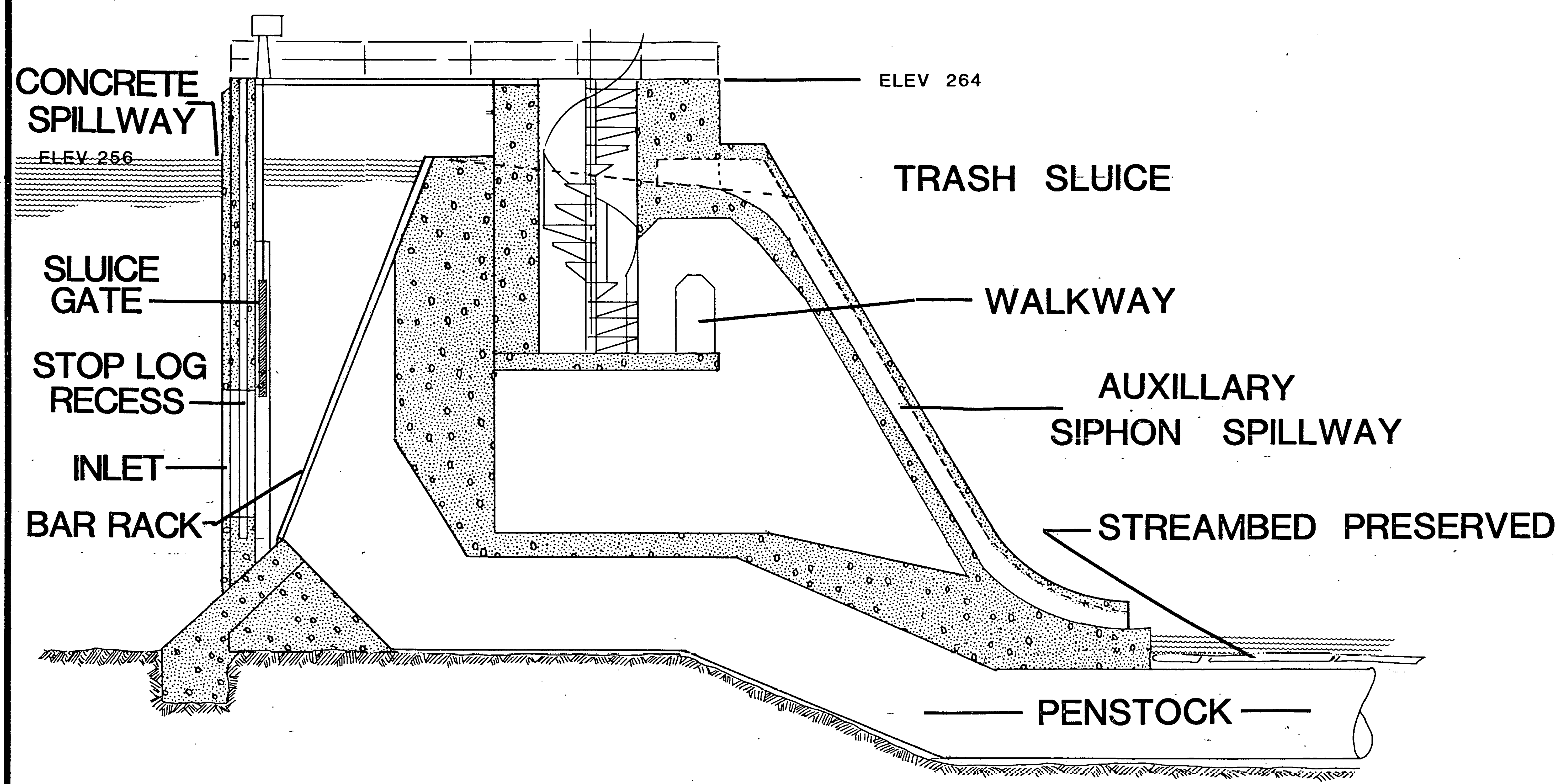


PLAN

PROPOSED INTAKE AT DAM

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT -EW-78-F-07-1765



DAM SECTION AT BAY #5

