BNL-NUREG-28115
INFORMAL REPORT
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QUANTITATIVE NUCLEAR POWER PLANT SITING METHODS: A REVIEW OF CURRENT PRACTICE

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August 1979

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PREPARED FOR THE
SITE STANDARDS DESIGNATION BRANCH
U.S. NUCLEAR REGULATORY COMMISSION
UNDER CONTRACT NO. DE-AC02-76CH00016

PREFACE

This report is one of a series on quantitative methods for nuclear power plant siting prepared by the BNL Division of Regional Studies for the Site Standards Designation Branch of the U.S. Nuclear Regulatory Commission. The other reports in this series are:

- Hobbs, Benjamin F., Analytical Multiobjective Decision Methods for Power Plant Siting: A Review of Theory and Applications, Division of Regional Studies, Brookhaven National Laboratory, Upton, N.Y., September 1979.

- Hobbs, Benjamin F., and Michael D. Rowe, A Comparison of Regional Screening Methodologies. Division of Regional Studies, Brookhaven National Laboratory, Upton, N.Y., September 1979.

- Rowe, Michael D., and Barbara L. Pierce, A Comparison of Site Selection Methodologies, Division of Regional Studies, Brookhaven National Laboratory, Upton, N.Y., August 1979.

- Rowe, Michael D., Benjamin F. Hobbs, Barbara L. Pierce, and Peter M. Meier, An Assessment of Nuclear Power Plant Siting Methodologies, Division of Regional Studies, Brookhaven National Laboratory, Upton, N.Y., November 1979.

ABSTRACT

This report reviews the site selection Chapters of 48 Environmental Reports submitted to the U.S. Nuclear Regulatory Commission (NRC) since February 1973. Detailed analyses are presented of the 13 studies that use a quantitative technique for some part of the site selection process, with particular emphasis on identifying the validity of application of decision rules, and the adequacy of information presented. Most of the 48 studies are qualitative and contain little information about the site selection process. Weighting summation is by far the most commonly used method in the quantitative studies; the theoretical requirements of the weighting summation method are rarely met and never acknowledged.

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ACKNOWLEDGMENTS

The writers acknowledge the assistance of our Brookhaven colleagues B. Hobbs, W. Metz, and P. Meier. S. Lee served as the sponsor's project monitor: his guidance and support is gratefully appreciated. We are also indebted to P. Miller for typing of the manuscript.

I. INTRODUCTION

The purpose of this survey is to analyze site selection methodologies in use by utility companies and their consultants for siting nuclear power plants and, for quantitative methodologies, to determine whether or not they have been correctly applied. To that end we have reviewed the site selection chapters of 48 Environmental Reports submitted to the Nuclear Regulatory Commission (NRC) between February 1973 and August 1979.

Site selection is generally a three stage process: candidate area selection, candidate site selection, and final site selection. Candidate area selection involves choosing a large area that appears to contain feasible and desirable sites. Candidate site selection involves further evaluation of the candidate area to define a number of potentially licensable sites. Final site selection involves detailed comparison of 2 or more sites and selection of a preferred site. Selection methodologies can be categorized as follows: favorability selection, exclusion screening, regional characterization, predefined sites, qualitative comparison, cost-effectiveness analysis, site rating, and formalized numerical rating (Table 1). Regional characterization, site rating, and formalized numerical rating are quantitative methods. This classification scheme was developed only to facilitate analysis and does not reflect on the validity of the methodologies or their application.

Thirteen quantitative site selection studies contained in Environmental Reports have been analyzed to determine if the methods used are theoretically valid. These studies include nine at the final site selection level, two at the candidate site selection level, and two at the candidate area selection level.

In addition, four consultant studies referenced in Environmental Reports were reviewed to determine if they contain information about the site selection methodology that is not presented in the Environmental Reports. Three of these studies contain no additional information; the fourth is included as Siting Study J-II. Siting Study J contains little information about the site selection process; weights used in the study are not even presented. The consultant Report (Study J-II), however, contains significantly more information although it does not present more detailed information than site selection chapters of other Environmental Reports.

TABLE 1

METHODOLOGY DEFINITIONS

I. Candidate Area

Favorability Selection. Candidate areas are selected because of one or more favorable characteristics.

Exclusion Screening. A set of explicitly stated exclusionary criteria is applied to a Region of Interest. Candidate areas are those areas which remain after this screening. Emphasis is on defining minimum standards of acceptability.

Regional Characterization. This involves ranking various areas within a region of interest using weighted and rated attributes.

II. Candidate Sites

Predefined Sites. Includes expanding existing sites, selecting from an inventory of previously identified sites, sites already owned by a utility, and unique sites, such as strip-mined areas or floating ocean platforms.

Favorability Selection.. As above.

Exclusion Screening. As above.

Regional Characterization. As above.

III. Proposed Site

Favorability Selection. A site is proposed on the basis of its merit, rather than on the basis of an alternate site evaluation. This includes selection of a site because it is already utility owned.

Qualitative Comparison. Subjective evaluation.

Cost-Effectiveness Analysis. Usually includes only engineering costs, and most often used when environmental impacts at candidate sites are judged to be equivalent.

Site Rating. Simple rating and/or ranking of sites, equal weights.

Formalized Numerical Rating. Attributes are rated and weighted.

2. SURVEY RESULTS

2.1 OVERVIEW

Each site selection study is of course unique. In candidate area selection, attributes generally used include cooling water availability, geology and seismology, population density, and power network considerations. The importance of these attributes, however, varies from region to region. In parts of Tennessee and California, seismology is a limiting factor; in Pennsylvania water availability may be a prime consideration. In some site selection studies, the candidate area is predefined by a utility to be that area within a certain distance of its projected load center; in others, a candidate area may be systematically selected from an area larger than the service area of the utility. At the candidate area selection level, a quantified methodology was used in 3 of the 48 studies reviewed in this report. Table 2 summarizes the salient points of our review.

Candidate site selection was frequently found to be a nebulous exercise between selection of a candidate area and the selection of a preferred site. A utility may choose candidate sites within an area by considering additional criteria or, as in 9 studies, by selecting sites from an existing inventory of potential sites. In several studies, sites to be considered were limited to those already owned by the utility. At this level of the site selection process, quantitative methods were used in 5 of the studies reviewed.

Selection of a proposed may be based on a qualitative comparison or on a formalized quantitative c ison of alternative sites. Quantification was used in only 10 studies. In study, expansion at an existing site was proposed because the time required for a site selection study would not allow the utility to meet projected demand. Some siting studies include selection of fuel type and cooling system by comparing site/plant alternatives; in others these decisions were made independently of the site selection process. Economics is a common attribute in all power plant site selection; yet it may be included in a comprehensive comparison, it may be considered after all other comparisons have been made, or it may not be a separate attribute at all but included within several other attributes.

The most striking characteristic of these 48 site selection studies is a lack of specific information about the site selection process. Many studies contain elaborate descriptions of alternative sites, but few present a clear picture of the methodology used or the tradeoffs made in choosing a proposed

TABLE 2. Classification of Site Selection Studies

Docket Number	Candidate Area			Candidate Sites				Proposed Site				
	Favorability Selection	Exclusion Screening	Regional Characterization	Predefined Sites	Favorability Selection	Exclusion Screening	Regional Characterization	Favorability Selection	Qualitative Comparison	Cost Effectiveness Analysis	Site Rating	Formalized Numerical Rating
50-423	X			X		X			X	X		
50-424/425	X			X	X				X			
50-434/435	X				X			X(b)	X			
50-438/439	X			e					X			
50-440/441	X			c						X		
50-443/444	X				X				X	X		
50-445/446	X				X				X			
50-448/449	X				X				X			
50-450/451	X			X	X						a	
50-452/453	X					X	X	d	X			
50-454/455	X								X			
50-456/457	X			f				f	(X)			
50-458/459	X			g					X			
50-460	X			X				X				
50-461/462	X				X				X			
50-463	X				X						k	
50-466/467	X				X							h
50-471	X			c					X			
50-477/478	X				X				X			
50-482		X								X		
50-483/486	X				X					i		
50-484		X					j					j
50-485	X						X(m)		X			
50-488/490	X				X					X		
50-491/493	X				X					X		
50-496/497	X				X				X			
50-498/499	l		j		X							
50-500/501		X		X				X				
50-502/503	X			X					X	X		
50-508/509	X											h

TABLE 2. (Continued)

Docket Number	Candidate Area			Candidate Sites				Proposed Site				
	Favor-ability Selection	Exclusion Screening	Regional Character-ization	Pre-defined Sites	Favor-ability Selection	Exclusion Screening	Regional Character-ization	Favor-ability Selection	Quali-tative Comparison	Cost Effec-tiveness Analysis	Site Rating	Formalized Numerical Rating
50-510/511	X				X					X		
50-513	X			X				X				
50-514/515	X				X					X		
50-516/517	X						X				n	
50-518/521	X				X				X		o	
50-522/523												j
50-524/527	X											
50-528/530			j				X	X	(X)			
50-537	X			X					X	X		
50-546/547	X			g					X			
50-548	X			g								j
50-549	X			j					X			
50-553/554	X			g					X			
50-556/557	X				X							j
50-564	X				X				X			
50-566/567	X			p					X	X		
50-568/569		X			X				X			
50-580/581		X			X				X			
50-582/583	X				X				X	X		
50-582/583 (Appendix)		X	X									

a) Sites ranked for each of 10 factors; added together to give final ranking
b) Expansion at existing site
c) Currently owned sites
d) Higher rated sites were not considered for current development due to distance from load center
e) Ongoing site selection studies
f) Abandoned strip mine site
g) Previous site studies
h) weighted ratings for each factor were summed in 3 major categories; the results were multiplied to give a final ranking
i) includes socio-economic benefits
j) sites rated (0-5) for each factor, ratings multiplied by weights, summed to give ranking
k) sites rated 1 (preferred) or 2 (acceptable) for each factor; ratings summed to give rank
l) 3 high rated areas eliminated for other reasons
m) sites rated
n) sites rated for each factor, ratings summed to give rank
o) sites were ranked for some factors, but not all. The rankings were not amalgamated, and the final decision was qualitative and economic
p) from ongoing inventory

site. When a preferred site is selected on the basis of qualitative comparison, it was not possible to establish whether a rigorous and comprehensive method was used, or whether site selection was actually the arbitrary and subjective process presented in the Environmental Report. In addition, the attributes used to compare alternative sites are not concisely defined. In both qualitative and quantitative studies, this obscures tradeoffs and creates an impression of a vague and subjective site selection process. From the information presented in most of these Environmental Reports, it is only possible to determine that an acceptable site was chosen, not that a sound and comprehensive site selection methodology was used.

2.2 QUANTITATIVE STUDIES

Four aspects of the site selection studies were analyzed in this study: 1) attribute definition, 2) attribute scaling and resulting level of measurement, 3) weight selection and resulting level of measurement, and 4) decision rule and theoretical requirements (Table 3). In addition to requiring that attributes be independent, each decision rule requires specific levels of measurement of weights and scaled attribute values. These requirements must be met for application of a method to be theoretically valid.

Most of the studies emphasize descriptions of candidate areas and alternative sites, rather than the site selection methodology. Thus, information necessary for a thorough analysis of theoretical validity is often incomplete or absent.

2.2.1 Attributes

Every decision rule requires that all important attributes be considered, i.e., that the list of attributes be comprehensive. There is no master list, however, because some attributes are important in certain regions of the country and not in others. Also, an attribute may be judged to be the same for all sites and thus omitted from consideration in site evaluation. Attributes which are easily quantified, such as cost, and attributes required by NRC regulations, such as population density, are included in all of the siting studies. Attributes which are subjective or difficult to measure, such as socioeconomics or aesthetics, are often omitted. Six of the nine studies at the final site selection level contain no explicit consideration of socioeconomic impacts. It is difficult to determine if this is because the impact is the same at all sites. Siting Study D, for example, states that those impacts which were the same at all sites wre not considered, but does not list

TABLE 3

SUMMARY OF ANALYSIS

Siting Study	Stage of Site Selection: Candidate Area	Candidate Sites	Final Site	Level of Measurement[a]: Attributes	Weights	Decision Rule
A		X		I	R	ΣWF
B			X	O	N/A	ΣF
C			X	I	?	Ratings Multiplied
D			X	I	?	ΣWF
E		X		O	N/A	Lexicographic Screening
F			X	I	R	ΣWF
G			X	?	?	Multiplication
H			X	O	N/A	ΣWF
I			X	O	?	ΣWF
J	X			O	?	ΣWF
J-II	X			I	R	ΣWF
K			X	I	?	ΣWF
L			X	O	?	ΣWF
M	X			I	N/A	Non-inferior Set Generation

Key
O = Ordinal
I = Interval
R = Ratio
? = Undetermined

ΣWF = Weighting summation
ΣF = Summation of attribute ratings
N/A = Not applicable

[a]Levels of measurement are given the benefit of doubt and listed at the highest possible level.

the impacts omitted for this reason. Socioeconomics may have been omitted because the impacts were estimated to be the same at all alternative sites.

All decision rules also require that each attribute be conceptually independent. The importance of independent attributes is obvious. Dependent particular attributes would tend to "double-count" and the resulting decision would be biased. To determine if attributes are actually independent, however, is often not possible because of qualitative, vague definitions. Each attribute should be defined in terms of the specific impact being measured; the method of definition in most Environmental Reports is inadequate.

Two studies present attribute definitions only as site-specific descriptions. Siting Study L is an example:

	Site #1
Foundation Conditions	Site Elev. 710-750'.1'-5' residual soil over geological formation. 10'-23' massive crystalline limestone. 10'-25' shale and limestone. Possible fractures, solution channels in limestone but not extensive. Generally favorable foundation stability.
Excavating	Limestone may require blasting. May be difficult to drill because of presence of chert.

This type of attribute definition shows differences among sites, but does not allow analysts to determine whether or not attributes are independent.

Five studies present attribute definitions which are too vague to determine independence. Siting Study J is an example.

> "Accessibility ratings were based not only on the proximity of the region to major U.S. highways and railroads but also on the degree of preparation needed for the access road to the region from the main highway or railroad."
>
> "Ease of access was also considered in evaluting regions for the ecological impact. The construction of access roads and transmission lines requires the disruption of some plant and animal communities and may open the area to potential further disturbance as relatively inaccessible areas are made available to more people."

The above explanation of ecological impact is not useful; it is no more than a justification for including access-related considerations in the measurement of ecological impact. It is not possible to determine from this description whether or not accessibility is "double-counted." In another example, Siting Study A defines material transportation as "...an assessment of the variation in material transportation costs throughout the study area." Site preparation includes "...road and bridge construction and relocation." Without detailed definitions of the attributes, it is again not possible to determine if these are actually separate considerations.

At least five studies contain instances of possible "double-counting." In Siting Study K, for example, attributes are defined in terms of the rating scale and several attributes seem to overlap or to be over-represented. Site Accessibility, attributes 5a, b, and c, is one such example with railroad, highway, and river navigation each considered separately. It is possible that the importance of each kind of access is dependent on the levels of the other two and that the three types of access should be considered as a single criterion. It is unclear exactly what the difference is between attribute 9b, Land Consumption of Critical Environmental Importance, and attribute 9c, Land Consumption (Plant Site Only); both are defined in terms of acres of land removed. Gamelands appear to be included in two attributes, and terrestrial biology in three.

Siting Study J-II, a consultant report, considerably improves upon the information presented in the Environmental Report. Nevertheless, it seems to contain "double-counting." Pumping requirements for the cooling water supply is included in both topography and hydrology. Topography is

> "based on the criterion that an ideal region should not vary more than 100 feet in elevation over an area of 1000 acres. This would minimize large earth moving requirements in site preparation, as well as pumping requirements for the cooling water supply."

Yet, hydrology ratings

> "were influenced not only by the distance of the regions from the three hydrological alternatives, but also by the pumping head requirements for transferring water from the source to the region. Thus, the differences in the elevations of the candidate regions and the corresponding water sources had to be considered."

Siting Study D presents the most quantitative, specific definitions found in any of these studies, yet may also contain "double-counting." For example, Loss of Existing Land Use, attribute #7, is defined as the weighted number of acres of open land, swamp, or forest converted to site use; attribute #9, Loss of Recreational Land Use, is defined as "qualified opinion of the relative worth of existing land uses." It is unclear what the difference is between these two impacts, or whether in fact they are the same. These examples demonstrate that determination of attribute independence is not clear-cut or simple. Part of the problem stems from the nature of the attributes themselves and part from inadequate definition in the Environmental Reports. Some instances of apparent "double-counting" may instead be ambiguous definition.

2.2.2 Scaling

In quantitative site selection methodologies, raw impact measurements, such as dollars or acres, are transformed to some type of value scale in order to compare one attribute with another and in order to combine values for all attributes to obtain one measure of suitability for each site. The levels of measure of the scaled attributes required by each amalgamation technique (usually ordinal or interval) are defined by measurement theory.

To verify the level of measurement achieved in transformation of raw impact measurements to a rating scale, it is necessary to know how the transformation is made. Most studies present only partial raw data and no information about scaling techniques. An analyst can only assume a particular level of measure and cannot verify this "guess."

Six studies use ordinal level attribute values of the form:

1 = poor

2 = fair

3 = good

4 = excellent

In this type of scale magnitudes of differences between numbers are usually not meaningful.

Six studies use interval-scaled attribute values, including some questionable but apparently higher-than-ordinal studies classified as using interval scales. Siting Study F is an example. Sites are rated on

> "a point scale from zero to five with five representing a particularly favorable condition and zero conditions not presently feasible from an engineering or economic standpoint."

Because decimal ratings are permitted, this study is described as using interval-scaled attributes even though raw measurements and transformations are not presented with which to verify the level of measurement.

2.2.3 Weights

Weights used in any amalgamation technique should be on a ratio level of measurement. It should be clear whose values the weights represent and whether or not they measure the correct type of relative importance. They should be expressed in terms of willingness to make tradeoffs among units of attribute values as opposed, for example, to "political significance" or relative range of values represented. To determine if they meet these requirements, it is necessary to know how weights are selected. Of the ten studies that use weights, none states who chose the weights or how they were chosen. This is a serious omission in all of the studies.

In two studies, A and F, weights are presented as percentages, so these may achieve a ratio level of measurement. Siting Study J does not even present the weights, although the consultant report J-II does contain weights expressed as decimals and is classified as possibly achieving a ratio level of measurement. Other studies assign weights of 1, 2, or 3, for example, or distribute "points" among attributes. No attempt is made to judge the level of measure on the basis of the limited information in these Environmental Reports.

2.2.4 Decision Rule

Considering J and J-II as one study, eight of the thirteen siting studies examined use weighting summation as the decision rule. Three of these, A, F, and J-II, may be theoreticaly valid in terms of measurement theory. Four use ordinal-scaled attributes and are thus not theoretically valid whatever the level of measurement of the weights. Three studies use a variation of weighting summation which simply adds the attribute ratings, or adds weighted ratings for subcategories, then multiplies categories. Siting Study E, and the candidate site selection level, uses lexicographic screening (sequential screening in order of attribute importance) and is theoretically valid in its use of ordinal scaled attributes. Siting Study M uses a simplified form of non- inferior set generation, and is also theoretically valid in terms of measurement theory.

3. DISCUSSION

Violations of assumptions and correct procedures, such as algebraic manipulation of ordinal numbers, incorrect application of a method, and weighting before scaling of attributes, can produce unintended tradeoffs and unreliable results. None of the siting studies recognize implications of not meeting theoretical requirements.

Addition of ordinal numbers is not theoretically valid. Ordinal measures should not be manipulated algebraically because such manipulation presumes that magnitudes of differences are meaningful. At least five site selection studies violate this important theoretical requirement. In Siting Study B, for example, attributes were scaled into one of two categories, preferred or acceptable. This scale is valid when used in Copeland's Reasonable Welfare Function, which involves a site-by-site comparison for each attribute, and choosing the site "winning" the most comparisons. When this decision rule is applied to Siting Study B, the top-ranked site remains the same, but the other sites are ranked differently. Thus, different results can be obtained when ordinal numbers are manipulated incorrectly.

Two studies used a variation of the Power Law not described in the existing siting methodology literature, in which weighted ratings for a few major categories are multiplied instead of added to yield a total site score. These provide good examples of the problems that can result from misapplication of siting methodologies. Multiplication causes differences among sites to produce proportional differences in total site score instead of additive differences; therefore, small differences among bad sites (low ratings) have a much larger influence on total site score than small differences among good sites. This causes the actual relative importance of each attribute to the total site score to be different from the stated relative importance implied by weights. Although in these examples the final site rankings are not changed by multiplication instead of addition, it is clear that under other circumstances this might not be the case.

This difference between stated weights and what we call "effective" or "implied" weights (the actual relative effect of each attribute on total site score) can be found in several studies. We identify five types of effective weights. The first is use of multiplication instead of addition, as described above, which causes weights to have a proportional instead of additive effect on total site score. The second is double counting (usually of cost) which causes the double-counted attribute to have more than its stated share of influence. The third is unspecified nonlinear transformations at the scaling stage (see Study G) which causes extreme attribute levels to have relatively more impact than less extreme levels. Included in ths general category is unequal ranges of scales used in equally-weighted categories as in Studies B and C. The fourth is aggregation of different numbers of attributes into equally-weighted categories so that the relative weights of the components of the categories are different. The fifth is possible reverse order of the scaling and weighting exercises so that the stated weights are not properly based on the magnitudes of the scaled attribute levels. This can occur whenever attributes are weighted in a general sense without specification of the range of impacts under consideration so decsion makers do not know the tradeoffs implied by their weights.

The purpose of quantitative siting methodologies is to reduce the effort required to evaluate tradeoffs among different alternatives. This requires both objective and subjective judgments. Methodologies should be specifically designed to formalize combination of objective and subjective judgments; they should provide rigorous treatment of subjectivity. If the methodologies are incorrectly designed or applied, then the results of the application will not correcty represent the subjective judgments of the persons involved.

None of the studies examined acknowledge the existence of theoretical requirements, and most appear to violate one or more of the above requirements. Eight of 13 studies which use weighting summation appear to violate the assumption of attribute independence; ten of 13 studies appear to violate theoretical requirements of measurement theory. Conclusions about particular studies are necessarily less than definitive, however, because a study may appear to be theoretically incorrect only because insufficient information was presented in the Environmental Report. Those identified as "theoretically correct" may only appear so because they have been given the benefit of doubt. Attribute definitions are generally inadequate for determination of independence; descriptions of scaling an weighting techniques are absent. Lack of such information is a severe constraint to an analysis of theoretical validity.

APPENDIX I

SITING STUDY A

SITING STUDY A:

CANDIDATE SITE SELECTION

An area of approximately 4,000 sq. miles is screened to identify all favorable sites of about 5 to 6 mi^2 each. Approximately 3,000 mi^2 are eliminated and 5 favorable areas are identified.

I. ATTRIBUTES

The nine attributes used in this study are qualitatively defined in general terms. These vague definitions make it difficult to determine if all important impacts are considered and if each attribute is independent. For example, material transportation is defined as "...an assessment of the variation in material transportation costs throughout the study area." Site preparation includes "...road and bridge construction and relocation." Without detailed definitions of the attributes, it is not possible to determine if these are separate considerations.

Socioeconomic concerns are included in the attribute Public Acceptance. This is measured in inverse relation to population density, giving areas of low population higher ratings. If in fact socioeconomic impacts are more intensely felt in smaller communities, then this is actually a measure of potential public opposition and socioeconomic concerns are not considered at all.

In general, attribute definition in this study is inadequate.

II. SCALING

Both economic and non-economic attributes are "rated" on a 0 to 5 scale, where 0 is exclusionary and 5 is exceptionally favorable (see Exhibit A-1). This is usually an ordinal level of measurement. The actual transformation of raw impact measurements into the scale is given only for the sub-attribute population density, in the form of a "rating" map legend. As shown in Exhibit A-2, this is similar to logarithmic perception with an arbitrary zero. Population density, therefore, is on an interval or quasi-interval level of measurement. It is possible that other attributes achieve a higher-than-ordinal level of measurement, but this can not be determined from information given.

III. WEIGHTS

The utility and its consultant agreed that economic and noneconomic considerations should each be worth 50% of the total. The report does not state who determined the distribution of the 50% within each major category. Neither does it state how the weights were selected, so the kind of importance they represent cannot be determined. The weights seem to be on a ratio level of measurement because they are presented as percentages (Exhibit A-3).

IV. DECISION RULE

The report states that "...the final rating of the study area was undertaken by combining all information into a composite evaluation." A presentation of the weights follows, but nowhere is it explained how the ratings and weights are combined. There are individual ratings maps for each attribute and a composite rating map for all attributes. Use of weights may imply weighting summation, but this can not be verified with the limited information presented.

V. DISCUSSION

This study does not contain enough information to determine the method used or the theoretical validity of its application.

EXHIBIT A-1

NUMERICAL RATING SCALE FOR ECONOMIC FACTORS

0 Site development is not impossible, but is impractical from an engineering or economic standpoint. (A zero rating in any component excludes the area from further consideration.)

1 Site development is costly, but practical.

2 Site development will require unusual design, construction, or analysis methods to overcome physical deficiencies of the location. Land acquisition costs are moderately high.

3 Site conditions are acceptable.

4 Site conditions are favorable.

5 Site conditions are unusually favorable.

NUMERICAL RATING SCALE FOR ENVIRONMENTAL FACTORS

0 Unacceptable disturbance of natural ecosystem, recreational areas, or areas with unique aesthetic quality. (A zero rating in any component excluded the area from further consideration.)

1 Considerable disturbance of ecosystems, degradation of recreational potential or aesthetic quality. No danger to aquatic, terestrial or plant species considered rare, endangered or unique.

2 Some disturbance to natural ecosystems, degradation of recreational potential, or aesthetic quality.

3 Little disturbance of the natural environment. Area has land use patterns favoring power plant siting.

4 No appreciable disturbance of the natural environment. Area has land use patterns favoring power plant siting, and some opportunities exist for environmental or recreational enhancement.

5 No appreciable disturbance of the natural environment. Land use patterns strongly favor power plant siting, and unusual opportunities exist for environmental or recreational enhancement.

EXHIBIT A-2

TRANSFORMATION OF POPULATION DENSITY

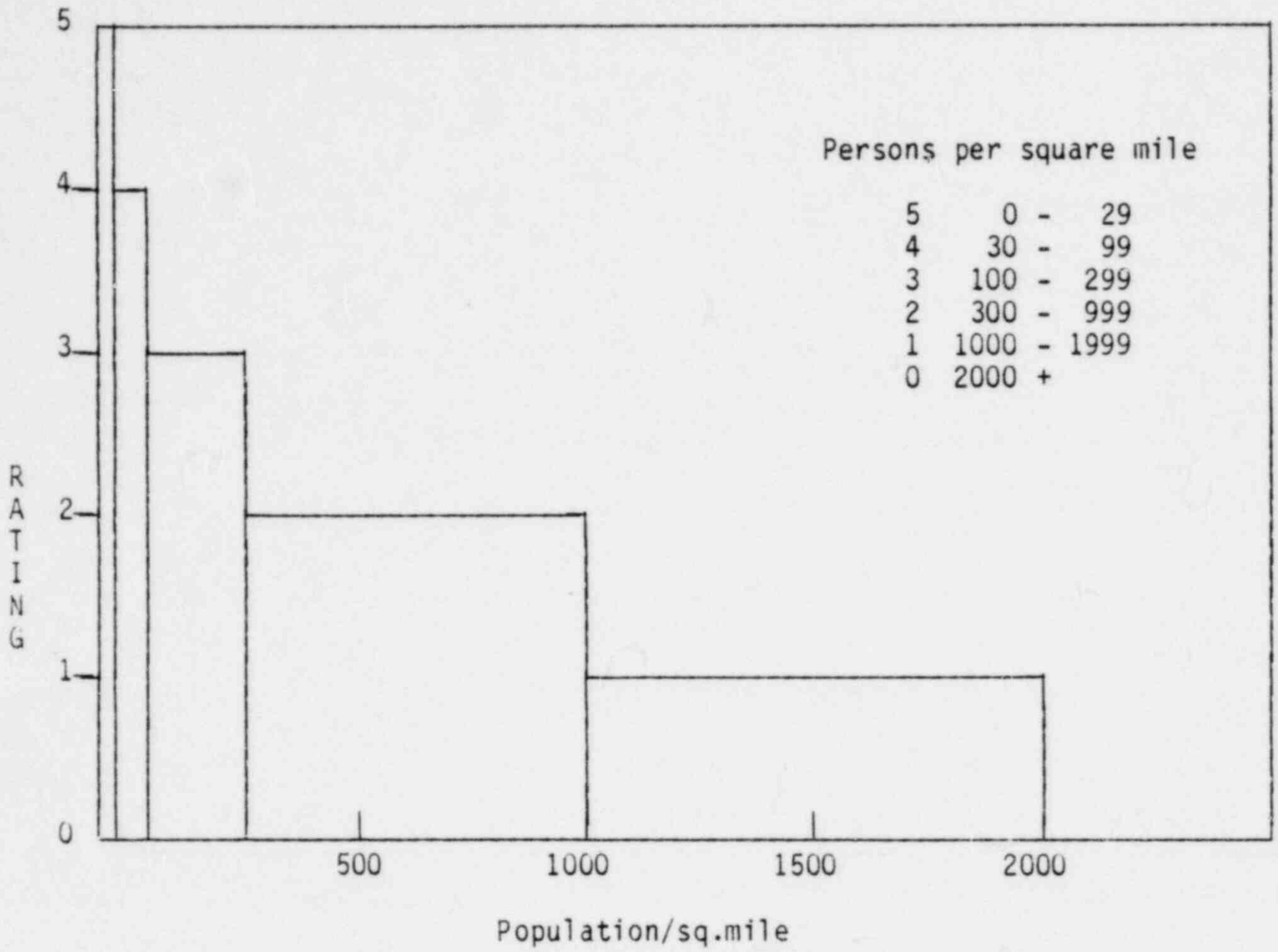

EXHIBIT A-3

WEIGHTING OF ECONOMIC AND NON-ECONOMIC FACTORS

ECONOMIC FACTORS	PERCENT
Cooling Water Supply	10
Cooling Water Recirculation	10
Land Acquistion	5
Foundations	5
Site Preparation	5
Materials Transportation	5
Design Safety Features	10
Subtotal of Economic Factors	(50)
NON-ECONOMIC FACTORS	
Ecological Quality and Recreational Value	25
Public Acceptance	25
Subtotal of Non-Economic Factors	(50)
Total of All Factors Rated	100

APPENDIX II

SITING STUDY B

SITING STUDY B

FINAL SITE SELECTION

Five alternative sites are compared using a hierarchical organization of attributes.

I. ATTRIBUTES

Three major categories are used: 1) engineering and environmental, 2) economic, and 3) institutional. Engineering and environmental considerations are divided into 9 categories, each of which has several sub-categories. These are well-defined. For example:

> "Total exposure. The total projected population for the year 2020 within a radius of 50 miles was reduced to an average density/square mile, in comparing the total population exposure from a possible release of each of the five sites without regard to prevailing wind direction."

Raw impact measurements are presented. The list of attributes seems to be comprehensive. Economics may be over-represented because some of the engineering attributes seem to include cost considerations. For example:

> "Proximity of Cooling Water Supplies: Both the cost and environmental effects of providing cooling water are affected by the distance and elevation difference between source and plant site."

Distance and elevation are engineering attributes; cost of building a pipeline is included in economics.

II. SCALING

Engineering/environmental attributes are rated 1 (preferred) and 2 (acceptable). These are ordinal measures, and transformation of ratio- scaled measurements to this scale results in loss of a significant amount of information. The sites are ranked for economic and institutional attributes.

III. WEIGHTS

There are no explicitly defined weights.

IV. DECISION RULE

Ratings within each of 9 engineering/environmental attributes are summed and used to rank the five sites. These 9 rankings are summed to give an engineering/environmental ranking which is added to the economic and institutional rankings to give an overall ranking. Ranks are ordinal measures. (See Exhibit B-1.) Exhibits B-2 through B-7 illustrate some of the individual ratings and rankings.

V. DISCUSSION

Adding ordinal numbers is theoretically invalid. Ordinal numbers are only comparative and absolute differences are not meaningful.

The report states that: "No attempt was made to weight the relative significance of either factors or categories in arriving at the final order of preference." The authors do not recognize the implied weighting contained in the methodology: In fact, the three major categories each contribute 1/3 to the final decision. Geology and seismology, one of the 9 engineering/environmental attributes, thus contributes 1/27 of the final decision; the single economics attribute has 9 times the importance of geology and seismology.

Use of only two categories in the scaling is appropriate for Copeland's Reasonable Welfare Function, a valid decision rule for ordinal numbers.* This involves a site-by-site comparison of each attribute; the site "winning" the most comparisons is chosen. Application of the method to this study yields:

Site #	Wins	Losses	Ties	Rank	Rank from Summation (from Table B-1)
1	30	5	9	1	1
2	16	20	8	3	2.5
3	15	26	3	4	5
4	13	23	8	5	4
5	19	19	6	2	2.5

The top-ranked s[illegible] remains the same, but the others are ranked differently. Copeland's Reasonable Welfare Function can contain inherent inconsistencies, as discussed by Hobbs, but it is interesting to note that different results are obtained when ordinal numbers are manipulated incorrectly.

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*For a detailed discussion of this method, see e.g., B. Hobbs, "Analytical Multiobjective Decision - Methods for Power Plant Siting: A Review of Theory and Application.

EXHIBIT B-1

COMPARISON OF ALTERNATIVE SITES: OVERALL SUMMARY

Groups of Comparison Factors	Site Ranks 1	2	3	4	5
Engineering and Environmental Factors	1	5	3.5	3.5	2
Economic Factors	1	2	4	5	3
Institutional Factors	1.5	1.5	5	3.5	3.5
Total Score	3.5	8.5	12.5	12	8.5
Overall Order of Preference	1	2.5	5	4	2.5

EXHIBIT B-2

COMPARISON OF ALTERNATIVE SITES ON THE BASIS OF GEOLOGY AND SEISMOLOGY

Site Comparison Factors & Variables	Data Units	Site 1 Data	Site 1 Rtq	Site 2 Data	Site 2 Rtq	Site 3 Data	Site 3 Rtq	Site 4 Data	Site 4 Rtq	Site 5 Data	Site 5 Rtq
Site Topography											
Average Grade	%	2-8 SE	1	Flat	2	Flat	2	3-5	1	1-6 NW	1
Surface Stability											
Liquefaction Potential	Yes/No	No	1	Yes	2	Yes	2	No	1	No	1
Settlement Potential	Yes/No	No	1	Yes	2	Yes	2	No	1	No	1
Ease of Excavation											
Depth to rock	ft	5-10	2	300-600	1	>1000	1	10-15	2	10-20	2
Hardness of fresh rock	psi	5,000	2	<75	1	< 100	1	1,000 to 5,000	2	5,000	2
Earthquake Damage											
Potential Distance to known fault	Miles	0.3	2	10	1	23	1	1.5	2	3	2
Horizontal accel. for plant design	ft/sec	.12q	1	.15q	2	.15q	2	.12q	1	.12q	1
Foundation Factors											
Need for piling	Yes/No	No	1	Yes	2	Yes	2	No	1	No	1
Need for dewatering	Yes/No	No	1	Yes	2	Yes	2	No	1	No	1
Total Score			12		15		15		12		12
Ranking Order			2		4.5		4.5		2		2

Rating System: 1 = Preferred
2 = Acceptable

EXHIBIT B-3

COMPARISON OF ALTERNATIVE SITES ON THE BASIS OF POPULATION DISTRIBUTION

Site Comparison Factors & Variables	Data Units	Site 1 Data	Site 1 Rtg	Site 2 Data	Site 2 Rtg	Site 3 Data	Site 3 Rtg	Site 4 Data	Site 4 Rtg	Site 5 Data	Site 5 Rtg
Licensability Distance to nearest major pop. center	1000's people & miles	26 7.4	1	21 5.2	2	23 3.9	2	21 8.1	1	42 4.4	2
Total Exposure Average density within 50 miles	people per sq.mile	860	1	1090	1	1020	1	1660	2	1170	1
Employment Expos.	Employees	-		650		1323		72		5410	
Nearest major indus. plant	Miles	-	1	5	2	4	2	4	2	4-1/2	2
People Subject to Evacuation Enhab. of Low Pop. Zone	People	800	2	1000	2	400	1	1050	2	375	1
People to be Moved for Plant Construction Inhab. of Exclusion Area	People	15	1	3	1	10	1	40	2	40	2
Total Score			6		8		7		9		8
Ranking Order			1		3.5		2		5		3.5

Rating System: 1 = Preferred
2 = Acceptable

EXHIBIT B-5

COMPARISON OF ALTERNATIVE SITES ON THE BASIS OF BILOGICAL FACTORS

Site Comparison Factors & Variables	Data Units	Site 1 Data	Site 1 Rtq	Site 2 Data	Site 2 Rtq	Site 3 Data	Site 3 Rtq	Site 4 Data	Site 4 Rtq	Site 5 Data	Site 5 Rtq
Sensitivity to Entrainment											
Sport fish breeding grd.	Yes/No	No	1	Yes	2	No	2	No	2	No	1
Uniqueness of Wildlife Habitat											
Special legislation	Yes/No	No	1	No	1	Yes	2	No	1	No	1
Removal of Natural Vegetation											
Area needed for const.	Acres Cleared	25	2	5	1	70	2	11	1	23	2
Food value of dominant plants to wildlife	Dietary Index	426	2	359	2	233	1	424	2	363	2
Habitat suitability for game species	No. of Species	9	1	9	1	8	1	15	2	14	2
Reduction of Habitat of Rare or Endangered Species	No. of Species	0	1	0	1	1	2	0	1	0	1
Exposure of Aquatic Life to Construction Operations	Acres of Ponds Etc.	0	1	0	1	Many tidal channels	2	0	1	0	1
Total Score			9		9		12		10		10
Ranking Order			1.5		1.5		5		3.5		3.5

Rating System 1 = Preferred
2 = Acceptable

EXHIBIT B-4

COMPARISON OF ALTERVATIVE SITES ON THE BASIS OF TRANSMISSION CONSTRAINTS

Site Comparison Factors & Variables	Data Units	Site 1 Data	Site 1 Rtg	Site 2 Data	Site 2 Rtg	Site 3 Data	Site 3 Rtg	Site 4 Data	Site 4 Rtg	Site 5 Data	Site 5 Rtg
Major Physical Obstacles											
Estuary crossing	No.	0	1	0	1	1	2	0	1	0	1
System Stability	*	N/A	2	N/A	2	N/A	2	N/A	2	N/A	2
Reliability	*	N/A	2	N/A	2	N/A	2	N/A	2	N/A	2
Operating Costs Maintenance	Circuit miles added	49	2	74	2	30	2	52	2	29	1
Permits	Time	-	1	-	1	-	2	-	1	-	1
Total Score			8		8		10		8		7
Ranking Order			3		3		5		3		1

Rating System: 1 = Preferred
2 = Acceptable

*Site design to same criteria

EXHIBIT B-6

COMPARISON OF ALTERNATIVE SITES
SUMMARY OF ENGINEERING AND ENVIRONMENTAL FACTORS

Site Comparison Factors & Variables	Refer to Table No.	Site 1 Rating	Site 2 Rating	Site 3 Rating	Site 4 Rating	Site 5 Rating
Geology and Seismology	B-2	2	4.5	4.5	2	2
Hydrology and Cooling Water	B-3	1.5	5	4	1.5	3
Transportation Facilities	B-4	3.5	1.5	1.5	5	3.5
Population Distribution	B-5	1	3.5	2	5	3.5
Transmission Constraints	B-6	3	3	5	3	1
Transmission Effects	B-7	2	5	3	1	4
Human Usage	B-8	1	5	3.5	3.5	2
Biological Factors	B-9	1.5	1.5	5	3.5	3.5
Resource Commitment	B-10	2.5	2.5	1	5	4
Total Score		18.0	31.5	29.5	29.5	26.5
Ranking Order		1	5	3.5	3.5	2

Rating System: 1 = Preferred
2 = Acceptable

EXHIBIT B-7

COMPARISON OF ALTERNATIVE SITES
ECONOMIC FACTORS
(Millions $)

Site Comparison Factors & Variables	Site 1	Site 2	Site 3	Site 4	Site 5
Cost of Transmission Facilities	54.0	62.4	110.4	124.2	39.0
Cost of Water Supply Pipeline	0	0	0	0	33.6
Total Cost	54.0	62.4	110.4	124.2	72.6
Order of Preference	1	2	4	5	3

APPENDIX III

SITING STUDY C

SITING STUDY C

FINAL SITE SELECTION

Four sites were compared with respect to suitability for an initial two-unit installation and an ultimate four-unit installation. A fifth site, which is an existing plant site, was considered for expansion from two units to four, so all five sites were compared on the basis of a two-unit extension to an existing installation.

I. ATTRIBUTES

The attributes were organized into three major categories: 1) economics, environmental impact, and 3) nuclear licensing considerations (Exhibit C-1).

II. SCALING

Each site was rated from 0 to 1 (best) for each of the three categories. Because they were expressed as decimals the ratings are probably at least on an interval level of measure. There is no description of scaling techniques; raw data is given only for economics. In each comparison the lowest cost is assigned a value of 1. There is no information on sub-category ratings.

III. WEIGHTS

The report does not state how weights (Exhibit C-1) were selected or whose values they represent. It is not possible to determine the kind of importance they represent or the level of measurement they achieve.