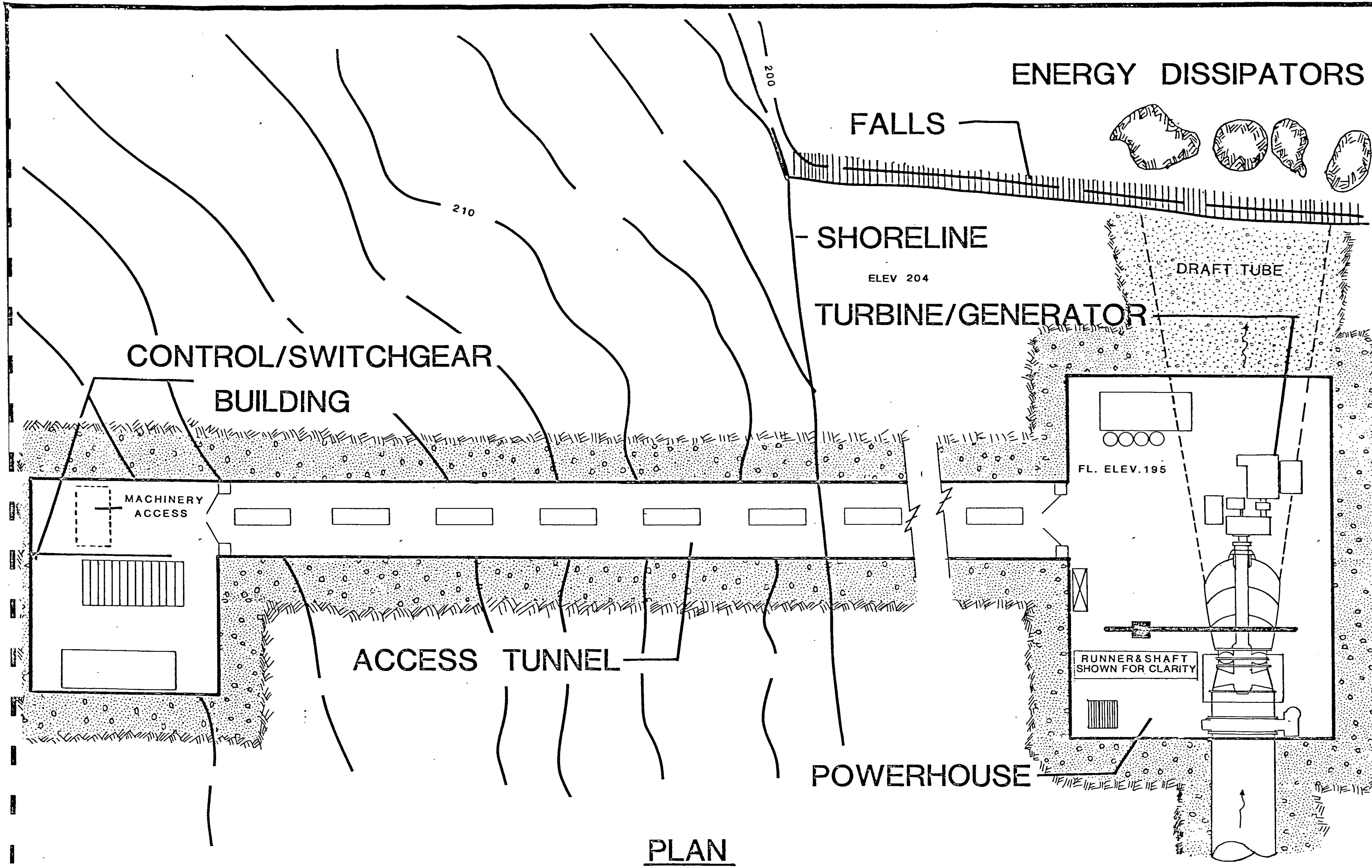
SCALE 1" 8'-0"

71A

PROPOSED INTAKE SECTION

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



PLAN

SCALE 1/8"= 1'