IV. DECISION RULE

There is no indication of how ratings (Exhibit C-2) are combined within each category. Ratings for each of the three categories were multiplied to give a final site ranking.

V. DISCUSSION

Virtually no information is presented in this study which can be used to determine theoretical validity in terms of attribute independence or levels of measure.

Nevertheless, we note that although each of the three major categories are given equal weight, economics is actually more heavily weighted than the other two because the lowest-cost site is given a rating of 1. The other categories have a different range because they are not scaled relative to the best site. The relative rankings of the sites would not be changed, however, by rescaling the other categories (see Exhibit C-3), because the best site is best in both economic and environmental attributes and thus dominates the other sites. This implied weighting is not acknowledged.

No reason is given for multiplying the final ratings instead of adding them. Although site rankings are not changed (see Exhibit C-4), multiplication magnifies the influence of low values and this should be acknowledged. Also, if the ratings are on an interval level of measurement, it is theoretically incorrect to multiply them except by a constant.

EXHIBIT C-1

ATTRIBUTES AND WEIGHTS

A.	Economics	100
B.	Environmental Impact[a]	100
	1. water use (20)	
	2. land use (40)	
	3. meteorology (10)	
	4. ecological sensitivity (20)	
	5. joint use for recreation (10)	
C.	Nuclear Licensing[b]	100
	1. population and dose considerations (40)	
	2. regional land use (20)	
	3. geology and seismology (20)	
	4. hydrology (10)	
	5. meteorology (10)	

[a]These five categories are broken down into 10 minor categories. The minor categories are not presented.

[b]These five categories are broken down further into 10 specific items. They are not presented.

EXHIBIT C-2

SITE RATING

A. ECONOMICS

Four-Unit Sites

Site	Initial Two Units: Capitalized Annual Costs*	Initial Two Units: Rating Points	Ultimate Four Units: Capitalized Annual Costs*	Ultimate Four Units: Rating Points
1	246,922	1.000	431,380	1.000
2	272,760	0.905	458,310	0.941
3	257,161	0.960	441,774	0.976
4	299,804	0.824	471,532	0.915

Two-Unit Extension

Site	Capitalized Annual Costs*	Rating Points
1	183,796	0.906
2	185,050	0.900
3	187,879	0.886
4	171,532	0.971
5	166,539	1.000

*All costs in $1000.

B. ENVIRONMENTAL IMPACT

Site	Rating Points
1	0.72
2	0.70
3	0.62
4	0.64
5	0.79

C. NUCLEAR LICENSING

Site	Rating Points
1	0.90
2	0.94
3	0.93
4	0.82
5	0.81

D. SUMMARY

	Four Unit Sites			
	Initial Two Units		Ultimate Four Units	
Site	Rating Points	Rank	Rating Points	Rank
1	0.648	1	0.648	1
2	0.595	2	0.619	2
3	0.554	3	0.563	3
4	0.432	4	0.480	4

	Two-Unit Extension to Existing Site	
Site	Rating Points	Rank
1	0.587	3
2	0.592	2
3	0.511	4
4	0.510	5
5	0.640	1

EXHIBIT C-3

RATINGS USING RESCALED ENVIRONMENTAL

AND NUCLEAR LICENSING CRITERIA

Site	Economics	Environmental	Nuclear Licensing	Sum	Rank	Product	Rank
Initial Two Units							
1	1.000	1.00	0.96	2.96	1	0.96	1
2	0.905	0.98	1.00	2.885	2	0.89	2
3	0.960	0.90	0.99	2.85	3	0.86	3
4	0.824	0.92	0.88	2.624	4	0.66	4
Ultimate Four Unit							
1	1.000	1.000	0.96	2.96	1	0.96	1
2	0.941	0.98	1.000	2.921	2	0.92	2
3	0.976	0.90	0.99	2.866	3	0.79	3
4	0.915	0.92	0.88	2.715	4	0.74	4
Two Unit Extension							
1	0.906	0.93	0.96	2.796	3	0.81	3
2	0.900	0.91	1.00	2.81	2	0.82	2
3	0.886	0.83	0.99	2.706	4	0.728	4
4	0.971	0.85	0.88	2.701	5	0.726	5
5	1.000	1.00	0.87	2.87	1	0.87	1

EXHIBIT C-4

RANKINGS FROM RATING SUMMATION

Site	Economics	Environmental	Nuclear Licensing	Sum	Rank
Initial Two Units					
1	1.000	0.72	0.90	2.62	1
2	0.905	0.70	0.94	2.545	2
3	0.960	0.62	0.93	2.51	3
4	0.824	0.64	0.82	2.284	4
Ultimate Four Units					
1	1.000	0.72	0.90	2.62	1
2	0.941	0.70	0.94	2.581	2
3	0.976	0.62	0.93	2.526	3
4	0.915	0.64	0.82	2.375	4
Two Unit Extension					
1	0.906	0.72	0.90	2.526	3
2	0.900	0.70	0.94	2.54	2
3	0.886	0.62	0.93	2.436	4
4	0.971	0.64	0.82	2.431	5
5	1.000	0.79	0.81	2.6	1

APPENDIX IV

SITING STUDY D

SITING STUDY D

FINAL SITE SELECTION

Three alternative sites are compared, each with both cooling towers and a cooling pond, for a total of 6 site-plant combinations. Economic and environmental comparisons are presented separately; one site ranks first in both areas.

I. ATTRIBUTES

Twenty-two environmental attributes are defined specifically in an appendix to the Environmental Report. For example:

> "The impact from construction noise is evaluted as the product of the number of machine years involved in construction activities and the number of residences within two miles of the site perimeter."

Each attribute is measured quantitatively, but several are defined as "qualified opinion" and on close scrutiny it is unclear exactly what impact is measured. For example, Loss of Existing Land Use is defined as the "weighted number of acres of open land, swamp, or forest converted to site use;" Loss of Recreational Land Use is defined as "qualified opinion of the relative worth of existing land uses." It is unclear what is the difference between these two impacts, or whether or not they are in fact the same. Detailed attribute definitions and comments follow this summary.

The Environmental Report states that impacts common to all sites are not considered, but these are not listed. If one assumes socioeconomic effects are omitted because their impact is similar at all sites, the list of attributes appears comprehensive.

II. SCALING

> "For each individual impact consideration the impact rating was scaled relative to the site having the maximum impact rating for that particular consideration. Thus, all impact ratings were reduced to a common or normalized scale."

Raw impact measurements and weighted normalized ratings are presented. Apparently the largest (worst) score for each impact was arbitrarily set to 12.2 and a linear transformation made from the raw impact scores to a 0 to 12.2 scale (Exhibit D-1). No reason is given for selection of 12.2 as the maximum value.

Each attribute has a maximum (worst) value of 12.2, but not all attributes have a minimum of zero. This implies that the zero point may be nonarbitrary and if the raw data are ratio-scaled, the attributes may be ratio-scaled. Many of the raw scores, however, include an opinion rating or other type of weight, and without knowing the level of measurement of these numbers it is not possible to determine if the raw scores are even on an interval level of measurement. For example, Construction Noise, the product of machine/years and number of residences, is interval-scaled. Increased Turbidity is defined as the product of acres and a 0 to 10 rating which is "a qualified opinion of the effect of clearing upon the local terrain." The origin of these "ratings" is not specified; this attribute is probably interval-scaled.

III. WEIGHTS

A weight from 1 to 10 is assigned to each attribute (Exhibit D-2), but it is not stated who chose the weights or how they were selected. It is therefore not possible to determine the level of measure of the weights or the kind of importance they represent.

IV. DECISION RULE

The decision rule method is weighting summation. There is no acknowledgment of the theoretical requirements of this method.

V. DISCUSSION

This study contains the most complete attribute definitions found in our survey; they are presented separately in Appendix V. Unfortunately, there is no mention of the methods used for selection of weights of the "opinion ratings" included in some of the attributes. This, however, is a serious shortcoming in all of the studies analyzed.

The explicit weights presented in the Environmental Report are multiplied by normalized attribute scores. Contained within the normalization, however, is an implicit set of weights. That is, the unit amount of each attribute that contributes equally to the final site ranking is determined by both the explicit weights and the normalization process. Because this study uses many well-defined attributes, we have chosen it for more detailed analysis of implied weights.

A normalizing factor is the maximum raw score for a particular attribute divided by the normalizing constant, in this case 12.2. Impact units of equal importance in the final decision are these normalizing factors divided by the respective weights. Exhibit D-3 shows a breakdown of impact units. For weights to be theoretically valid, that is, to insure that they measure the correct type of importance, one would determine the relative importance of each normalized attribute value. The explicit weights imply that Fogging-Communities, criterion #2, is twice as important as Construction Noise, criterion #1. Without knowing how the weights are selected, it is not possible to determine if the decisionmaker actually intends, for example, that 0.8197 "ratings" of Fogging be twice as important as 7,377 machine/year-residences of Construction Noise, or that 3,688.5 machine/year-residences equal 0.2049 "ratings" in importance.

The problem is compounded by use of weights or ratings within individual attributes. Attribute #18, Construction-Transmission Lines, and attribute #22, Maintenance-Transmission Lines, both include a rating for the value of the terrain through which the line passes, yet ratings for the same site are different. Attribute #2, Fogging-Communities, and attribute #21, Icing-Flora, both use a rating for type of cooling system, yet ponds are rated 3 and 5 respectively. The origins of these ratings are not specified, and the intention of the decision-maker is unclear.

EXHIBIT D-1

RAW IMPACT SCORES

Attributes	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
1	779	11715	4488	90000	4891	12000
2	0	0	10	3	0	0
3	200	78	270	27	210	39
4	0	111000	0	288000	0	61000
5	39	26	1154	761	1538	1015
6	24	5	676	133	707	158
7	4440	22800	3060	43000	1806	21200
8	2	33	3	35	0	14
9	3	3	10	10	5	5
10	10960	5922	27280	19096	3090	1442
11	0	1	0	10	0	4
12	7400	37600	1080	64800	900	31000
13	2	2	5	2	10	2
14	900	183	1500	294	4920	[illegible]69
15	10	5	10	5	10	5
16	95	1775	240	3000	670	1600
17	42	58	31	100	25	132
18	1836	1836	688	688	3272	3273
19	740	23500	1620	81000	1350	62000
20	11	1238	6	310	45	488
21	820	165	820	235	820	225
22	1530	1530	1032	1032	2856	2856

NORMALIZED SCORES

Attributes	1	2	3	4	5	6
1	0.106	1.59	0.608	12.2	0.663	1.63
2	0	0	12.2	3.66	0	0
3	9.04	3.52	12.2	1.22	9.49	1.76
4	0	4.70	0	12.2	0	2.58
5	0.309	0.206	9.15	6.04	12.2	8.05
6	0.414	0.0863	11.7	2.3	12.2	2.73
7	1.26	6.47	0.868	12.2	0.512	6.01
8	0.697	11.5	1.05	12.2	0	4.88
9	3.66	3.66	12.2	12.2	6.1	6.1
10	4.90	2.65	12.2	8.54	1.38	0.645
11	0	1.22	0	12.2	0	4.88
12	1.39	7.08	0.203	12.2	0.169	5.84
13	2.44	2.44	6.1	2.44	12.2	2.44
14	2.23	0.454	3.72	0.729	12.2	2.40
15	12.2	6.1	12.2	6.1	12.2	6.1
16	0.386	7.22	0.976	12.2	2.72	6.51
17	3.88	5.36	2.87	9.24	2.31	12.2
18	6.84	6.84	2.56	2.56	12.196	12.2
19	0.111	3.54	0.244	12.2	0.203	9.34
20	0.108	12.2	0.0591	3.05	0.443	4.81
21	12.2	2.45	12.2	3.5	12.2	3.35
22	6.54	6.54	4.41	4.41	12.2	12.2

EXHIBIT D-2

WEIGHTINGS APPLIED TO IMPACT CONSIDERATIONS

Impact Consideration	Weighting Values
1. Construction Noise	2
2. Fogging - Communities	4
3. Fogging - Roads	1
4. Groundwater	1
5. Surface Water	7
6. Plant Releases	5
7. Loss of Existing Land Use	10
8. Displacement of Residences	10
9. Loss of Recreational Land Use	8
10. Relative Visual Exposure	6
11. Damming and Ponding	10
12. Increased Turbidity	7
13. Thermal Releases	4
14. Total Dissolved Solids	5
15. Process Control Additives	1
16. Construction Noise	2
17. Construction Activity	6
18. Construction - Transmission Lines	6
19. Loss of Natural Habitats	10
20. Uniqueness of Habitats	10
21. Icing - Flora	3
22. Maintenance - Transmission Lines	4

EXHIBIT D-3

IMPACT UNITS OF EQUAL IMPORTANCE TO THE FINAL DECISION

Criteria	Maximum Raw Score	÷ 12.2 = Normalizing Factor	÷ Explicit Weight	= Impact Unit	
1. Construction Noise	90,000	7,377.0	2	3,688.5	Machine/year - residences
2. Fogging - Communities	10	0.8197	4	0.2049	Cooling type rating
3. Fogging - Roads	270	22.13	1	22.131	Weighted miles - rating
4. Groundwater	288,000	23,607.0	1	23,607.0	acre - housing
5. Surface Water	1,538	126.07	7	18.01	% flow reduction - people
6. Plant Releases	707	57.95	5	11.59	Flow - people - rating
7. Loss of Existing Land Use	43,000	3,524.6	10	352.5	Weighted acres
8. Displacement of Residences	35	2.869	10	0.2869	Houses
9. Loss of Recreational Land Use	10	0.8197	8	0.1025	Rating
10. Relative Visual Exposure	27,280	2,236.1	6	372.68	People - rating
11. Damming and Ponding	10	0.8197	10	0.082	Rating
12. Increased Turbidity	64,800	5,311.5	7	758.8	Acre - rating
13. Thermal Releases	10	0.8197	4	0.2049	Flow - rating
14. Total Dissolved Solids	4,920	403.3	5	80.66	% TDS increase - rating
15. Process Control Additives	10	0.8197	1	0.8197	Rating
16. Construction Noise	3,000	245.9	2	122.95	Machine/year - animals
17. Construction Activity	132	10.82	6	1.803	1000 ft
18. Construction - Transmission Lines	3,272	268.3	6	44.71	Miles - rating
19. Loss of Natural Habitats	81,000	6,639.3	10	663.9	Acre - rating
20. Uniqueness of Habitats	1,238	101.5	10	10.15	% land type
21. Icing - Flora	820	67.21	3	22.4	Acre - rating
22. Maintenance - Transmission Lines	2,856	234.1	4	58.53	Miles - rating

APPENDIX V

ATTRIBUTE DEFINITIONS FOR SITING STUDY D

I. CONSTRUCTION NOISE

The impact from construction noise is evaluated as the product of the number of machine years involved in construction activities and the number of residences within 2 miles of the site perimeter. The number of machine years was based upon site development estimates for the number of acres to be cleared and the cubic yards of fill moved. Conversion factors are:

104 acres cleared = one machine-year
174,000 cubic yards filled = one machine year

The number of residences was obtained in a manner similar to that described for impact No. 8, below, but with reference to a map upon which the site boundary and a 2-mile perimeter band were laid out.

Site		Machine Years	Residences	Product Mach/Yr x Population	Magnitude of Impact
1.	Tower	1.9	41	77.9	779
	Pond	35.5	33	1171.5	11,715
2.	Tower	2.4	187	448.8	4,488
	Pond	30.0	300	9000.0	90,000
3.	Tower	6.7	73	489.1	4,891
	Pond	16.0	75	1200.0	12,000

Comment: This attribute is interval scaled.

II. FOGGING - COMMUNITIES

This impact is simply a go-no go estimate of whether there is an excessive concentration of residences within a range of 2 miles of a cooling tower or 1/2 mile of a pond, and then rating the situation by the type of cooling scheme involved. The determination was made by laying out the site and pond boundaries on a map in the same way as done for specific impacts No. 1 and No. 3.

Site		Community Within 2 Miles of Tower or 1/2 Mile of Pond		Rating for Type of Cooling	Magnitude of Impact
		Yes	No		
1.	Tower		x	10	0
	Pond		x	3	0
2.	Tower	x		10	10
	Pond	x		3	3
3.	Tower		x	10	0
	Pond		x	3	0

Comment: The actual number of people affected is not specified. This is a weighted ordinal measure, and is theoretically invalid.

III. FOGGING - ROADS

The number of miles of primary and secondary road within 2 miles of a tower and 1/2 mile of a pond were determined by laying out the site and pond boundaries on a USGS 1 : 250,000 scale topographic map. All roads lying within the respective 2- and 1/2 mile wide zones were measured. No relocation was assumed.

Site	Miles of Road	Weighting for Type of Road	Weighted Mileage of Roads	Rating for Type of Cooling	Magnitude of Impact
1. Tower					
Primary	2	4	8		
Secondary	12	1	12		
			20	10	200
Pond					
Primary	4	4	16		
Secondary	10	1	10		
			26	3	78
2. Tower					
Primary	2	4	8		
Secondary	18.5	1	19		
			27	10	270
Pond					
Primary	0	4	0		
Secondary	9	1	9		
			9	3	27
3. Tower					
Primary	1.5	4	6		
Secondary	15	1	15		
			21	10	210
Pond					
Primary	2	4	8		
Secondary	5	1	5		
			13	3	39

Comment: If the road weights and cooling ratings are ratio-scaled, this attribute is interval-scaled.

IV. GROUNDWATER

This impact is based upon a qualified opinion of the area that might be affected by the establishment of a pond. The factors taken into account in making this assessment were: local topography, soil types, pond size, and special terrain features. A second factor of this impact was the number of residences within the area so defined. A residence count was obtained in the same manner as described for specific impact No. 8.

Site		Land Area Potentially Affected by Establishing a Pond	Number of Residences Within This Land Area	Magnitude of Impact
1.	Tower	1	0	0
	Pond	3,700	30	111,000
2.	Tower	1	0	0
	Pond	7,200	40	288,000
3.	Tower	1	0	0
	Pond	6,100	10	61,000

Comment: This is interval-scaled. It is unclear how acres affect groundwater; this seems to be a measure of displacement of residences (#8) and loss of existing land use (#7).

V. SURFACE WATER

The basic data used to evalute this impact are: 1) the makeup water requirements at each site, 2) the mean flow rate of the river over selected reaches, and 3) an estimate of the population along these reaches.

For the level of analysis undertaken here, the river was divided into three reaches: 1) from Site #3 to the confluence of the F.... River, 2) from this confluence to Site #2, and 3) from Site #2 to Site #1. Each site was assumed to affect only those reaches downstream from it, plus the effect of all sites on the river at Site #1.

The effective impact over each reach as well as the effect at Site #1, were modeled as the percent flow reduction due to plant operation times the population living along the river over than reach. The total impact due to a plant at a particular site is the sum of the impacts over those reaches affected.

Site	Makeup Water Requirements	Mean Flow	% Flow Reduction	Population	Magnitude of Impact
1. Tower					
a) at Site 1	94	7,300	1.29	3,000	39
Pond					
b) at Site 1	62	7,300	0.85	3,000	26
2. Tower					
a) at Site 1		-	-	-	39
b) river reach 3		5,800	1.63	68,800	1,115
					1,154
Pond					
a) at Site 1	62	-	-	-	26
b) river reach 3		5,800	1.07	68,800	735
					761
3. Tower	94				
a) at Site 1		-	-	-	39
b) river reach 3		-	-	-	1,115
c) river reach 2		3,800	2.47	5,100	126
d) river reach 1		1,600	5.88	4,400	258
					1,538
Pond	62				
a) at Site 1		-	-	-	26
b) river reach 3		-	-	-	735
c) river reach 2		3,800	1.63	5,100	83
d) river reach 1		1,600	3.88	4,400	171
					1,015

Comment: This is interval-scaled (arbitrary zero) because impacts downstream of Site #1 are not included.

VI. PLANT RELEASES

The impact of various plant releases as contained in the blowdown discharge is treated in a manner similar to the impact of surface water reduction (specific impact No. 5). The impact upon each reach of the river is based upon: 1) the blowdown discharge rate, 2) the dilution potential, which is inversely proportional to the mean flow, 3) the population (as under No. 8) and 4) a factor to account for the flexibility with which blowdown can be scheduled. (Towers are rated 10; cooling ponds are rated 3.)