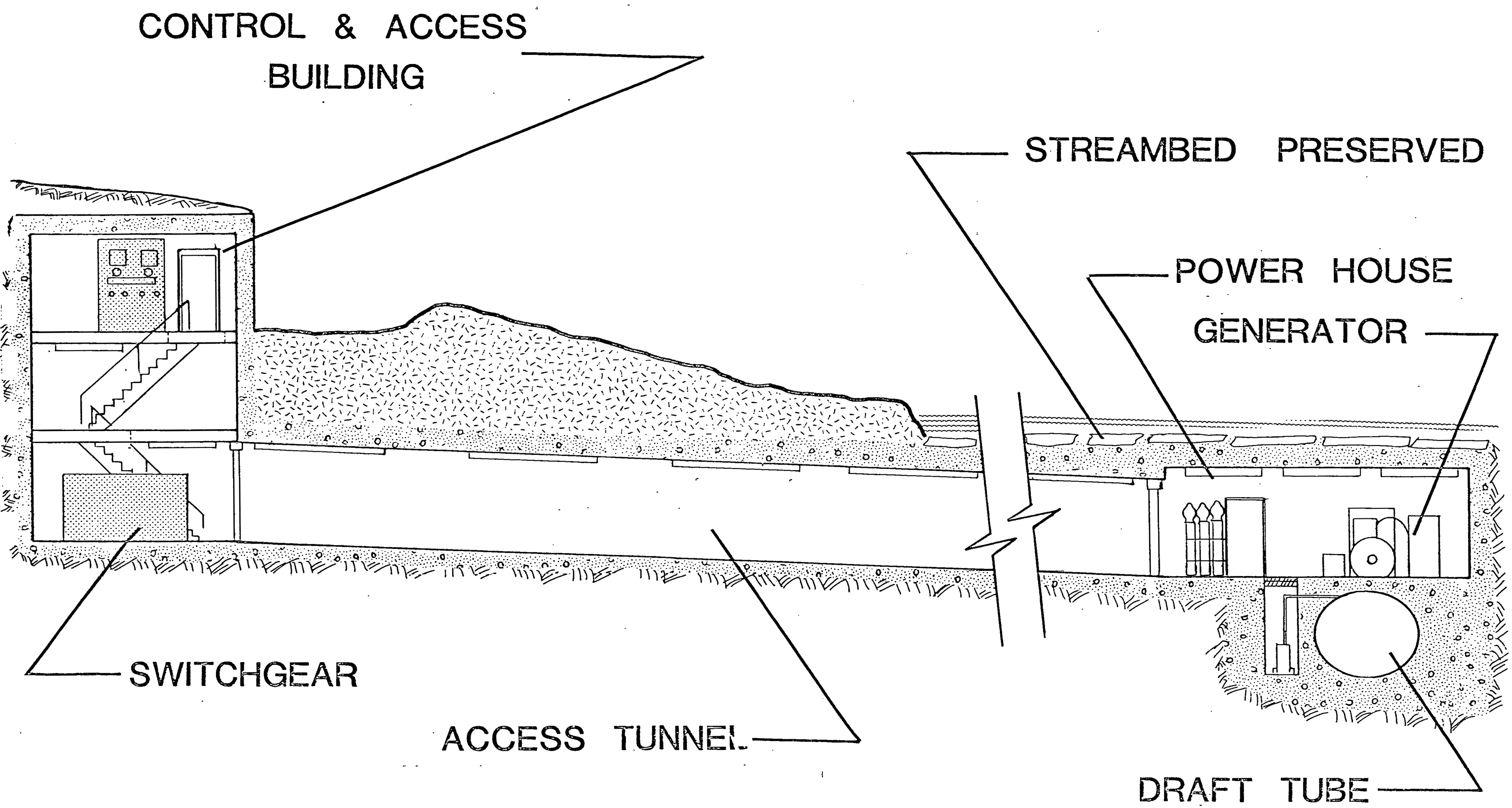
PLAN-POWERHOUSE

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

TRANSVERSE SECTION

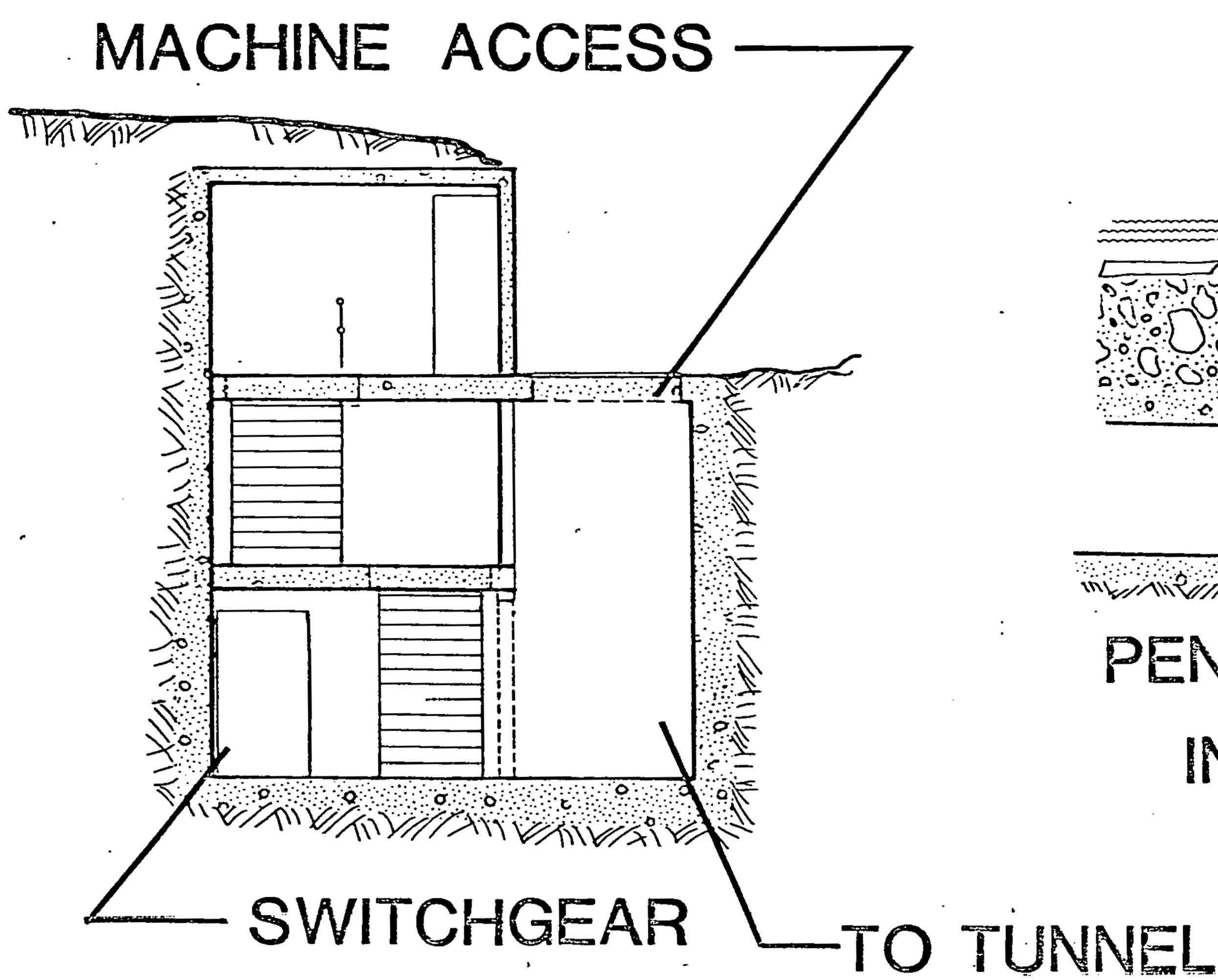