The rate of blowdown discharge is assumed to be adjusted so that the concentration of solids in the discharge does not exceed 1,500 ppm. The rate of blowdown, in turn, will depend upon the concentration of solids in the makeup water supply. The relationship is:

$$Q_{blowdown} = \frac{TDS_{makeup} \times Q_{consumptive\ losses}}{(1500 - TDS_{makeup})}$$

Figures for the total dissolved solids in the water supply used for makeup were derived from data contained in "Water Resources Data for Wisconsin - 1970," and "Quality of Surface Waters of the United States, 1967," U.S. Department of Interior, Geological Survey. The consumptive losses were based upon a 2,200-MW nuclear plant operating at 85 percent capacity and an efficiency of 7000 Btu/kWhr. For towers, the evaporative losses are about 1 pound of water per 1000 Btu, and for ponds they are about two-thirds as much. From this the blowdown rate is tabulated as follows:

Site	TDS of Makeup Supply (ppm)	Consumptive Losses (cfs)	Blowdown Rate (cfs)
1. Tower	135	60	5.9
Pond	135	40	4.0
2. Tower	125	60	5.5
Pond	125	40	3.6
3. Tower	75	60	3.2
Pond	75	40	2.1

Using the flow rates and population figures tabulated for specific impact No. 5, the impact magnitudes for blowdown can be tabulated as:

Site	Blowdown Flow Rate	Mean Flow	Dilution as % of Flow	Population	Rating for Type of Cooling	Magnitude of Impact
1. Tower						
a) at Site 1	5.9	7,300	0.081	3,000	10	24
Pond						
a) at Site 1	4.0	7,300	0.055	3,000	3	5
2. Tower	5.5					
a) at Site 1		-	-	-	10	24
b) river reach 3		5,800	0.095	68,000	10	652
						676
Pond	3.6					
a) at Site 1		-	-	-	-	5
b)		5,800	0.062	68,800	3	128
						133
3. Tower	3.2					
a) at Site 1		-	-	-	-	24
b) reach 3		-	-	-	-	652
c) reach 2		3,800	0.084	5,100	10	43
d) reach 1		1,600	0.200	4,400	10	88
						707
Pond	2.1					
a) at Site 1		-	-	-	-	5
b) reach 3		-	-	-	-	128
c) reach 2		3,800	0.055	5,100	3	8
d) reach 1		1,600	0.131	4,400	3	17
						158

Comment: Ratings for flexibility of blowdown are the same as the ratings used for fogging. Neither rating is supported. This is an easy way to bias the results against towers.

VII. LOSS OF EXISTING LAND USE

For this impact, the base data are a measurement of the number of acres of land converted to site use. These acreages were obtained from a study of the most recent USGS National Topographic 1 : 250,000 series maps. The base data are dated 1953, revised in 1964. Only three general types of land use were distinguished for this level of analysis: 1) open lands, 2) swamplands, 3) forest lands. The measured acreages of these three types of land are tabulated below, along with the weighting values given in the attached memo. From a knowledge about the site, however, it is known that the swampland at site #2 is part of a hunting reserve. Therefore, the acreages of swampland at Site #2 are rated 4 instead of 2. Weighted values are given below along with their sum, which is the magnitude of impact value input to the computation.

Site		Land Type	Acres by Type	Importance Rating	Weighted Value	Magnitude of Impact
1.	Tower	Open	740	6	4,440	
		Swamp	-	2	-	
		Forest	-	4	-	4,440
	Pond	Open	3,300	6	19,800	
		Swamp	1,300	2	2,600	
		Forest	100	4	400	22,800
2.	Tower	Open	450	6	2,700	
		Hunting	-	4	-	
		Forest	90	4	450	3,060
	Pond	Open	5,300	6	31,800	
		Hunting	2,200	4	8,800	
		Forest	600	4	2,400	43,000
3.	Tower	Open	44	6	264	
		Swamp	37	2	74	
		Forest	367	4	1,468	1,806
	Pond	Open	200	6	1,200	
		Swamp	2,000	2	4,000	
		Forest	4,000	4	16,000	21,200

Comment: No discussion of the origin of the weights is given. It is not clear why open land is more important than forests or swamps. It is unclear if open land means farms or houses or undeveloped land.

VIII. DISPLACEMENT OF RESIDENCES

For the level of modeling used in this analysis, this impact was assumed to be simply the number of dwellings located within the site boundary. A dwelling count was obtained with reference to the most current 15-minute series USGS maps upon which the site boundaries were laid out. Site layouts were taken from the Commonwealth Associates Power Plant Siting Study, dated October 14, 1971. The date of the maps varied depending upon the site involved. The dwelling counts and magnitude of impact figures are tabulated as follows:

Site	Residences	Magnitude of Impact
1. Tower	2	2
Pond	33	33
2. Tower	3	3
Pond	35	35
3. Tower	0	0
Pond	14	14

Comment: This attribute is ratio-scaled. It is possible that this double-counts open land from attribute #7.

IX. LOSS OF RECREATIONAL LAND USE

This impact is based upon a qualified opinion of the relative worth of existing land uses. The principal basis for this evauation was a site visit which had been made early in November 1972. A zero-to-ten rating scale was used.

Site	Land Use Rating (Magnitude of Impact)
1. Tower	3
Pond	3
2. Tower	10
Pond	10
3. Tower	5
Pond	5

Comment: This appears to double-count hunting as measured in attribute #7. The level of measurement is unclear.

X. RELATIVE VISUAL EXPOSURE

This impact is the product of: 1) the population within a 10-mile radius of the site, 2) a visibility rating based upon a judgment of the influence of topography, vegetation, etc., and 3) a rating for the type of cooling. The population figure was obtained from 1970 Census data and with reference to a map upon which the 10-mile radius was laid out.

Site	Population Within 10-Mile Radius	Subjective Visibility Rating	Rating for Type of Cooling	Magnitude of Impact
1. Tower	13,700	8	10	10,960
Pond	14,100	6	7	5,922
2. Tower	34,100	8	10	27,280
Pond	34,100	8	7	19,096
3. Tower	10,300	3	10	3,090
Pond	10,300	2	7	1,442

XI. DAMMING AND PONDING

The impacts of damming and ponding at this level of analysis are based upon a qualified opinion of the condition or "worth" of a stream prior to construction. This impact will be zero at tower sites since, with the present designs, there will be no damming. The ratings for stream worth on a zero-to-ten scale are:

Site		Stream Worth (Magnitude of Impact)
1.	Tower	0
	Pond	1
2.	Tower	0
	Pond	10
3.	Tower	0
	Pond	4

Comments: The ratings scale is not defined.

XII. INCREASED TURBIDITY

This impact is the product of: 1) the area of land to be cleared, and 2) a qualified opinion of the effect of clearing upon the local terrain. Without extensive onsite evaluation, it is assumed that clearing and grading will involve nearly all of the onsite area. Land type data were obtained from USGS topographic maps. The qualified opinion of drainage condition was based upon site visit data.

Site		Area Cleared	Rating For Effect of Clearing	Magnitude of Impact
1.	Tower	740	10	7,400
	Pond	4,700	8	37,600
2.	Tower	540	2	1,080
	Pond	8,100	8	64,800
3.	Tower	450	2	900
	Pond	6,200	5	31,000

XIII. THERMAL RELEASES

This impact is based upon a rating scheme which takes into account the flow rate of the receiving waters and the flexibility with which blowdown can be scheduled. Since ponds have a large retention capacity, they are given a rating of 2. Towers are rated roughly inversely to the mean flow of the receiving waters.

Site		Flow of Receiving Waters (cfs)	Thermal Release Rating (Magnitude of Impact)
1.	Tower	7,300	2
	Pond		2
2.	Tower	4,400	5
	Pond		2
3.	Tower	1,300	10
	Pond		2

XIV. TOTAL DISSOLVED SOLIDS

This impact is a measure of the increase of total dissolved solids in the receiving waters. The percentage increase in TDS is multiplied by a rating factor to account for the flexibility with which blowdown can be scheduled.

The resulting concentration of total dissolved solids in the receiving waters as a result of blowdown is:

$$\frac{(A_1Q_1) + (A_2Q_2)}{Q_1 + Q_2}$$

where:

A_1 = original concentration of TDS in receiving system
Q_1 = flow rate of receiving stream
A_2 = concentration of TDS in blowdown
Q_2 = blowdown flow rate

As discussed under specific impact No. 6, A_2 is assumed to be 1500, and values for Q_2 were derived for impact No. 6. Note that at all sites Q_1 is very much larger than Q_2. Thus, the resulting concentration of TDS is approximately:

$$A_1 + A_2(Q_2/Q_1)$$

The percentage increase in TDS is:

$$\%\text{ increase} = \frac{A_1 + A_2(Q_2/Q_1) - A_1}{A_1} = \frac{A_2Q_2}{A_1Q_1}$$

A_1 and Q_1 are also tabulated for impact No. 6. Using these values, the percentage increase in TDS can be evaluated as:

Site		A_1	Q_1	A_2	Q_2	% Increase in TDS
1.	Tower	135	7,300	1,500	5.9	0.90
	Pond	135	7,300	1,500	4.0	0.61
2.	Tower	125	4,400	1,500	5.5	1.50
	Pond	125	4,400	1,500	3.6	0.98
3.	Tower	75	1,300	1,500	3.2	4.92
	Pond	75	1,300	1,500	2.1	3.23

Site		% Increase in Tds	Rating for Type of Cooling	Magnitude of Impact
1.	Tower	0.90	10	900
	Pond	0.61	3	183
2.	Tower	1.50	10	1,500
	Pond	0.98	3	294
3.	Tower	4.92	10	4,920
	Pond	3.23	3	969

XV. PROCESS CONTROL ADDITIVES

For the level of analysis involved in this study a simply rating was used for this impact. Cooling towers were rated 10 and cooling ponds were rated 5.

Site		Magnitude of Impact
1.	Tower	10
	Pond	5
2.	Tower	10
	Pond	5
3.	Tower	10
	Pond	5

XVI. CONSTRUCTION NOISE

The impact of construction noise on inhabiting organisms is the product of: 1) machine-years, derived under specific impact No. 1, and 2) a qualified opinion of the number of animals possibly affected, rated on a zero-to-ten scale.

Site		Machine-Years	Susceptibility of Animals to Noise	Magnitude of Impact
1.	Tower	1.9	5	95
	Pond	35.5	5	1,775
2.	Tower	2.4	10	240
	Pond	30.0	10	3,000
3.	Tower	6.7	10	670
	Pond	16.0	10	1,600

XVII. CONSTRUCTION ACTIVITY

This specific impact accounts for the fact that above a certain threshold the effect of construction activity on the natural setting depends more upon the area over which it occurs than upon its intensity in just one spot. Also, there will tend to be fairly well-defined areas of substantial activity, and other areas where there is relatively little activity. As an example, the impact associated with reservoir construction will be concentrated in regions where the earthwork for dams is being done.

The magnitude of this impact is the product of: 1) the number of man-years involved in construction, and 2) the perimeter distance around areas where substantial activity takes place. For the level of design detail currently developed for these sites, however, it is not possible to distinguish significant differences in the amount of construction at different sites. Therefore, this factor is assumed to be constant and the magnitude of this impact is taken simply as the perimeter of regions of substantial activity. These data were obtained by tracing out regions of high activity on the site layouts contained in Commonwealth Associates Power Plant Siting Study, dated October 14, 1971.

Site	Area Perimeters of Significant Earthwork (in thousands of feet) (Magnitude of Impact)
1. Tower	42
Pond	58
2. Tower	31
Pond	100
3. Tower	25
Pond	132

Comment: This attribute is ratio-scaled. It is unclear how this differs from #12, increased Turbidity, and other land use and construction effects attributes.

XVIII. CONSTRUCTION - TRANSMISSION LINES

The impact of transmission line construction on the natural environment is taken as the product of: 1) the length of the line to be constructed, 2) a rating for the value of the terrain through which the line passes. The number of miles of line to be constructed is taken from the line layouts in Appendix A of the Commonwealth Associates Power Plant Siting Study, dated October 14, 1971. The rating for terrain value is based upon a general assessment of the region and observations made during the site visit.

Site	Miles of Transmission Line	Rating for Value of Terrain	Magnitude of Impact
1. Tower	306	6	1,836
Pond	306	6	1,836
2. Tower	344	2	688
Pond	344	2	688
3. Tower	409	8	3,272
Pond	409	8	3,272

IXX. LOSS OF NATURAL HABITATS

The impact of losing natural habitat is: 1) the amount of habitat by various type that is lost to site uses, and 2) a qualified opinion of the ability of these habitats to support the important species of the area. However, from the data available a meaningful determination of the extent of various habitats could not be made. Therefore, the entire site was considered as

Site	Site Area	Opinion of Ability of Site to Support Important Species	Magnitude of Impact
1. Tower	740	1	740
Pond	4,700	5	23,500
2. Tower	540	3	1,620
Pond	8,100	10	81,000
3. Tower	450	3	1,350
Pond	6,200	10	62,000

one general type of habitat, and rated accordingly. The rating of the ability of the site to support important species was based upon: 1) "Wildlife, People and the Land," Publication N 621, Department of Natural Resources, Madison, Wisconsin, 1970; 2) other related publications; and 3) site visit data.

XX. UNIQUENESS OF HABITATS

This impact is a measure of the uniqueness of particular types of habitat. It is the percentage of a particular type of habitat that occurs on the site, with respect to similar types of habitat within a 25-mile radius of the site. If the habitat is common within the region, the impact is low; if it occurs principally on the site, the impact is high.

The land areas occupied by open land, forest, and swampland within 25 miles of the site were measured from USGS maps. The percentage of each land type occurring onsite was then computed. The highest percentage figure was taken as a measure of impact without regard to type of land involved.

Site		Type	Within 25 Mi.	Area by Type Onsite	% of Land Type Onsite	Magnitude of Impact
1.	Tower	Open	668,000	740	0.11	
		Swamp	10,500	0	0	
		Forest	578,000	0	0	11
	Pond	Open	668,000	3,300	0.49	
		Swamp	10,500	1,300	12.38	
		Forest	578,000	100	0.02	1,238
2.	Tower	Open	753,000	450	0.06	
		Swamp	71,000	0	0	
		Forest	433,000	90	0.02	6
	Pond	Open	753,000	5,300	0.70	
		Swamp	71,000	2,200	3.10	
		Forest	433,000	600	0.14	310
3.	Tower	Open	764,000	44	0.01	
		Swamp	410,000	37	0.01	
		Forest	82,000	367	0.45	45
	Pond	Open	764,000	200	0.03	
		Swamp	410,000	2,000	0.49	
		Forest	82,000	4,000	4.88	488

Comment: This may be related to Loss of Natural Habitats, #19, or to various land use attributes.

XXI. ICING - FLORA

This impact is the product of: 1) the area within a 2-mile radius of a cooling tower or within a half mile strip around a cooling pond, and 2) a vapor concentration rating for the type of cooling. The areas were planimeterized from site plan layouts, and the vapor concentration ratings are: cooling towers = 10, cooling ponds = 5.

Site	Area Within 2 Miles of Tower or 1/2 Mile of Pond	Vapor Concentration Rating	Magnitude of Impact
1. Tower	8,200	10	820
Pond	3,300	5	165
2. Tower	8,200	10	820
Pond	4,700	5	235
3. Tower	8,200	10	820
Pond	4,500	5	225

Comment: It is unclear why the cooling type ratings are different from those used for fogging.

XXII. MAINTENANCE - TRANSMISSION LINES

This impact is the product of the length of the transmission line involved, and a qualified opinion of the value of the terrain through which it passes. The length of the line is the same as derived for specific impact No. 18. The rating for the value of the terrain was based upon general knowledge of the region and site visit data.

Site	Length of Transmission Line	Rating for Value of Terrain	Magnitude of Impact
1. Tower	306	5	1,530
Pond	306	5	1,530
2. Tower	344	3	1,032
Pond	344	3	1,032
3. Tower	409	7	2,856
Pond	409	7	2,856

Comment: It is unclear why the terrain ratings are different from terrain ratings used in attribute #18, Construction - Transmission Lines.

APPENDIX VI

SITING STUDY E

SITING STUDY E

CANDIDATE SITE SELECTION

Twenty-seven potential sites are evaluated in a 4-stage screening process. Three sites emerge as most suitable for further evaluation and three others are stated to be almost as suitable. Procedure is summarized briefly in Chapter 9 of the Environmental Report in question, and the consultant's report is included as Appendix 9A. This analysis is based on the information presented in the Appendix.

I. ATTRIBUTES

The attributes (Exhibit E-1) are well-defined and the rationale for eliminating each site is clear. The explanation of terrestrial biology is exceptionally good. Minimum requirements or cutoffs are not stated, however. Eleven sites are eliminated due to lack of sufficient water, for example, but the minimum amount of water necessary is not stated.

Cost and system planning were considered in selecting the 27 sites to be evaluated, and are not included as explicit considerations at this stage of site selection. Cost is a factor in elimination of several sites, however. In Phase III, 2 sites are eliminated due to unfavorable geology/seismology characteristics which "...would require considerably higher costs in the design and construction of the sites' major structures." Subtle consideration of cost in this manner results in double counting and hidden tradeoffs between cost and other attributes.

II. SCALING

Each site is 'rated' 0 to 3 for each attribute, where:

0 = favorable
1 = unfavorable
2 = unacceptable
3 = prohibitive

This is an ordinal scale which is theoretically valid as applied. The numbers are not combined in any way but are used simply to distinguish more suitable sites from less suitable sites. Boundaries between categories are not presented.

III. WEIGHTS

No explicit weights are used. Attributes considered in the first phase are more important than those considered later, which results in an implied set of weights based on the hierarchy of attributes.

IV. DECISION RULE

A 4-phase lexicographic screening process is used which results in elimination of sites at each step. Each successive phase considers the attributes in more detail or includes additional attributes.

V. DISCUSSION

This study is apparently theoretically valid in its use of an ordinal scale. Implied weights based on the hierarchy of attributes are not a problem unless non-inferior sites have been eliminated. This is difficult to determine, however, without knowing how the raw data were transformed into the "rating" scale, and without knowing the actual considertion given to cost. A decisionmaker can eliminate favorable sites on the basis of cost without intending or even being aware that cost is a major factor in the decision.

EXHIBIT E-1

ALTERNATE SITE EVALUATION MATRIX

STUDY PHASE	SITING FACTOR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26A	26B	27	Remarks
PHASE I 27 Sites	Water availability (1000 Mw fossil or nuclear)	0	3	3	3	3	3	0	0	0	3	3	3	3	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0	Sites 26A & 26B counted as one. 16 of 27 sites eliminated from study.
	Other hydrologic factors (flood plain, topography, etc.)	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	
	Population distribution within ten miles	(All are favorable)																												
	Land use (extensive relocation of facilities)	(All are favorable except Site 15)																												
	Regional geologic, seismic and groundwater conditions	(All are favorable)																												
PHASE II 11 Viable Sites	Special land uses within 2,000 feet								0	0							0		0		0		0	0	0	0	0	0	0	Sites 26A & 26B counted as one. No sites eliminated.
	Land uses within 5 miles (parks, schools, airfields, etc.)								0	0							0		0		0		0	0	0	0	0	0	0	
	Historic or archaeological sites (10 miles, prelim. evaluation)								0	0							0		0		0		0	0	0	0	0	0	0	
	Population characteristics (10 miles, rural vs. incorporated)								0	0							0		0		0		0	0	0	0	0	0	0	
PHASE III 7 Most Viable Sites	Geology, seismology								0	0							2		2		0		0	0	0	0	0	0	0	Sites 26A & 26B counted as one. Sites 20,22,23,, 24,25, 26A & 26B, 27 remain.
	Groundwater characteristics								2	2							0		0		0		0	0	0	0	0	0	0	
PHASE IV 3 Most Suitable Sites	Terrestrial Biology:																													
	-rare or endangered species																				0		0	0	0	0	0	0	0	
	-habitat diversity and managed areas																				3		0	2	2	2	1	2	0	Sites 22, 26A and 27 the most suitable sites.
	Aquatic Biology																				3		0	0	0	0	0	0	0	
	-diffusion characteristics																				3		0	0	0	0	0	0	0	
	Present and future land uses (within 5 miles)																				0		0	0	0	0	0	0	0	
	Historical/archaeological significance of site																				1		1	1	0	1	0	0	0	
	Meteorology																				1		0	0	0	0	0	0	0	

Key to ranking: 0 - Favorable
1 - Unfavorable
2 - Unacceptable
3 - Prohibitive

APPENDIX VII

SITING STUDY F

SITING STUDY F

FINAL SITE SELECTION

Eignt sites are compared using 7 attributes.

I. ATTRIBUTES

The attributes are defined qualitatively in broad terms (see Exhibit F-1). For example:

> "The evaluation of the aquatic ecology at each of the eight candidate sites includes consideration of:
> 1. Water quality standards and requirements
> 2. Biological factors, and
> 3. The identification of sensitive ecological areas."

Except for 2 attributes, raw impact measurements are presented as site-specific descriptions (Table F-1). Socioeconomic impacts are not considered. The definitions are too vague to determine if the attributes are independent; there are suggestions that geotechnic considerations may include cost-related items.

II. SCALING

Sites are rated on "a point scale from zero to five with five representing a particularly favorable condition and zero conditions not presently feasible from engineering or economic standpoint." Decimal ratings are permitted. Although quantitative raw measures and transformations are not presented, this appears to be an interval level of measurement.