SCALE: 1/8" = 1'



POWERHOUSE & ACCESS

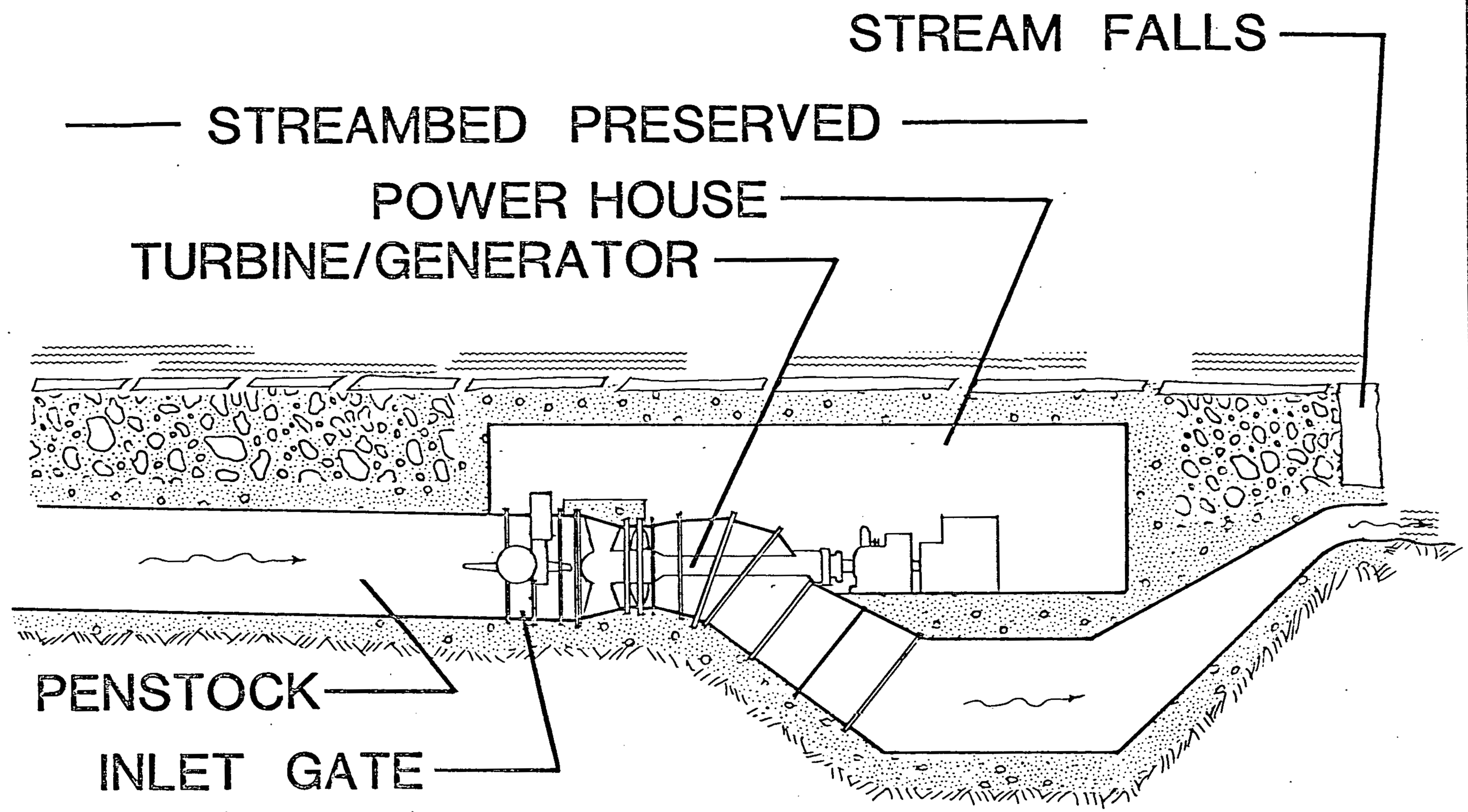
NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



TRANSVERSE SECTION - ACCESS

SCALE: 1/8"= 1'



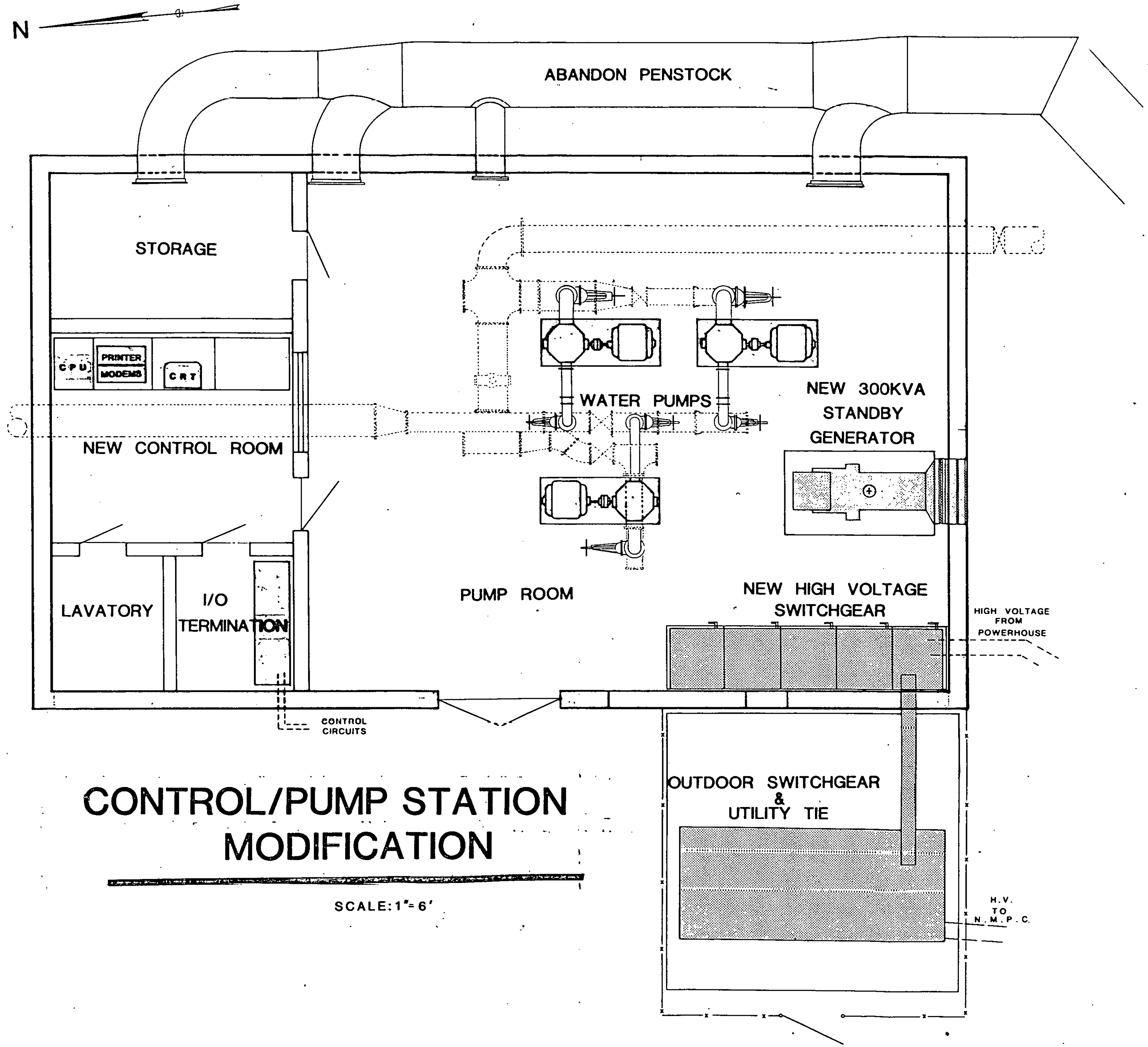
LONGITUDINAL SECTION - POWERHOUSE

SCALE: 1/8" 1'

POWERHOUSE & ACCESS