III. WEIGHTS

The weights (Table F-2) appear to be ratio-scaled because they are expressed as percentages. It is not stated how the weights were chosen or whose values they represent so it is not possible to verify the level of measure or to determine the kind of importance they represent.

IV. DECISION RULE

Weighting summation is used. Comparative ratings are shown in Table F-3.

V. DISCUSSION

This is one of the few studies that apparently meets the requirements of interval-scaled factors and ratio-scaled weights. Lack of information about weight-selection techniques and absence of specific attribute definitions are serious shortcomings, however. Attribute independence is an important assumption of weighting summation, and the definitions presented in this Environmental Report are too general to determine independence. In fact, the definitions are too general for this stage of site selection.

EXHIBIT F-1

ATTRIBUTE DEFINITIONS

I. DIFFERENTIAL COSTS

"Differential cost breakdowns by site and cost element were calculated on the basis of a generating plant consisting of two, 1,150 MWe (nominal) units."

"Acquisition costs for each of the eight sites were estimated by a professional real estate appraiser."

"Preliminary designs were established for each candidate site in order to estimate differential construction and operating costs. Design variations included the following itens:

1. Modifications to the foundation mats for the reactor and auxiliary building structures to reduce soil bearing pressures and affect a more uniform load distribution, as determined by soil conditions.
2. Increase in foundation sizes of other structures, as necessary to reduce soil bearing pressures.
3. Additions to structures and foundations resulting from placement of the structures at greater depths to minimize anticipated settlements.
4. Flood protection variations.
5. Variations in plant site preparations.
6. Effects of hurricane wind design on secondary, non category I structures.
7. Excavation dewatering requirements.
8. Relocations of existing structures, roads and installations."

"Power plant construction personnel visited each site to evaluate factors that would affect construction costs such as labor availability, access for heavy equipment, availability and proximity of construction materials, equipment storage requirements, etc. Differential construction cost estimates were then developed from economic studies."

"Differential operating costs were also estimated and included such items as purchase and pumping of makeup water and the additional maintenance costs caused by the saltwater-laden atmosphere associated with coastal sites."

II. GEOTECHNIC CONSIDERATIONS

"Preliminary assessments of soils, structural geology and seismic conditions were determined for each of the candidate sites through reconnaissance-level investigations."

EXHIBIT F-1 (continued)

Qualitative descriptions c. the geology and soils, and faults and subsidence of the siting areas presented. For example,

"Underlying formations consist of sedimentary rocks ranging in depth from occasional outcroping...to several thousand feet."

III. LAND USE

"The land use evaluation placed particular emphasis upon potentially competitive land uses. In agricultural areas more importance was attached to cultivated areas and less to grazing or pastureland. The extent of mining operations such as the presence of oil or gas wells was also considered both from the land value point-of-view and the adverse influence of potential fires or explosions. The presence of other industry was considered mainly from the possible interaction with the generating plant in the event of an incident at the industrial plant and subsequent release of toxic chemicals, fire or explosion. The presence of military installations, parks, game reserves, residences and resorts was also considered."

IV. DEMOGRAPHY

"The cumulative populations within 5, 10, and 50 miles of each site were obtained for 1970 and estimated for the year 2020."

V. TERRESTRIAL ECOLOGY

"Each site was rated numerically on the basis of the following ecological criteria:

1. Successional stage of vegetation on the proposed site,
2. Rare or scientifically important plant communities likely to be found on the site,
3. Numbers of mammals, birds, reptiles and amphibians likely to be affected and,
4. Rare or endangered plant and animal species which might occur on the site."

VI. AQUATIC ECOLOGY

"The evaluation of the aquatic ecology at each of the eight candidate sites includes consideration of:

1. Water quality standards and requirements,
2. Biological factors, and
3. The identification of sensitive ecological areas."

EXHIBIT F-1 (continued)

VII. METEOROLOGY

"The meteorological characteristics considered were:

1. topography;
2. ventilation;
3. dispersion;
4. annual average relative humidity;
5. extreme wind speed expected once in a 100 years; and
6. frequency of tornado occurrence."

EXHIBIT F-2

ATTRIBUTES AND WEIGHTS

1.	Cost Differential	50%
2.	Geotechnic Considerations	10%
3.	Land Use	10%
4.	Demography	5%
5.	Terrestrial Ecology	10%
6.	Aquatic Ecology	10%
7.	Meteorology	5%

EXHIBIT F-3

COMPARISON OF CANDIDATE SITES

Attributes		Ratings						
	Site #1	Site #2	Site #3	Site #4	Site #5	Site #6	Site #7	Site #8
Cost Differential (50%)	3.0	3.0	4.0	5.0	4.0	5.0	2.0	2.0
Geotechnic Considerations (10%)	3.9	4.0	0.8	3.0	3.2	2.0	2.4	2.8
Land Use (10%)	3.0	3.0	3.0	3.0	2.0	3.0	2.0	3.0
Demography (5%)	5.0	2.0	4.0	4.0	2.0	4.0	3.0	4.0
Terrestrial Ecology (10%)	3.4	3.4	3.5	4.0	4.0	3.2	3.4	3.1
Aquatic Ecology (10%)	2.7	2.7	4.0	4.0	4.0	4.0	3.9	3.9
Meteorology (5%)	2.9	2.9	3.7	3.7	3.7	3.7	3.7	3.7
Combined Rating	3.20	3.06	3.52	4.29	3.61	4.11	2.51	2.67
Overall Rating	5	6	4	1	3	2	8	7

APPENDIX VIII

SITING STUDY G

SITING STUDY G

FINAL SITE SELECTION

Four sites are compared.

I. ATTRIBUTES

The attributes are divided into 3 major categories: engineering--site cost, nuclear licensing, and environmental impact. The list appears to be comprehensive. The attributes are qualitatively well-defined, but quantitative measures are presented only for site cost.

II. SCALING

Site scores are point allocations based on the total number of points available for each criterion. How points are allocated is not specified.

Raw impact measurements are presented only for site cost. The transformation from dollars to the rating scale is shown in Exhibit G-1. This graph is not shown in the Environmental Report. It is approximately linear over the range of costs, except for the least expensive site. Deviation from linearity means that the low-cost site is weighted more heavily than a high-cost site on a per dollar basis. The difference, about 12 points on the rating scale, is significant relative to the differences in ratings among sites. The difference between site #4 and site #1 is 38.7 points in this siting study, but only 26.7 points using a linear transformation. The nonlearity of this transformation is not acknowledged.

III. WEIGHTS

Each of the three major categories is allowed 100 points. It is not clear that these actually represent weights, defined as relative importances of the various attributes. The points allowed seem rather to describe a maximum score for an "ideal" site, and are used to "grade" the individual sites. The "weights" are not included in suitability calculations.

IV. DECISION RULE

"Ratings" are summed for each of the three major categories, and the results are multiplied to give a final site ranking (Tables G-3 through G-6).

V. DISCUSSION

Multiplication instead of addition in the final step of amalgamation causes small differences in good sites (high ratings) to be weighted less heavily than small differences in bad sites (low ratings). This is because multiplication shows proportional differences, not absolute differences. Note that:

$$(0.6)(0.9)(0.2) = 0.108$$

If the high rating of 0.9 is decreased by 0.1,

$$(0.6)(0.8)(0.2) = 0.096$$

a difference in the site score of 0.012 results. But if the low rating is decreased by 0.1,

$$(0.6)(0.9)(0.1) = 0.054$$

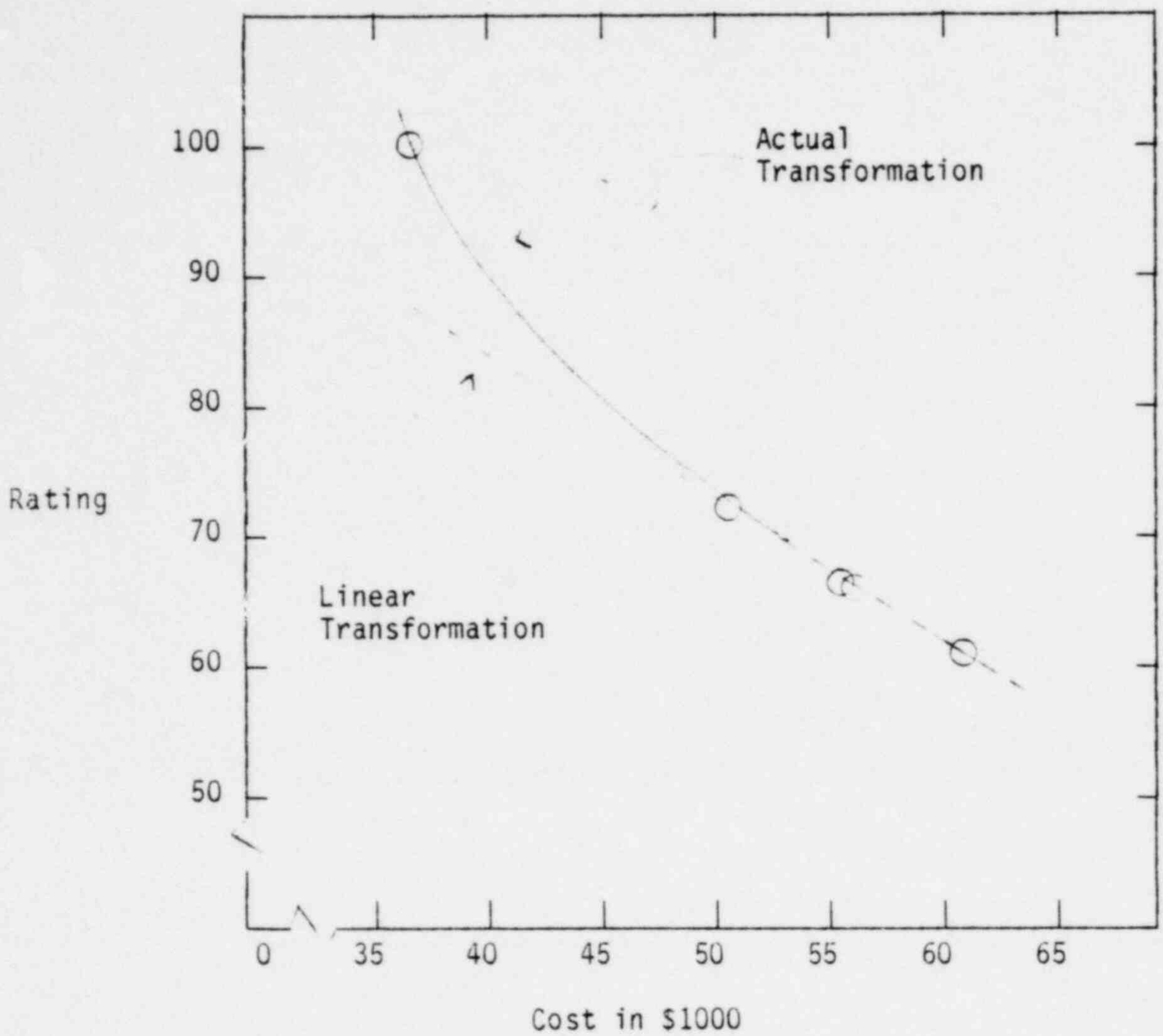
the change in the site score is 0.054. A 50% change in rating yields a 50% change in total score. The final site rankings in this study are not changed by multiplying instead of adding, but the reason for using multiplication is not presented, nor is it acknowledged that it could make a difference.

It was apparently intended that each of the three major categories have equal weight, 100 points. Cost is the only category, however, for which the best site is rated 100; the other attributes never reach the allowed maximum. Cost therefore represents more than one-third of the final decision.

This study contains insufficient information about the method used or the raw impact measurements to permit a detailed analysis of theoretical validity.

EXHIBIT G-1

SITE COST RATINGS



——— Actual transformation

------ Linear transformation

EXHIBIT G-2

ATTRIBUTE DEFINITIONS

ENGINEERING-COST RELATED ITEMS

The factors used to rate the sites in this category were those items in the total construction cost which might vary significantly from site to site. The unit costs assigned to these items were intended only to convey relative magnitude of cost to a degree sufficient for the purposes of this review.

1. Site Development Costs

This factor includes the cost of land for the plant structures, the cost of providing road and rail access to the site, and the cost of removing and/or relocating any encumbrances from the plant site. All other items generally related to site preparation and development were assumed to remain constant, or to vary insignificantly from site to site.

2. Circulating Water System

This factor includes the costs of cooling water supply, recirculation, and heat rejection systems. When the site development plan called for it, the evaluation includes the cost of land for a makeup water storage reservoir or cooling pond, clearing the reservoir or pond area, and all required embankments and dams; the cost of circulating water piping; the cost of makeup water intake, piping, pumps, and pump structures; the cost of blow-down piping and cooling pond requirements; the cost of cooling towers - where applicable; and the cost of removing and/or reloacting any encumbrances in the reservoir or cooling pond area.

3. Transmission Lines

This factor consists of the estimated relative cost for providing transmission lines from the site to the transmission network.

4. Construction Cost Penalties

This factor consists of any cost penalty that might be imposed on any site due to restrictive transportation facilities that would necessitate either field fabrication of large vessels or an increase in their delivery costs.

PLANT LICENSING CONSIDERATIONS

The factors used to rate the sites in this category are those which the ATomic Energy Commission considers when reviewing a site for licensing suitability.

1. Population and Dosage

a) Cumulative Population vs. Distance: Data for population density were taken from 1970 census information (U.S. Government Census Bureau). This information was compared with similar information for sites previously licensed. As the distance from a site tc population centers of 25,000 or more increased, a relatively higher rating was assigned to the respective site.

b) Exclusion Area Radius: An exclusion area radius was determined for each site using the preliminary plant layouts. Sites with a larger radius were given higher ratings.

c) Low Population Zone Distance: A low population zone radius was determined for each of the potential sites. The ratings scale considered the population zones falling within this radius; and, the sites with lower populations recieved higher ratings.

2. Regional Land Use

a) Offsite Activities Affecting Plant: This item is concerned with any activity - taking place offiste, but in the general vicinity of the plant that might adversely affect the plant. Examples are such activities as chemical, petroleum, or gas facilities where explosion or fire possibilities exist. Major airports, including their approach zones, are additional considerations for plant safety. The more remote, or isolated, sites recieved higher ratings.

b) Plant Affecting Offsite Activities: This item is concerned with the effects that a plant might have on the surrounding area. Some critical land uses are dairy farming, public water supplies, schools, and hospitals. The more remote, or isolated, sites again received higher ratings.

c) Site Location with Respect to Faults: This item concerns the surface position of geologic faults relative to each site. Sites farther from known faults received higher ratings.

3. Hydrology

a) Flooding Potential: Each site was studied for the possibility of flooding from a nearby river. Each site evaluation was compared with an estimated probable maximum flood - including the possibility of upstream dam failures.

b) Dilution Potential: Dilution potential is concerned with reducing the downstream effects of any opertional or accidental radiological releases. Where water resources indicate a greater adequacy for dispersion purposes, a site received a higher rating.

5. Diffusion Meteorology

Diffusion meteorology is concerned with the diffusion of gaseous radioactive materials. The general meteorological factors of prevailing winds, humidity, temperature ranges, and inversion frequency were studied for all site areas. In addition, topography, ground cover, and site elevation are other factors contributing to the site score in this category. Since the general meteorological factors are almost similar from site to site, the ranking depended heavily upon the particular topographic conditions for each site. Sites situated in narrow valleys close to ridges score lower from a meteorological viewpoint.

ENVIRONMENTAL IMPACT FACTORS

The environmental impact factors relating to the effects of the existence of a nuclear power plant on the surrounding area were also evaluated.

1. Water Use

a) Water Availability: As related to environmental impact, the water availability factor refers to the quantity of water required for plant use - and the source of water as well. Since the plant must share the water resources with the surrounding area, a sufficient volume for all uses must be available. Preference was given to those sites located on major rivers where sufficient water would be available for all uses.

b) Current Usage: This refers to the use of the existing water resources by the surrounding area. Included in this item was the effects of plant discharge on the current water quality.

2. Land Use

a) Pre-emption of Current Land Use: Lower scores were assigned to those sites where there was a greater proportion of conflict with the land use of the area.

b) Site Land Use: Consideration was given to the percentage of land use for the actual plant with respect to the total site area, and the modification necessary to prepare the site for a power plant installation. Additional considerations for site land use are the makeup water storage area, fuel storage area, cooling tower area, transmission facilities, rail and highway access routes.

c) Compatibility With Area Development: This item is concerned with overall area development; projected residential development, agricultural and industrial usage, and recreational potential. Land use and population trends were considered in this item.

d) Proximity to Recreation: This item is concerned with the effects of plant construction and operation on the public use of areas of recreational significance. Site locations within a zone preponderant with recreational facilities were rated low due to their contrasting land use and purpose. Exceptions were conditions where development of cooling ponds or reservoirs would enhance the recreational capability of an area by the multiple use of those resources.

e) Proximity to Historical Areas: A major consideration of this factor is the potential impact or damage through construction operations or due to plant effluents to established landmarks.

f) Visual Impact of Plant: This item is concerned with the total visual effect of the plant on the surrounding area. Existing topography and vegetation of the surrounding area were considered to be vital conditions for minimizing the visual impact of a power plant installation.

g) Transmission Route: This item refers to the route from the plant to the transmission grid. Terrain conditions, horizontal distance, and route encumbrances are of primary importance in this factor. The most direct routes that would least damage the environment received the higher scores.

h) Construction Effects: This item is concerned with the effects of site preparation and plant construction on area residents. Rating was on the basis of problems of erosion in surrounding areas due to removal of vegetation, disruption of transportation, and resulting inconvenience, noise, and dust.

3. Ecological Sensitivity

This item is concerned with the impact on the ecology of the site and the surrounding area. The use of cooling towers that would preclude the return of cooling waters to public water bodies indicates that there would be little or no damage to the aquatic ecology at a site. A major component of this factor is the terrestrial ecology of the site and its immediate surrounding area. Of prime importance was the amount of land that would be removed from its natural state for a site, as well as the effects upon the biota of that portion of land. Of equal importance was the criteria offered by regulatory bodies to ensure that no significant or permanent changes would be induced by the plant to the surrounding area during plant construction and operation.

4. Meteorological Sensitivity

This category is concerned with the impact on the surrounding area by the power plant due to adverse meteorological conditions. For rating purposes, an examination of site meteorology - general wind conditions, temperatures, and humidity range - was made. In addition, terrain studies were made to determine the approximate diffusion characteristics of each site. Regulatory agency criteria require that cooling tower water vapor releases have no adverse impact on the immediate area - since water vapors may cause fogging and icing on the surrounding roads and agricultural land.

EXHIBIT G-3

ENGINEERING-COST-RELATED ITEMS
(Cost in $1000)

Factor	Sites #1	#2	#3	#4	#5
Site Development	1,149	2,693	1,534	4,443	3,948
Circulating Water System	59,734	50,777	49,785	26,004	44,700
Transmission Lines	330	84	930	3,090	3,090
Construction Cost Penalties	-	-	4,000	4,000	4,000
Total Comparative Cost	61,213	53,554	56,249	37,537	55,738
RATING	61.3	70.1	66.7	100	67.3

IMAGE EVALUATION TEST TARGET (MT-3)

6″

IMAGE EVALUATION
TEST TARGET (MT-3)

6″

EXHIBIT G-4

PLANT LICENSING CONSIDERATIONS

Category	Item	Weight	Sites #1	#2	#3	#4	#5
Population and Dosage	Cumulative Population vs Distance	10	8	8	6	9	9
	Exclusion Area Radius	10	8	8	7	7	7
	Low Population Zone Distance	10	9	9	7	9	9
Regional Land Use	Off-Site Activities Affecting Plant	30	25	25	15	5	5
	Plant Affecting Off-Site Activities	10	9	9	8	8	8
Geology and Seismology	Seismic History of Region and Site	10	5	5	3	4	4
	Site Location with Respect to Faults	5	2	1	2	1	1
Hydrology	Flooding Potential	5	5	5	3	3	4
	Dilution Potential	5	2	2	1	4	4
Diffusion Meteorology	Diffusion Meteorology	5	1	1	2	3	3
	TOTAL SCORE	100	74	73	54	53	54

EXHIBIT G-5

ENVIRONMENTAL IMPACT FACTORS

Category	Item	Weight	Sites #1	#2	#3	#4	#5
Water Use	Water Availability	20	7	7	2	14	14
	Current Usage	10	7	7	7	3	7
Land Use	Pre-emption of Current Land Use	5	4	4	3	3	2
	Site Land Use	5	5	4	[illegible]	1	2
	Compatibility with Area Development	15	10	10	12	5	5
	Proximity to Recreation	5	5	5	2	1	1
	Proximity to Historic Areas	5	5	5	5	2	2
	Visual Impact of Plant	5	3	3	5	2	1
	Transmission Route	5	5	5	2	1	1
	Construction Effects	5	5	5	2	1	3
Ecological Sensitivity	Ecological Sensitivity	15	9	11	6	13	11
Meteorological Sensitivity	Meteorological Sensitivity	5	1	1	2	4	3
	TOTAL SCORE	100	66	67	50	49	52

EXHIBIT G-6

RANKING OF SITES

Factors	Sites #1	#2	#3	#4	#5
Engineering-Cost Related Items	0.613	0.701	0.667	1.000	0.673
Nuclear Licensing Considerations	0.740	0.730	0.540	0.530	0.540
Environmental Impact Factors	0.660	0.670	0.500	0.490	0.520
RATING	0.299	0.343	0.180	0.260	0.189
RANK	2	1	5	3	4

APPENDIX IX

SITING STUDY H

SITING STUDY H

FINAL SITE SELECTION

Five sites :re compared, each with once-through and closed-lop cooling systems, for a total of 10 site-plant alternatives.