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



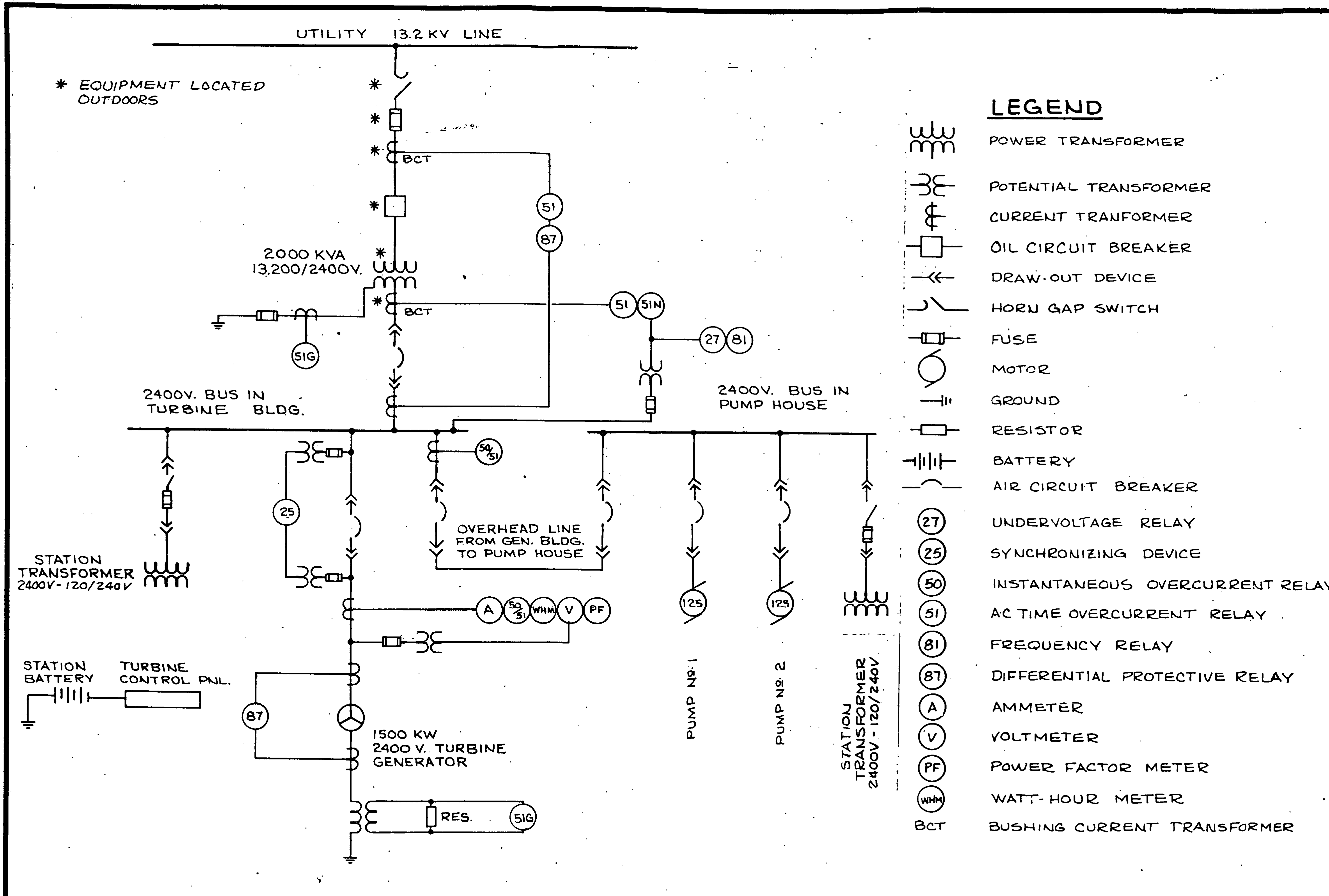
CONTROL/PUMP STATION MODIFICATION

SCALE: 1"= 6'

CONTROL/PUMP STATION MODIFICATION

NORMANSKILL HYDROELECTRIC FACILITY

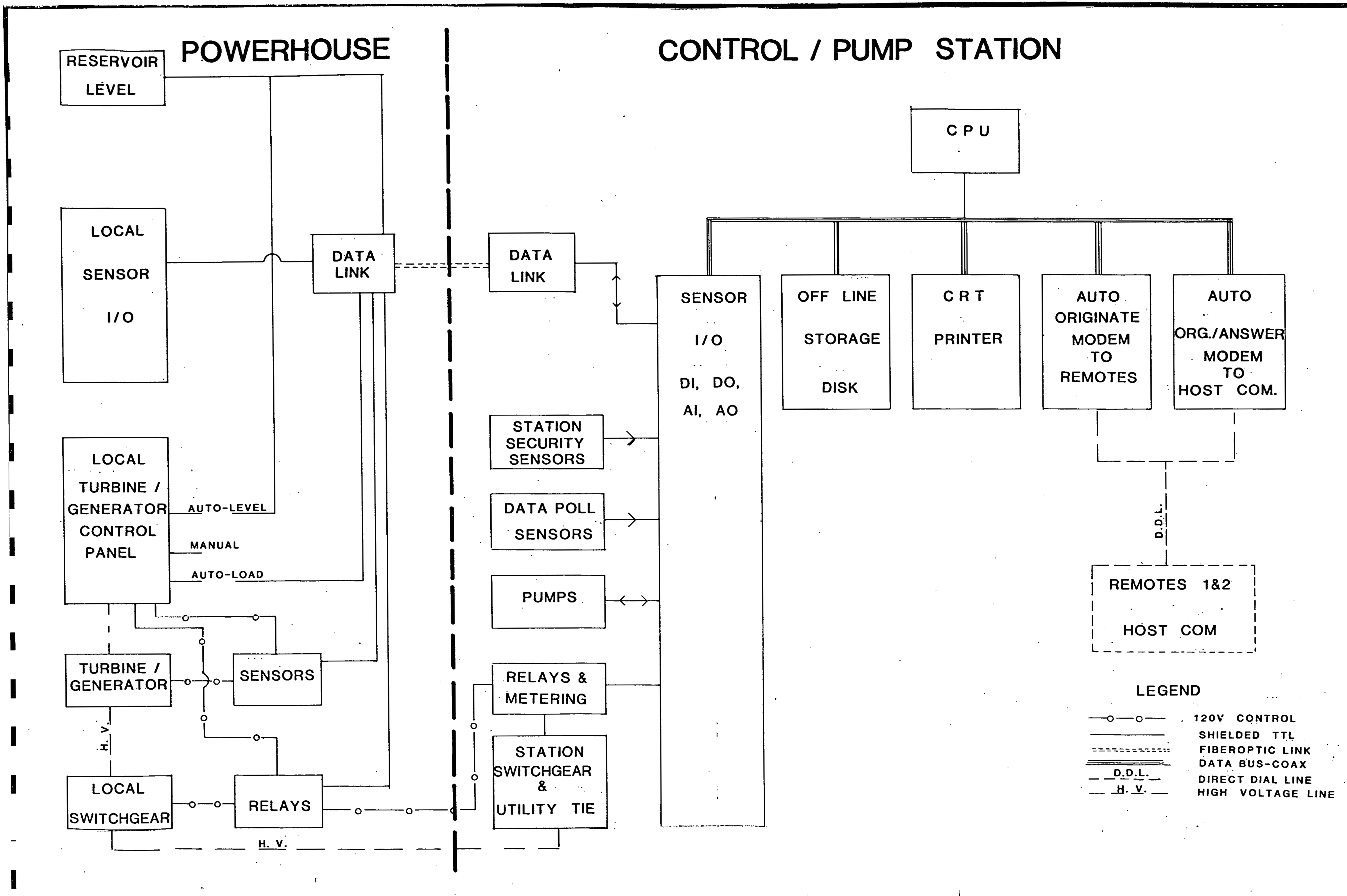
FEASIBILITY ASSESSMENT-EW-78-F-07-1765



ELECTRICAL SCHEMATIC

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765



CONTROL SCHEMATIC

NORMANSKILL HYDROELECTRIC FACILITY

FEASIBILITY ASSESSMENT-EW-78-F-07-1765

SCHEDULE OF CREDITS AND DISBURSEMENTS

PROJECT B

NORMANS KILL HYDRO-ELECTRIC FEASIBILITY STUDY
SCHEDULE OF CREDITS AND DISBURSEMENTS (CFP3)
PROJECT B
50 YEAR ANALYSIS PERIOD ASSUMING 8.000 PERCENT DISCOUNT RATE
WITH 25 YEAR BONDS @ 6.300 PERCENT

YR.	CAP.REC. +	LABOR +	POWER +	O & M +	PWR.CR. =	NET	CUM. PW
1.	-165984	-19709	-3745	-57200	76826	-169812	-157233
2.	-163626	-20853	-4007	-59488	82204	-165770	-299354
3.	-161196	-22062	-4288	-61868	87958	-161456	-427523
4.	-158691	-23342	-4588	-64342	94115	-156848	-542811
5.	-156113	-24696	-4909	-66916	100703	-151931	-646213
6.	-153462	-26128	-5253	-69593	107752	-146684	-738649
7.	-150738	-27643	-5620	-72376	115295	-141082	-820969
8.	-147940	-29247	-6014	-75271	123366	-135106	-893962
9.	-145069	-30943	-6435	-78282	132001	-128728	-958358
10.	-142124	-32738	-6885	-81413	141241	-121919	-1014831
11.	-139106	-34636	-7367	-84670	151128	-114651	-1064002
12.	-136015	-36645	-7883	-88057	161707	-106893	-1106451
13.	-132850	-38771	-8434	-91579	173027	-98607	-1142709
14.	-129612	-41019	-9025	-95242	185139	-89759	-1173268
15.	-126300	-43398	-9657	-99052	198098	-80309	-1198585
16.	-122916	-45916	-10333	-103014	211965	-70214	-1219080
17.	-119457	-48579	-11056	-107135	226803	-59424	-1235140
18.	-115926	-51396	-11830	-111420	242679	-47893	-1247125
19.	-112320	-54377	-12658	-115877	259667	-35565	-1255366
20.	-108642	-57531	-13544	-120512	277843	-22386	-1260169