I. ATTRIBUTES

Engineering, environmental, and economic attributes are considered. The list appears to be comprehensive. Raw impact measurements and qualitative discussions are presented for each attribute. Economic considerations are included in engineering attributes; it is difficult to determine if the attributes are independent. "The effects of the engineering factors, such as geology, seismology, hydrology, cooling water supply, transportation facilities, population distribution and the constraints of transmission systems include both the viewpoint of cost and technical feasibility." Transmission capital costs are included in the economic attribute, but transmission-maintenance costs are included in the engineering attribute Transmission Constraints. It is possible that the attributes are in fact independent and only seem to overlap because the presentation is confusing.

II. SCALING

Each attribute is "rated" as follows:

1 = preferable
2 = favorable
3 = acceptable

This is an ordinal scale. The method of transformation of raw data into the three categories is unclear and appears to be subjective.

III. WEIGHTS

The study does not use explicit weights. The implicit weights contained in the scaling are acknowledged, however. It is stated that "the engineering and environmental factor ratings are weighed (sic) equally: that is, a rating of '2' for an engineering factor is weighted (sic) the same as a rating of '2' for environmental impact." In this manner, scaling and weighting are combined into a single subjective evaluation.

IV. DECISION RULE

The engineering and environmental "ratings" are summed for each site to give an overall engineering-environmental ranking. The sites are then ranked according to cost, and the two rankings are averaged to give a final ranking. Because the weights implied in the scaling process are acknowledged, this is essentially weighting summation done in two steps instead of three. If the "weighted ratings" are actually on an ordinal level of measurement as they appear to be, it is not theoretically valid to add them.

V. DISCUSSION

In addition to the unspecified weights contained in the scaling process, a second set of weights is implied in the decision rule. Economic considerations contribute 50% to the final decision. Certain ceconomic considerations are scattered throughout the engineering attributes, however, and economics actually determines more than half of the decision. Assuming 50% economics, 12 environmental-engineering attributes each represent 1/12 of 50% of the final decision, or 4%. In other words, the economic attribute is 12 times more important than, for example, geology and seismology, or aquatic ecology. Within each of the engineering or environmental attributes, there are several sub-attributes. Within Community Features are land use, recreational facilities, public institutions, and aesthetics. It is unclear how the sub-attributes contribute to the "rating" for Community Features, but if each contributes equally, consideration of land use represents 1/4 of 1/12 of 1/2, or 1% of the final decision. Not only are ordinal numbers manipulated incorrectly in this study, but the tradeoffs made due to the relative importance or weights of each attribute are not considered explicitly.

EXHIBIT H-1

SITE RATING AND RANKING: ONCE-THROUGH COOLING SYSTEM

	Site #1	Site #2	Site #3	Site #4	Site #5
Engineering Factors					
Geology and Seismicity	3	3	3	3	3
Hydrology and Cooling Water Supply	3	3	3	3	3
Transportation Facilities	1	1	1	2	1
Population Distribution	2	3	1	1	2
Transmission Constraints	2	3	2	3	1
Environmental Factors					
Transmission Impact	2	3	2	3	1
Community Features	1	1	1	3	1
Aquatic Ecology	2	3	1	3	3
Terrestrial Ecology	1	2	1	3	3
Air Quality and Meteorology	1	1	1	1	1
Water Quality	2	1	2	2	3
Noise	1	1	1	1	1
Overall Rating	21	25	19	28	23
Engineering - Environmental Rating	2	4	1	5	3
Total Cost - 1981 \$ x 10^6	737	748	680	885	694
Economic Ranking	3	4	1	5	2
Overall Ranking	2(1)	4	1	5	2(1)

(1)Equivalent ranking of second.

EXHIBIT H-2

SITE RATING AND RANKING: CLOSED-LOOP COOLING SYSTEM

	Site #1	Site #2	Site #3	Site #4	Site #5
Engineering Factors					
Geology and Seismicity	3	3	3	3	3
Hydrology and Cooling Water Supply	3	3	3	3	3
Transportation Facilities	2	1	1	2	1
Population Distribution	2	3	1	1	2
Transmission Constraints	2	3	2	3	1
Environmental Factors					
Transmission Impact	2	3	2	3	1
Community Features	3	3	3	3	3
Aquatic Ecology	1	2	1	3	2
Terrestrial Ecology	2	3	2	3	3
Air Quality and Meteorology	3	3	3	3	3
Water Quality	1	1	1	1	2
Noise	2	3	1	1	3
Overall Rating	26	31	23	29	27
Engineering - Environmental Rating	2	5	1	4	3
Total Cost - 1981 $ x 10^6	768	808	726	933	702
Economic Ranking	3	4	2	5	1
Overall Ranking	3	4(1)	1	4(1)	2

(1)Equivalent ranking of fourth.

EXHIBIT H-3

ATTRIBUTE DEFINITIONS

In addition to the definitions below, the Environmental Report contains site-specific descriptions in terms of each attribute.

ENGINEERING FACTORS

From the technical standpoint, it is possible to develop each of the five candidate sites under consideration with nuclear fuel and either a once-through or a closed-loop cooling system. The effects of the engineering factors, such as geology, seismology, hydrology, cooling water supply, transportation facilities, population distribution and the constraints of transmission system include both the viewpoint of cost and technical feasibility. The costs associated with construction and operation, in some instances, adequately reflect the engineering aspects of the siting problem. Other engineering factors, however, such as population density and seismic features, cannot be adequately described on the basis of cost.

I. Geology and Seismicity: This attribute is discussed site-specifically.

Based upon the available data, all of the five candidate sites appear equally well suited for the siting of a nuclear power plant.

II. Hydrology and Cooling Water Supply: The five candidate site-plant combinations all have adequate quantities of cooling water available for the supply of either a once-through cooling system or the make-up water requirements for a closed-loop cooling tower system.

The distance and elevation difference between the cooling water source and the plant site has an impact on both the economic and environmental effects of providing circulating or make-up water supply for the station.

The location of the five candidate sites is such that the quantity of dissolved solids, an indication of the quantity of blowdown and treatment required for make-up water, and the pH value, as indication of the treatment required to achieve a slightly alkaline quality required for the control of algae, would not be significantly varied to be a meaningful point of comparison among the alternatives.

The topography of all the sites is such that adequate site drainage can easily be provided. The flood damage potential is discussed in another section.

The five candidate sites are rated as "3" for this category since the factors unique to each site and used for comparison are related primarily to economics (such as longer pipe lengths and pumping head).

III. Transportation Facilities: Although it is feasible to construct and operate a nuclear generating station using only highway transportation, it is more economical and there is less potential for impact on the public if the heavy components can be transported by barge or rail. Nevertheless, the absence of water transportation or the difficulty of bringing a railroad to the site would not result in the site being declared unacceptable.

The only waterway traffic contemplated at any of the candidate sites would be by barge fcr the delivery of large pieces of equipment and possible future shipping of the nuclear fuel casks. All candidate sites have direct access to deep water. A water depth of 6 feet at mlw plus a tidal range of 6 feet is assumed to be required for barge access. The distance from the short to the 6-foot mlw contour is considered as indicative of the length of channel required.

Road access is necessary for the transport of crews and materials during construction. This type of access is also a factor involved in the transport of crews and wastes during operation, and to provide emergency egress of crews and local residents during a possible accident.

The transportation factors ae rated based mainly upon highway and barge access, since the railroad vacilities would not be used extensively in site construction. Also, the barge access is not considered in the rating of transportation facilities in the once-through cooling system alternative because an intake canal of sufficient depth would be required for station operation.

<u>IV. Population Distribution</u>: This section discusses the factors of population distribution relevant to the comparison of the five candidate site-plant combinations In addition to local community population figures and population densities, site-orinted population figures are discussed with reference to both the number of dwellings within the 1,400-foot exclusion radius from the reactor and the number of residences within the low population zone, defined as a one-half-mile radius from the center of the proposed reactor.

The ratings for population are based mainly on the number of residences within 1/2 mile of the proposed reactors and the population within immediate vicinity of the site.

<u>V. Transmission Constraints</u>: The transmission system associated with each site is basically the same. Any diffferences in reliability are predominately a function of the length of the generator leads to the grid system.

The maintenance costs will also be related to the length of the lines added for each site. The cost is assumed to be a linear relationship except for sections where underground cable might be installed.

The transmission constraints factor rating is based principally upon reliability and maintenance costs.

ENVIRONMENTAL FACTORS

I. Transmission Impact: The Applicant has examined existing and proposed land use, vegetative cover, topography, hydrology, existing and proposed cultural development, and other environmental factors both within and around the several corridor areas. There are no apparent reasons why the required transmission facilities could not be established within the designated areas.

This environental impact of the transmission facilities required for each of the candidate sites is rated according to the general terrain in the transmission corridor, the total length of line required, and screening/exposure considerations.

II. Community Features: This section discusses community factors and includes those aspects of construction and operation of the proposed generating station that may affect the use of each of the five candidate sites and the surrounding areas. Consideration is also given to those people who presently live in the area, and those who pass through or visit the area. The visual impact of th facility is discussed under aesthetics, which examines the available screening.

The compatibility of site development is estimated with respect to the potential effects on present or planned usage on adjacent lands rather than whether a nuclear generating station would be a permitted use on the site in question under existing or planned ordinances. The location of wetlands and tidal marsh is also an important consideration for preserving the natural quality of surrounding areas as a habitat for wildlife.

Local and regional planning commissions are contacted by the Applicant to review the land use compatibility of each site-plant alternative with established development plans and goals.

The effects on the enjoyment of historical and cultural monuments are considered in relation to distance and atendance, where available. No attempt is made to assess the degree of historic or aesthetic incompatibility of any such monument with the presence of a nuclear generating station.

The effects on the usage of public institutions such as schools, hospitals, churches, and community centers are assumed to be inversely proportional to distance and directly proportional to the capacity of the institution. No attempt is made to assess differences in sensitivity between one kind of public institution and another.

The effects on the usage of existing recreational facilities near each of the candidate sites are related to the distance from the site and the number of people estimated to use the facility annually. The potential impact would be expected to decrease with increasing distance from the facility and a decreasing number of site visitors.

EXHIBIT H-3 (continued)

Each site is also analyzed on the basis of suitability for other competing uses of the site itself and of the water supply that would be consumed as a result of power generation. The suitability of the site itself for other competing uses is analyzed by determining the existing land use of both the site and surrounding area, and the present site zoning.

Thus, available screening and proximity to historical sites, parks, recreational areas, and population centers were considered in determining the aesthetic and social impact potential for each site. The present and possible future productive use of the sites is used to determine the relative impact on land use.

The environmental impact of the proposed nuclear power station on community features for the once-through system is rated primarily according to the land area available, the public institutions and recreational facilities within a 10-mile radius, planning considerations, and aesthetics. The impact of the station with the natural draft cooling tower closed-loop system is rated principally on the aesthetics.

III. Aquatic Ecology: The potential impact of site development on aquatic ecology is difficult to assess without long term site studies. Nevertheless, some judgments can be made using major features at he site, e.g. potentially productive fishery areas such as shoals, estuaries, and marshes. The relative rating of a site is determined by its proximity to this type of area and by available biological data.

IV. Terrestrial Ecology: The five candidate sites are rated according to the impact of the nuclear power station on terrestrial ecology according to the cooling system alternative. The once-through cooling system is rated based principally on the type and amount of vegetation cleared, fauna, and erosion potential. The closed-loop natural draft tower system is rated based principally upon the potential impact of salt drift on vegetation in the area surrounding the site.

V. Air Quality and Meteorology: The five candidate sites are rated according to their impact on air quality based upon the cooling system alternative. The once-through cooling system is rated "1" for impact on air quality for all sites. The closed-loop cooling system is rated based primarily on the impact of icing on surrounding residential areas. Thus all sites are rated "3."

VI. Water Quality: The five candidate sites are rated according to the impact of the nuclear power station on water quality according to the cooling system alternative. The once-through and closed-loop cooling systems are both rated based primarily on: the diffuser length; the maximum length of discharge pipe; the surface area within the differential isotherm of 1.5 °F; the water volume subjected to a temperature increase greater than 1.5 °F; and the amount of water entrained in the thermal plume.

EXHIBIT H-3 (continued)

VII. Noise: Each site is rated for each cooling system alternative based upon the expected sound levels and the location of the nearest residential areas

ECONOMICS

Preliminary estimates of the 1981 present worth of revenue requirements for capital, operation and maintenance costs of the circulating water system, and for the transmission capital costs were developed for the 10 site-plant alternatives to provide an economic basis for comparison.

The preliminary capital cost estimate covers the site grading, the circulating water system, the service water system, and transmission. These items are the major site-related costs.

The cost estimates do not reflect the cost of land or land rights, haul roads, or the effect on scheduling created by unique engineering problems particular to a given site.

APPENDIX X

SITING STUDY I

SITING STUDY I

FINAL SITE SELECTION

Three sites are compared, using 13 attributes.

I. ATTRIBUTES

Definitions of the attributes are qualitative but concise. The list of attributes appears comprehensive. Economics is not a separate attribute, but is included in other appropriate categories. Raw impact measurements are not presented, and it is not always clear what variables were used or how they were measured.

II. SCALING

Each site was "rated" for each attribute,

1 = poor
2 = fair
3 = good
4 = excellent

Transformations from raw impact measurements into this scale are not presented. This appears to be an ordinal scale.

III. WEIGHTS

A weight of 1, 2, or 3 is assigned to each attribute. The report does not state how the weights were selected or whose values they represent; it is therefore not possible to determine if they measure the correct type of importance. These weights are apparently on an ordinal level of measure, but may be interval level because, "A weight was given to each of these factors based on the relative importance of the factor...."

IV. DECISION RULE

The decision rule is weighting summation. Theoretically, attributes should be interval-scaled and weights ratio-scaled. The ordinal-scaled attributes and the ordinal- or interval-scaled weights used in this study are therefore theoretically invalid.

V. DISCUSSION

There is insufficient information in this study for a detailed analysis. It is not possible to verify the level of measurement of the scaled attributes or the weights.

EXHIBIT I-1

COMPARISON OF CANDIDATE SITES

Attribute	Weight	Site #1 Rating	Site #1 Weighted Rating	Site #2 Rating	Site #2 Weighted Rating	Site #3 Rating	Site #3 Weighted Rating
Access	1	2.5	2.5	4	4	3	3
Aesthetics	1	4	4	2.5	2.5	4	4
Benefit Potential	2	3	6	3	6	2.5	5
Environmental Effect	3	3	9	3	9	2.5	7.5
Geology & Foundations	3	3.5	10.5	3	9	3	9
Labor Supply	1	4	4	3	3	3.5	3.5
Land Use	3	4	12	3	9	3	9
Meteorology	1	2.5	2.5	3	3	2	2
Population Density	2	3	6	2.5	5	4	8
Seismicity	3	4	12	3	9	3.5	10.5
Topography	1	2	2	3	3	4	4
Transmission	1	4	4	3	3	4	4
Water Supply	3	4	12	2	6	3	9
Total (Max = 100)			86.5		71.5		78.5
Site Rating			1		3		2

APPENDIX XI

SITING STUDY J

SITING STUDY J

CANDIDATE AREA SELECTION

Minimum site requirements were established a priori and used in a statewide screening to identify 11 candidate valleys, defined as areas of several hundred square miles. The candidate valleys are compared and the 3 top-ranked valleys further studied to identify 28 candidate regions, defined as areas of several square miles. The candidate regions are compared, resulting in identification of the 5 top-ranked candidate regions.

I. ATTRIBUTES (Exhibit J-1)

The attributes are separated into primary (land availability, water availability, and seismotectonic characteristics) and secondary attributes (land use, meteorology, accessibility, transmission line access, demography and general topography). Minimum requirements are stated quantitatively, e.g., cooling water availability: 35,000 acre-feet per year per unit for 40 years (total 1,400,000 acre-feet per unit), but most of the attributes are defined qualitatively. Without specific definition of each attribute, it is not possible to determine if all important factors are included or if any duplication occurs.

II. SCALING

Each region or valley is "graded" on a 0 to 5 scale, where 5 represents highly favorable and 0 reflects sufficient uncertainties to eliminate a region or valley. No further breakdown of this scale is presented; it is not stated how much available water is given a grade of 4, how many acres are worth 3, etc. This is an ordinal scale.

III. WEIGHTS

The weighting system is complex. "The weighting scheme used in combining the individual ratings to make up the overall rating again attached varying degrees of importance to the different screening factors. Thus, the ratings for hydrology and geology were each multiplied by different fractions before combining them into a single primary rating. Similarly, each rating for the individual secondary factors was multiplied by a fractional weight before combining them into a single secondary rating. The primary and secondary ratings were each, in turn, multiplied by corresponding fractional weights before adding them together to yield the overall rating for the candidate region." The report does not state how the weights were selected, who chose them, or what kind of importance they represent. In fact, the weights themselves are not presented.

IV. DECISION RULE

Weighting summation is used.

V. DISCUSSION

A consultant's study is referenced frequently in this Environmental Report; it is evaluated as Siting Study J-II.

The Environmental Report states that a matrix was used to evaluate candidate areas, but it is not presented. It also states that sensitivity analysis show that changes in the weighting system have no significant effect on overall rating of areas. Without individual site scores and weights, it is difficult to discuss questions of theoretical validity and impossible to verify sensitivity analysis. It is only possible to say that weighting summation requires intervally scaled attributes and that the use of an ordinal scale in this study is theoretically incorrect. The consultant's study may contain the missing information and permit a more detailed analysis.

EXHIBIT J-1

EVALUATIONS OF CANDIDATE REGIONS

The candidate regions were selected on the basis of the following guidelines:

The regions should have a total land area of 5000 acres in order to make possible a selection, within the region, of several suitable locations for the reactors.

The region selected should be representative of a much larger geographical area in the valley, to allow a wider choice in the eventual location of reactors.

The candidate region should be as far as possible from mountain peaks and other confining terrain features to obtain good meteorological dispersion characteristics.

The topography of the candidate region should be such that the change in elevation across an area of 1000 acres should be less than 100 feet in order to preclude extensive site grading requirements. Where possible, however, topography should be utilized for potential water impoundments.

The region should be located as far away as possible from agricultural lands to minimize potential land and water use competition.

PRIMARY ATTRIBUTES

Hydrology: The attributes utilized were basically those used in the larger scale candidate valley evaluation: i.e., a sufficient quantity of cooling water being available for the plant lifetime from one or more water source alternatives and, preferably, an alternate supply of cooling water, not necessarily of the same capacity, available for use in the event of temporary failure of the primary source.

Hydrological ratings included all three potential water source alternatives; groundwater, treated sewage wastewater effluent, and Central Arizone Project water. For the latter two possible sources, their distances from the candidate region were evaluated. For groundwater, each region was characterized with respect to depth of water table, potential well yields, withdrawal rate, estimated recoverable quantity, chemical quality, and competing water uses.

Geology: The attributes used in evaluating the geological characteristics included:

Proximity to long lineations which might be speculated to be faults and sources of earthquakes.
Proximity to known or suspected faults displaying possible evidence of late Quaternary displacement.

EXHIBIT J-1 (continued)

Nature of stratigraphic sequences.
Foundation conditions.

SECONDARY ATTRIBUTES

Land Use: The land use attributes were based on the extent of competitive land use in and near the regions and the historical and/or archaeological significance of the area. Some of the factors which may influence land use include agricultural land, airports, national forests, game preserves, parks, and existing underground features in the area.

Meteorology: Meteorological screening utilized the surrounding topographical features to determine whether unusual dispersive characteristics would be likely to occur.

The meteorological and topographical attributes are closely linked since the dispersion characteristics of a relatively small site region result primarily from the topographic characteristics. Flat, open terrain which allows clear unrestricted atmospheric dispersion is an ideal characteristic; also, avoiding major topographic features nearer than two to five times their height difference from the site is important.

Accessibility: The accessibility of a candidate region is an important consideration which comes into play not only during the construction phase but also in the operational phase of a nuclear plant. During the construction phase, the region should be accessible for transport of both construction equipment and materials. The labor force drawn from nearby towns and cities should have ease of commuting to and from the region during construction. The same condition should hold for the operating crew once the nuclear plant goes into operation. There should also be ease of transport to and from the plant for fresh and spent fuel. The region must therefore be close to suitable railroads and highways, and access roads from these main arteries to the region should already exist or be easily constructed at reasonable costs.