21.	-104890	-60868	-14492	-125332	297292	-8290	-1261816
22.	-101065	-64398	-15506	-130346	318103	6788	-1260567
23.	-97166	-68133	-16592	-135559	340370	22920	-1256664
24.	-93194	-72085	-17753	-140982	364196	40182	-1250327
25.	-89149	-76266	-18996	-146621	389690	58658	-1241762
26.	0	-80689	-20326	-152486	416968	163467	-1219661
27.	0	-85369	-21749	-158585	446156	180453	-1197070
28.	0	-90321	-23271	-164929	477387	198866	-1174019
29.	0	-95560	-24900	-171526	510804	218818	-1150534
30.	0	-101102	-26643	-178387	546560	240428	-1126641
31.	0	-106966	-28508	-185522	584819	263823	-1102365
32.	0	-113170	-30503	-192943	625756	289140	-1077730
33.	0	-119734	-32639	-200661	669559	316525	-1052760
34.	0	-126678	-34923	-208687	716429	346141	-1027476
35.	0	-134026	-37368	-217035	766579	378150	-1001900
36.	0	-141799	-39984	-225716	820239	412740	-976052
37.	0	-150023	-42783	-234745	877656	450105	-949953
38.	0	-158725	-45777	-244135	939092	490455	-923620
39.	0	-167931	-48982	-253900	1004828	534015	-897072
40.	0	-177671	-52411	-264056	1075166	581028	-870327
41.	0	-187976	-56079	-274618	1150428	631755	-843401
42.	0	-198878	-60005	-285603	1230958	686472	-816310
43.	0	-210413	-64205	-297027	1317125	745480	-789069
44.	0	-222617	-68700	-308908	1409323	809098	-761694
45.	0	-235529	-73509	-321265	1507976	877673	-734198
[illegible]	0	-249190	-78654	-334115	1613534	951575	-706596
[illegible]	0	-263643	-84160	-347480	1726482	1031199	-678899
48.	0	-278934	-90051	-361379	1847335	1116971	-651121
49.	0	-295112	-96355	-375834	1976649	1209348	-623274
50.	0	-312229	-103100	-390868	2115014	1308817	-595368
PW	-1524479	-575740	-139293	-1213322	2857466	-595368	

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