Accessibility ratings were based not only on the proximity of the region to major U.S. highways and railroads but also on the degree of preparation needed for the access road to the region from the main highway or railroad. It was assumed that a 3-percent grade for the access road was acceptable and anything greater would require some degree of surface grading.

Transmission Lines: Transmission line screening of the candidate regions was based on whether or not new rights-of-way would be required and if so, what route would be taken by the lines from the nuclear plant to existing electrical load centers. Distances of the regions to existing substations to handle the new transmission lines and as sources of power for support of construction activities were also evaluated.

Demography: Avoiding already overdeveloped or critical groundwater areas resulted in studying areas relatively remote from urban centers. Therefore, population density was not a significant factor from the safety standpoint since all regions considered were sparsely populated. Although urban areas are developing rapidly, the population density should not surpass projections. Among the candidate regions being considered, the demographic evaluation includes the small towns in the vicinity which might house the construction force and the operating staff.

Topography: Topographic factors were also considered separately in the evaluation (from meteorology), so that large earth moving requirements in site preparation and pumping requirements for the cooling water supply could be minimized.

The primary topographic criterion is that an ideal region should no vary more than 100 feet in elevation over an area of 1000 acres. Greater variations in elevation may be acceptable, depending on other site characteristics.

Ecology: The ecological screening for the candidate regions was based on several attributes. Those areas that seemed to have a high density of vegetation and high species diversity were considered to be less desirable as potential regions. Ease of access was also considered as the construction of roads and transmission lines would disturb plant and animal communities. Other factors that were considered included the presence of any unique areas which should not be disturbed and the presence of rare or endangered species.

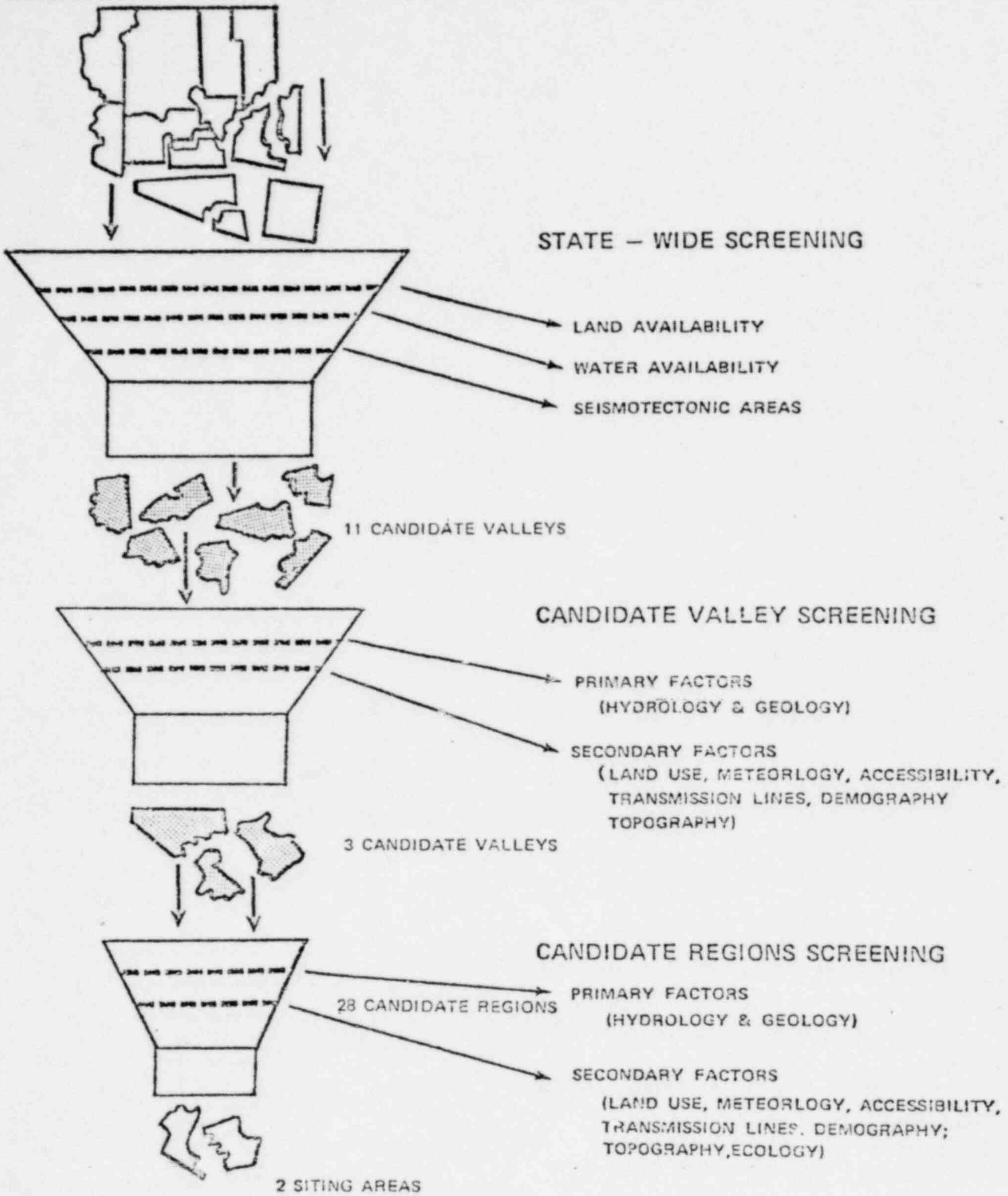


EXHIBIT J-2: SUMMARY OF SITE SCREENING PROCEDURE

APPENDIX XII

SITING STUDY J-II

(Consultant's Report)

SITING STUDY J-II

CANDIDATE AREA SELECTION

Twenty-eight regions in three valleys are compared using two primary attributes and seven secondary attributes. Five regions are selected for further evaluation.

I. ATTRIBUTES

The list of attributes appear to be comprehensive and each attribute is well-defined. Definitions and rating scales are shown in Exhibit J-II-3.

There appear to be several instances of double counting. Pumping requirements for the cooling water supply is measured in both topography and hydrology. Topography is "based on the criterion that an ideal region should not vary more than 100 feet in elevation over an area of 1000 acres. This would minimize large earth moving requirements in site preparation, as well as pumping requirements for the cooling water supply." Hydrology ratings "were influenced not only by the distance of the regions from the three hydrological alternatives, but also by the pumping head requirements for transferring water from the source to the region. Thus, the differences in the elevations of the candidate regions and the corresponding water sources had to be considered." Six regions in one valley were "given hydrology ratings of three because of unfavorable properties such as high elevation or great distance to groundwater sources, in addition to remoteness to th treated sewage source." All regions in another valley received ratings of four except one, which "received a slightly lower rating of three because it would require a greater water pumping head compared to the other candidate regions." Topography, defined above, also double-counts accessibility which is "based not only on the proximity of the region to major U.S highways and railroads, but also on the degree of preparation needed for the access road to the region from the main highway or railroad. It was assumed that a three percent grade for the access road was acceptable and anything greater would require some degree of surface grading." Regions are given higher accessibility ratings for smaller access road grades. Ecology appears to double count accessibility, measured as distance to major roads, and transmission lines, based on need for new rights-of-way and distance to existing substation. "Ease of access was also considered in evaluating regions for their ecological impact.... Therefore, those regions in areas closest to existing roadways and power line corridors would be the most preferable."

II. SCALING

Raw data and rating scales are presented for each attribute. Each attribute is rated 0 to 5, where 0 is unacceptable. Each level of the scale is specifically defined, but there is no indication that an interval level of measure is achieved. The rating scale is therefore quasi-interval.

III. WEIGHTING

A complex weighting system is used which separates primary and secondary attributes (Exhibit J-II-1). Multiplying the primary attribute weights by 0.60 and the secondary attribute weights by 0.40 does not change the site ratings.

The weights appear to be ratio-scaled because they are presented as decimals.

IV. DECISION RULE

Weighting summation is used. Results are shown in Exhibit J-II-2.

V. DISCUSSION

This study presents considerably more information than the Environmental Report and the use of weighting summation may be theoretically valid. It is not possible, however, to verify that weights are ratio-scaled without knowing scaling and weighting techniques.

EXHIBIT J-II-1

WEIGHTING OF PRIMARY AND SECONDARY SCREENING FACTORS FOR EVALUATING CANDIDATE REGIONS

Primary Factors		
Hydrology	0.60	(x 0.60 = 0.36)
Geology	0.40	(x 0.60 = 0.24)
Total Primary Constitutes 0.60 of Overall Rating		
Secondary Factors		
Engineering Factors		
Site Accessibility	0.15	(x 0.40 = 0.06)
Transmission Line Accessibility	0.15	(x 0.40 = 0.06)
Meteorology	0.15	(x 0.40 = 0.06)
Topography	0.10	(x 0.40 = 0.04)
Environmental Factors		
Land Use	0.20	(x 0.40 = 0.08)
Ecology	0.15	(x 0.40 = 0.06)
Demography	0.10	(x 0.40 = 0.04)
Total Secondary Constitutes 0.40 of Overall Rating		

EXHIBIT J-II-2

REGION EVALUATION RATING SUMMARY

	Primary Screening Factors			Secondary Screening Factors								
				Engineering Factors				Environmental Factors				
Region Designation	Hydrology (0.60)	Geology (0.40)	Primary Rating (0.60)	Accessibility (0.15)	Transmission Lines (0.15)	Meteorology (0.15)	Topography (0.10)	Land Use (0.20)	Ecology (0.15)	Demography (0.10)	Secondary Rating (0.40)	Overall Rating
1	3	4	3.4	3	4	4	5	5	3	3	3.9	3.6
2	4	2	3.2	5	4	4	5	3	4	5	4.2	3.6
3	3	4	3.4	4	4	3	4	5	3	3	3.8	3.6
4	3	4	3.4	4	4	2	5	4	4	4	3.8	3.6
5	4	2	3.2	4	4	4	5	3	4	4	3.9	3.5
6	4	2	3.2	3	4	2	4	5	3	3	3.5	3.3
7	4	1	2.8	5	4	4	5	3	4	5	4.2	3.3
8	3	3	3.0	4	3	4	5	4	3	3	3.7	3.0
9	4	2	3.2	4	4	2	4	3	3	3	3.3	3.2
10	4	2	3.2	4	4	2	4	3	3	3	3.3	3.2
11	4	2	3.2	4	4	2	4	3	3	3	3.3	3.2
12	3	2	2.6	3	4	4	4	4	3	4	3.7	3.0
13	4	1	2.8	4	4	2	5	2	4	4	3.4	3.0
14	3	3	3.0	3	3	2	5	3	3	3	3.1	3.0
15	4	1	2.8	4	4	2	4	3	3	3	3.3	3.0
16	3	1	2.2	3	4	4	4	5	3	3	3.8	2.8
17	3	1	2.2	5	4	2	4	4	3	3	3.6	2.8
18	3	1	2.2	3	4	2	4	4	3	4	3.4	2.7
19	3	1	2.2	3	4	2	5	2	4	4	3.3	2.6
20	5	0	-									
21	5	0	-									
22	4	0	-									
23	4	0	-									
24	3	0	-									
25	4	0	-									
26	3	0	-									
27	3	0	-									
28	3	0	-									

EXHIBIT J-II-3

ATTRIBUTE DEFINITION

1. PRIMARY SCREENING FACTORS

a. Hydrology

The hydrological screening for the candidate regions was based on the criterion of a sufficient quantity of cooling water being available for a minimum of 40 years from one of the water source alternatives. Preferably there should be, in addition, an alternative supply of cooling water available. The ideal region would have available sufficient quantities of a combination of groundwater, treated sewage wastewater and, in the future, Central Arizona Project water to support two or more plants located within the same site area. The least favorabe region would be one in which the competitive demands for groundwater are such that additional withdrawal for reactor cooling water cannot be supported for a period of 40 years. The following were the hydrological ratings used:

Rating	Definition
5	The availability of groundwater is reasonably assured for a minimum of 40 years. The site is within 25 miles of the Phoenix sewage wastewater system, and the Central Arizona Project, as planned, will pass within 5 miles of the site.
4	The availability of cooling water is reasonably assured for a minimum of 40 years by one of the water sources alternatives; one other alternative source is usually also available.
3	Cooling water is apparently available for a minimum of 40 years by one of the hydrological alternatives. Alternatives to groundwater are usually not readily available.
2	Competitive demands are sufficiently large so that more detailed evaluation would be desirable to determine the availability of groundwater for 40 years of withdrawal. Alternatives to groundwater are not available.
1	Both competitive demands and depletion of groundwater are large, suggesting sufficient quantities of water may not be available for 40 years' withdrawal.

EXHIBIT J-II-3 (continued)

Rating	Definition
0	Competitive demands and depletion of groundwater are presently so great that sufficient quantities of water are not available for 40 years' withdrawal.

These ratings were applied after each region was characterized with respect to the three water source alternatives available: surface water (Central Arizona Project), treated sewage wastewater, and groundwater. Fr the first two possible sources of water, their distances from the candidate regions were evaluated. For groundwater, each region was characterized with respect to depth of water table, potential well yields, withdrawal rate, estimated recoverable quantity, chemical quality and competing water uses.

It should be emphasized that these ratings were influenced not only by the distance of the regions from the three hydrological alternatives, but also by the pumping head requirements for transferring water from the source to the region. Thus, the differences in the elevations of the candidate regions and the corresponding water sources had to be considered.

b. Geology

In obtaining geological ratings incorporating the previously discussed criteria, the proximity to regional topographic lineations which would possibly be faults was given the greatest wieght because the investigation of such features is difficult an very time consuming. Less weight was given to short faults which can be more readily investigated and still less to stratigraphic sequences which are generally favorable in these regions. Further investigation of stratigraphy and foundation characteristics will be made when a specific site is selected.

(1) Proximity to Long Lineaments

Major lineaments (50 miles or longer), which may be faults, can hypothetically be potential sources of large earthquakes. Regions directly on such features, or within a major fault zone, rate the lowest and those farther away rate higher. Ideally, the best region should be at least 20 to 25 miles from a major fault because of the favorable attenuation of earthquake shaking that will occur within this distance and beyond. In the context of the valleys presently considered, however, 14 miles is the greatest distance that can exist between a major lineament and a candidate region. The proximity factors and ratings for major lineations were identified as follows:

Rating	Region to Lineation Distance
5	20 or more miles
4	10 to 19 miles
3	6 to 9 miles
2	3 to 5 miles
1	1 to 2 miles
0	Less than 1 mile.

EXHIBIT J-II-3 (continued)

(2) Proximity to Short Faults

Proximity to small (few to several miles long) faults, possibly displaying evidence of late Quaternary displacement, may require a detailed faulting investigation. Small faults are common in the areas under consideration but most show no evidence of Quaternary displacement, and are unlikely to require detailed faulting investigations to the extent dictated by the AEC proposed criteria. Nevertheless, the ideal region would contain no faults and would be located at least 10 miles from faults of any kind. The proximity factors for short faults were defined as follows:

Rating	Region to Fault Distance and Fault Characteristics
5	No faults within 10 miles of region
4	Pre-Quaternary faults within 5 miles, but ouside of region
3	Pre-Quaternary faults inside region
2	Suspected Quaternary minor faults within 5 miles of region
1	Suspected Quaternary faults within region
0	Known Quaternary faults within region.

(3) Stratigraphic Characteristics

Stratigraphic horizons, i.e., layers of sedimentary deposits, or geomorphic surfaces, are useful in detecting faults and are necessary to determine the minimum age of last displacement. The suitability of valley stratigraphy can be judged in terms of completeness of sequence, areal extent, great age, and access for observation by surface mapping and by drilling or trenching.

The ideal region would have a large number of lithologic geomorphic horizons having ages on the order of tens-of-thousands to hundreds-of-thousands of years, that are widespread in the region and beyond, and are well exposed or near enough to the ground surface that they can be easily reached with exploratory equipment. These horizons will provide required information on the history of known faults, or of unsuspected faults discovered during later detailed study at a site. Accordingly, the least favorable region would be one characterized by rock overlain by surficial deposits whose age is only a few thousand years old, and where the depth or distance to much older horizons is great and beyond the reach of exploratory techniques capable to providing adequately detailed data. The preliminary evaluation permitted the use of only subjective qualitative ratings on stratigraphy as follows:

Rating	Stratigraphic Characteristics
5	Excellent
4	Very Good
3	Good
2	Moderately Good
1	Fair
0	Poor.

EXHIBIT J-II-3 (continued)

(4) Composite Geological Rating Scheme

In the task of obtaining a geological rating scheme, which was a composite of the ratings for each of the three factors cited above, the proximity to regional topographic lineations which may represent faults was given the greatest weight because the future investigation of such features is difficult and very time consuming. In past siting studies outside Arizona, much controversy has evolved around interpretation of such features when regions were very close to them. Less weight was given to short faults which may or may not show evidence of late Quaternary displacement because such faults can be more readily investigated and, as a result, be dismissed from consideration or avoided in facility location. Least weight was placed on stratigraphic sequences because the extent of surficial deposits is very broad in these regions and the horizons appear to be generally favorable and because a quantitative evaluation would require field investigation beyond that undertaken in this study to date.

With these weighting factors in mind and with the judgment of the degree of difficulty expected relative to satisfying AEC criteria, the following composite geological rating scheme was obtained.

Rating	Definition
5	This distance to large (50 miles long or longer) lineaments is greater than 20 miles. There are no apparent faults of any kind within 10 miles and stratigraphic characteristics of the area are excellent. AEC proposed criteria are likely to be met without difficult for the reactor plant under consideration.
4	The distance to large (50 miles long or longer) lineaments is 10 or more miles. Apparent small preQuaternary faults are within 5 miles but outside of the candidate region and stratigraphic characteristics of the area are good to very good. AEC proposed criteria are likely to be met with minimum difficulty.
3	The distance to large (50 miles long or longer) lineaments is 6 or more miles. Small preQuaternary faults are suspected within the candidates region and stratigraphic characteristics are moderately good. AEC proposed criteria might be met with some difficulty.
2	The distance to large (50 miles long or longer) lineaments is 3 or more miles. Suspected Quaternary faults are within 5 miles and stratigraphic characteristics vary from fair to good. AEC proposed criteria might be met but with difficulty.
1	The distance to large (50 miles long or longer) lineaments is 1 to 2 miles. Suspected Quaternary faults are within the candidate region and stratigraphic characteristics vary from fair to good. AEC proposed criteria are unlikely to be met.

EXHIBIT J-II-3 (continued)

Rating	Description
0	The distance to large (50 miles long or longer) lineaments, the proximity to small (few to several miles long) faults and/or stratigraphic characteristics are such that AEC proposed criteria are impossible to meet.

2. SECONDARY SCREENING FACTORS

a. Engineering Factors

(1) Accessibility

The accessibility of a candidate region is an important consideration which comes into play not only during the construction phase but in the operational phase of a nuclear plant as well. During the construction phase, the region should be accessible for transport of both construction equipment and materials. The labor force drawn from nearby towns and cities should have ease of commuting to and from the region during construction. The same condition should hold for operating personnel once the nuclear plant goes into operation.

There should also be ease of transport to and from the plant for new and spent fuel. The region should therefore be close to suitable railroads and highways, and access roads from these main arteries to the region should be present or be easily constructed at reasonable costs.

As for the other screening factors discussed previously, a 0 to 5 rating scale was used for the region accessibility and the ratings were defined as follows:

Rating	Definition
5	Major highways and rail lines pass within 5 miles of the site. Potential access road grade is less than 1 percent.
4	Major highways and rail lines pass within 5 to 10 miles of the site. Potential access road grade is less than 2 percent.
3	Major highways and rail lines pass within 10 to 25 miles of the site. Potential access road grade is less than 3 percent.
2	Major highways and rail lines pass within 25 to 40 miles of the site. Potential road grade is less than 4 percent.
1	Major highways and rail lines pass within 40 to 50 miles of the site. Potential access road grade is less than 5 percent.
0	Major highways and rail lines pass more than 50 miles from the site. Potential access road grade is greater than 5 percent.

These ratings were based not only on the proximity of the region to major U.S. highways and railroads, but also on the degree of preparation needed for the access road to the region from the main highway or railroad. It was assumed that a 3 percent grade for the access road was acceptable and anything greater would require some degree of surface grading.

(2) Transmission Lines

The screening of the candidate regions for this secondary screening factor was based on whether or not new transmission rights-of-way would be required; if so, what route would be taken by the lines from the nuclear plant to existing electrical load centers. Distances from the regions to existing substations were evaluated. The primary substantion considerations were their expansion capability as sources of power for support of construction activities. Ideally, the best region would be one which could make full use of existing rights-of-way, transmission routes and substations. The least desirable region would require the right-of-way to pass through unavailable Federal lands.

Rating	Definition
5	No new right-of-way is required; existing transmission routes and substations can serve the new generation capacity.
4	New right-of-way is required; potential routes can avoid national and state parks and forests (unavailable Federal lands); construction power is available; substations exist within 25 miles of the site.
3	New right-of-way is required; potential routes can avoid national and state parks and forests (unavailable Federal lands); construction power is required; substations exist within 40 miles of the site.
2	New right-of-way is required; avoidance of unavailable Federal lands requires modest extension of routes; construction power is required.
1	New right-of-way can avoid unavailable Federal lands only by substantial extension of routes.
0	New right-of-way must traverse unavailable Federal lands.

(3) Meteorology

The meteorological screening of the candidate regions used the surrounding topographical features to determine whether unusual dispersive characteristics would be likely to occur. The following meteorological ratings were used:

Rating	Definition
5	Flat, open terrain, major terrain features such as mountains and foredsts all a distance of at least ten times their height differential from the site

EXHIBIT J-II-3 (continued)

Rating	Definition
4	Some rolling hills and nearby topographical features such as bluffs and canyons are not over 100 feet in height. Major terrain features such as mountains and forests are at a distance of at least ten times their height differential from the site
3	A broad valley (width greater than 5 miles) where channeling may exist, major terrain features such as mountains and forests all at a distance of at least ten times their height differential from the site
2	A special analysis is required for a narrow valley (width less than 5 miles) where channeling most likely exists, and/or major terrain features are less than ten times their height differential away from the site. Therefore a special analysis is required.
1	Major topographical features are between two and five times their height difference away from the site. Special analysis required.
0	Major topographical features are less than two times their height difference away from the site; novel designs required.

(4) Topography

The topographic screening for the candidate regions was based on the criterion that an ideal region should not vary more than 100 feet in elevation over an area of 1000 acres. This would minimize large earth moving requirements in site preparation, as well as pumping requirements for the cooling water supply. The following topographic ratings were adopted:

Rating	Definition
5	Site area relatively flat; elevation changes less than 100 feet in an area of 1000 acres
4	Site area slightly sloped; elevation changes between 100 and 200 feet in an area of 1000 acres
3	Site area has rolling terrain; elevation changes between 200 and 300 feet in an area of 1000 acres
2	Limited areas exist which are relatively flat; elevation changes between 300 and 400 feet in an area of 1000 acres
1	Region steeply sloped; elevation changes between 400 and 500 feet in an area of 1000 acres
0	Region very steeply sloped; elevation changes greater than 500 feet in an area of 1000 acres.

b. Environmental Factors

(1) Land Use

The land use screening for candidate regions was based on the extent of competitive land use in or near the regions. Factors which influenced land use included nearest agricultural land, nearest airport, nearest national forests, game pres[illegible]s and/or parks. The underground features in the area (such as gas lin[illegible] and coaxial lines), and the historical and/or archaeological significance of the area were also included. A special study was conducted by the staff of the Museum of Northern Arizona in screening the candidate regions to identify areas of potential archaeological significance. These archaeological surveys will be continued and extended in greater depth in the following phases of the project when specific sites are identified. The land use ratings were defined as follows:

Rating	Definition
5	No competing land use at present or projected
4	Present form of land use highly localized and little competing usage at present or projected
3	Extensive land use in much of the area; areas sufficient for site development exist with little competing usage likely
2	Land usage such that competing usage may exist
1	Land usage extensive and competing usage presently exists; historically or archaeologically significant sites likely to exist
0	Land usage sufficiently extensive and competitive that site acquisition would be extremely difficult and time consuming; historical or archaeological sites exist.

(2) Ecology

The ecological screening for the candidate regions was based on several criteria. Those areas that seemed to have a high density of vegetation and high species diversity were considered t be less desirable as potential regions. Ease of access was also considered as the construction of roads and transmission lines would disturb plant and animal communities. Other factors that were considered included the presence of any unique areas which should not be disturbed and the presence of endangered species. The following ratings were used for ecology screening:

Rating	Definition
5	Substantially barren; unusual opportunities exist to enhance environment
4	Low species diversity exists; some opportunities exist for environmental enhancement
3	Some disturbance of naturally low sensitivity area may occur
2	Some disturbance of natural high species diversity can be expected
1	High species diversity exists; plant construction or operation would significantly deplete resources
0	Unique or endangered species inhabit region.

EXHIBIT J-II-3 (continued)

(3) Demography

Demographic screening of the candidate regions was based on the availability of a major labor pool (large cities) within a reasonable commuting distance, and the existence of small towns in the vicinity which might be used by the construction force and the operating staff. Population density was not an important factor since all regions considered were very sparsely populated. The following demographic ratings were used:

Rating	Definition
5	Sparse population; few small towns within 10 miles; large city at reasonable commuting distance (20 to 30 miles)
4	Sparse population; some small towns within 10 miles; large city within moderate commuting distance (30 to 50 miles)
3	Sparse population; small towns within 10 miles; large city greater than 50 miles distant
2	Sparse population; no small towns within 20 miles; large city greater than 50 miles distant
1	Sparse population; no small towns within 20 miles; large city greater than 50 miles distant
0	Uninhabited area with no settlements within commuting distance thus requiring development of community for construction force and operating staff; or large city within 10 miles.

APPENDIX XIII

SITING STUDY K

SITING STUDY K

FINAL SITE SELECTION

Seven alternative sites are compared, using 14 engineering attributes and 21 environmental and socioeconomic attributes.

I. ATTRIBUTES

The attributes are presented in table form, in terms of the "rating" scale used (Exhibit K-1). The list appears to be comprehensive.

Several attributes seem to overlap or to be over-represented. Site Accessibility, criteria 5a, b, and c, has a weight of 5 because railroad, highway, and river navigation are each considered separately. It is possible that the importance of each kind of access is dependent on the levels of the other two and that the three types of access should be considered as a single attribute. It is unclear exactly what the difference is between attribute 9b, Land Consumption of Critical Environmental Importance, and attribute 9c, Land Consumption (Plant Site Only). Gamelands seem to be included in both attributes 8l and 9b. It is possible that terrestrial biology is overrepresented in attributes 8f, 8h, and 8l.

A thorough list of considerations is presented in this report, and it is possible that the above-mentioned instances do not represent double-billing, but simply inadequate definition in the Environmental Report.

II. SCALING

Each attribute measurement is transformed to a 1 to 5 "rating" scale:

1 = unacceptable
2 = poor
3 = fair
4 = good
5 = excellent

This is usually an ordinal level of measurement, but may be interval or quasi-interval in this study, because many of the transformations involve ratio-scaled raw measurements such as miles or acres.

III. WEIGHTS

A weight of 1, 2, or 3 is assigned to each attribute (Exhibit K-2). The report does not state how the weights were selected; it is therefore impossible to determine whose values the weights represent, the kind of importance they measure, or the level of measurement they achieve.

IV. DECISION RULE

Weighting summation is used. A matrix of site evaluations is shown in Exhibit K-3.

V. DISCUSSION

This report does not contain enough information to determine theoretical validity of the study.

EXHIBIT K-1

SITE EVALUATION CRITERIA

A. ENGINEERING CONSIDERATIONS

1. Compatibility with Cooling System Development (Weighting Factor 3)

RATING	CRITERIA
5 (Excellent)	Major River, Cooling Towers* and Ponds on site
4 (Good)	Major River, Cooling Towers
3 (Fair)	Major River only
2 (Poor)	Cooling Tower Capability only
1 (Unacceptable)	Ground Water only

2. Proximity to Load Center (Load Center at Midtown Omaha) (Weighting Factor 1)

RATING	CRITERIA
5	Within 20 miles
4	Within 40 miles
3	Within 60 miles
2	Within 80 miles
1	Within 100 miles

3. Proximity to Labor and Services (Weighting Factor 3)

RATING	CRITERIA
5	Within 20 miles of Major City (50,000+ Population)
4	Within 40 miles of Major City (50,000+ Population)
3	Within 60 miles of Major City (50,000+ Population)
2	Within 60 miles of Major City (50,000+ Population)
1	Within 100 miles of Major City (50,000+ Population)

4. Land Availability and Cost (Weighting Factor 1)

RATING	CRITERIA
5	Over 1,000 acres available for purchase[1]
4	Less than 750 acres available for purchase
3	Less than 500 acres available for purchase
2	Less than 250 acres available for purchase
1	Less than 100 acres available for purchase

5. Site Accessibility

a. Railroad (Main or Branch Line) (Weighting Factor 2)

RATING	CRITERIA
5	Railroad on site
4	0-1 miles from site
3	1-3 miles from site
2	3-10 miles from site
1	10+ miles from site

b. Highway (Primary or Secondary) (Weighting Factor 2)

RATING	CRITERIA
5	On-site highway
4	0-1 miles from site
3	1-3 miles from site
2	3-10 miles from site
1	10+ miles from site

c. River Navigation (Weighting Factor 1)

RATING	CRITERIA
5	Access of waterway 12 months of year
4	Access by waterway 9 months of year
3	Access by waterway 6 months of year
2	Access by waterway 3 months of year
1	Access by waterway 0 months of year

6. Power Transmission Connection Costs (Weighting Factor 1)

RATING	CRITERIA
5	345 kV transmission lines on site[2]
4	345 kV within 1-3 miles or 161 kV on site
3	345 kV within 3-7 miles or 161 kV within 1-3 miles
2	345 kV within 7-12 miles or 161 kV within 3-7 miles
1	Requires completely new transmission system

7. Site Development

a. Soil Condition for Foundation (Weighting Factor 2)

RATING	CRITERIA
5	Less than 20 feet to bedrock covered by consolidated sand
4	20 to 40 feet to bedrock covered with sand
3	40 to 60 feet to bedrock covered with sand or loess
2	60 to 100 feet to bedrock
1	Unacceptable existing foundation conditions

b. Seismic Rating (Weighting Factor 1)

RATING	CRITERIA
5	Zone 0
4	Zone 1
3	Zone 2
2	Zone 3
1	Zone 4

c. Site Fill and Borrow Requirements (Weighting Factor 2)

RATING	CRITERIA
5	Less than 500,000 cubic yards requires hauling[1]
4	500,000 to 1,000,000 cubic yards requires hauling
3	1,000,000 to 2,000,000 cubic yards requires hauling
2	2,000,000 to 3,500,000 cubic yards requires hauling
1	Greater than 3,500,000 cubic yards requires hauling

d. Flood Protection (Weighting Factor 1)

RATING	CRITERIA
5	Site above maximum flood level
4	Levee protection or less than 5 feet below maximum flood level
3	Between 5 and 10 feet below maximum flood level
2	Between 10 and 15 feet below maximum flood level
1	More than 15 feet below maximum flood level

e. Population Density (Within 5-mile Radius of Site) (Weighting Factor 1)

RATING	CRITERIA
5	Average population density less than 5/square miles
4	Average population density less than 50/square miles
3	Average population density less than 200/square miles
2	Average population density less than 1,000/square miles
1	Greater than 100 persons dwelling in exclusion area

f. Compatibility with Existing Power Generating Facilities (Weighting Factor 1)

RATING	CRITERIA
5	Expansion of existing facility by modification of generating and transmission systems
4	Expansion of existing nuclear facility, new generating and transmission systems required
3	New generating facility on site of existing generating facility
2	New generating facility, greater than 5 miles from other power generating facility
1	Interference with existing power generating facility

B. ENVIRONMENTAL AND SOCIOECONOMIC CONSIDERATIONS

8. Environmental Impact

a. Water quality (Dissolved Solids and Heat Dissipation) (Weighting Factor 3)

RATING	CRITERIA
5	Cooling Ponds
4	Cooling Towers
3	Once-Through Cooling on Missouri (Heat Dissipation Only)
2	Once-Through Cooling on Missouri (Heat and Waste Discharge Within EPA Limits)
1	Once-Through Cooling with Waste Discharge in Excess of EPA Limits

b. Air Quality (Weighting Factor 2)

RATING	CRITERIA
5	8-10 miles to population center[4] 50 miles to major city[5]
4	6-8 miles to population center 40 miles to major city
3	4-6 miles to population center 30 miles to major city
2	2-4 miles to population center 20 miles to major city
1	0-2 miles to population center 10 miles to major city

c. Dust Impact (Ground Level Operations and Related Traffic) (Weighting Factor 1)

RATING	CRITERIA
5	Nearest affected population center 2.0 miles
4	Nearest affected population center 1.6 miles
3	Nearest affected population center 1.3 miles
2	Nearest affected population center 1.0 miles
1	Nearest affected population center 0.6 miles

d. Noise Impact (Plant Operation and Related Traffic) (Weighting Factor 1)

RATING	CRITERIA
5	Nearest population center 2.0 miles
4	Nearest population center 1.6 miles
3	Nearest population center 1.3 miles
2	Nearest population center 1.0 miles
1	Nearest population center 0.6 miles

e. Aesthetics (Weighting Factor 1)

RATING	CRITERIA
5	Not visible from population center or major highway
4	Disrupts view from highway of natural scenery
3	Visible from major highway and population center
2	Adjacent to major city
1	Destroys recognized points of attraction

f. Terrestrial Biological Life (Weighting Factor 3)

RATING	CRITERIA
5	No effect
4	Displaces small quantities of abundant species
3	Effect unknown
2	Disrupts or destroys significant quantities of important species
1	Infringes on wildlife preserve, known breeding areas, or migratory territories

g. Aquatic Biological Life (Weighting Factor 3)

RATING	CRITERIA
5	No effect
4	Displaces small quantities of abundant species
3	Effect unknown
2	Disrupts or destroys significant quantities of important species
1	Completely destroys important species of the region

h. Effects on Endangered Species (Weighting Factor 1)

RATING	CRITERIA
5	Enhance species growth
4	No effect
3	Effect unknown
2	Reduces population
1	Eliminates population

i. Construction Effect (Temporary and Permanent Inconveniences) (Weighting Factor 1)

RATING	CRITERIA
5	No effect
4	Construction on secondary and light duty roads or branch rail lines
3	Construction on primary highways or mainline rail lines
2	Re-routing of primary highway or rail line
1	Relocation of industrial plant or resident communities greater than 10 dwellings

j. Transmission System Routing (Weighting Factor 1)

RATING	CRITERIA
5	No effect
4	Through productive farm or industrial area
3	Through residential or commercial area
2	Through dense residential area
1	Routing prohibited

k. Fuel and Waste Handling Corridor (Weighting Factor 2)

RATING	CRITERIA
5	No population center within 1 mile of corridor
4	Use of primary highways or railroads
3	Passes through population area (1,000+)
2	Passes through medium-sized population area (10,000+)
1	Passes through dense population center (100,000+)

l. Parks, Forest and Gamelands (Federal, State or Local) (Weighting Factor 1)

RATING	CRITERIA
5	More than 2 miles from Park, Forest or Gameland
4	Within 2 miles of Park, Forest or Gameland
3	Within 1 mile of Park, Forest or Gameland
2	Across river or adjacent to Park, Forest or Gameland
1	Coincident with Park, Forest or Gameland

m. Recreational Facilities (Weighting Factor 1)

RATING	CRITERIA
5	Creates recreational facility
4	No effect
3	Removes nondesignated or private recreation facility
2	Removes major public recreational facility
1	Removes immediate recreational facilities and renders inoperative remote recreational facilities

n. Historic Landmarks (Weighting Factor 1)

RATING	CRITERIA
5	No effect
4	Effect unknown
3	Remote interference with landmark
2	Reduces accessibility to minor landmark
1	Reduces accessibility to major landmark

o. Designated Area (Weighting Factor 1)

RATING	CRITERIA
5	No interference with committed land
4	Affects small airfields or cemeteries, or commercial operation
3	Disrupts small settlements (20 people or less)
2	Military land or government reservation
1	Indian reservation, major airfields, or other designated land

9. Resource Consumption

a. Water Consumption (Weighting Factor 3)

RATING	CRITERIA
5	Removes no water from alternate use
4	Removes water from alternate use at rate of 2,000 gpm
3	Removes water from alternate use at rate of 20,000 gpm
2	Removes water from alternate use at rate of 200,000 gpm
1	Significantly limits municipal or commercial water supply

b. Land Consumption or Critical Environmental Importance (Weighting Factor 2)[5]

RATING	CRITERIA
5	Creates productive land
4	Removes no land
3	Removes less than 5 acres
2	Removes less than 200 acres
1	Removes over 200 acres

c. Land Consumption (Plant Site Only) (Weighting Factor 1)

RATING	CRITERIA
5	Reclamation of land not used
4	Removes less than 200 acres
3	Removes less than 1,200 acres
2	Removes less than 2,000 acres
1	Removes large productive regions

10. Socioeconomic Impact

a. Impact or Regional Economy (Weighting Factor 2)[7]

RATING	CRITERIA
5	Major Contribution - Plant construction and operation represents the most significant commercial activity in the region
4	Positive Contribution - Plant construction and operation represent a major commercial activity in the region
3	No major effect on regional economy
2	Depletes region of economic resources
1	Net negative effect on regional economy

b. Contribution to Community Development (Weighting Factor 2)

RATING	CRITERIA
5	Provides major facilities and services to community
4	Provides employment of community within region
3	No contribution if no communities within region
2	Degradation of community structure
1	Displaces large numbers of people

c. Compatability with Intended Land Use (Weighting Factor 3)

RATING	CRITERIA
5	Increases productivity of land within regional planning guidelines
4	Consistent land use planning (i.e., near other industry)
3	Inconsistent with land use planning (Replaces Farm Land)
2	Major conflict with land use planning (Residential or Commercial Land)
1	Renders high productivity land useless

[1]Reduction in rating if land cost is in excess of $1,500 per acre.
[2]Reduction in rating for additional costs.
[3]Reduction in rating if hauling distances judged to be extraordinary or other unusual conditions.
[4]Popular Center - 1,000+ (Outside Exclusion Area).
[5]Major City - 50,000+.
[6]Land Recognized as Drainage Area, Gameland, or Points of Singular Natural interest.
[7]Region taken as 10 miles radius from site.

EXHIBIT K-2

CONSIDERATIONS	WEIGHTING FACTORS
A. ENGINEERING	
1. Compatibility with Cooling Systems Development	3
2. Proximity to Load Center	1
3. Proximity to Labor and Services	3
4. Land Availability and Cost	3
5. Site Accessibility	
a. Railroad	2
b. Highway	2
c. River Navigation	1
6. Power Transmission Connection Costs	1
7. Site Development	
a. Soil Condition for Foundations	2
b. Seismic Rating	1
c. Site Fill and Borrow Requirements	2
d. Flood Protection	1
e. Population Density	1
f. Compatibility with Existing Power Generating Facilities	1
TOTAL	24
B. ENVIRONMENTAL AND SOCIOECONOMIC	
8. Environmental Impact	
a. Water Quality	3
b. Air Quality	2
c. Dust Impact	1
d. Noise Impact	1
e. Aesthetic	1
f. Terrestrial Biological Life	3
g. Aquatic Biological Life	3
h. Effects on Endangered Species	1
i. Construction Effects	1
j. Transmission System Routing	1
k. Fuel and Waste Handling Corridors	2
l. Parks, Forests and Gamelands	1
m. Recreation Facilities	1
n. Historic Landmarks	1
o. Designated Area	1
9. Resource Consumption	
a. Water Consumption	3
b. Land Consumption of Critical Environmental Importance	2
c. Land Consumption	1
10. Socioeconomic Impact	
a. Impact on Regional Economy	2
b. Contribution to Community Development	2
c. Compatibility with Intended Land Use	3
TOTAL	36

EXHIBIT K-3

SUMMARY OF SITE EVALUATION CRITERIA

ENGINEERING CONSIDERATIONS

Site Rank	Criteria:	1	2	3	4	5 A	5 B	5 C	6	7 A	7 B	7 C	7 D	7 E	7 F	Engr. Total
	Weighting:	3	1	3	3	2	2	1	1	2	1	2	1	1	1	
1		12	5	15	15	10	10	4	5	4	4	6	3	3	4	100
2		12	3	9	15	10	10	4	5	4	4	6	2	3	3	90
3		12	5	15	12	8	8	4	3	4	4	6	2	3	2	88
4		6	5	15	12	6	4	1	3	2	3	8	1	5	2	78
5		6	4	12	15	8	6	1	3	2	3	8	3	4	2	77
6		12	4	12	9	4	4	4	3	4	4	4	2	4	2	72
7		6	4	12	9	8	6	1	4	2	3	8	4	4	2	73

ENVIRONMENTAL CONSIDERATIONS

Site Rank	Criteria:	8 A	8 B	8 C	8 D	8 E	8 F	8 G	8 H	8 I	8 J	8 K	8 L	8 M	8 N	8 O	9 A	9 B	9 C	10 A	10 B	10 C	Env. Tot.	Grand Tot.
	Weighting:	3	2	1	1	1	3	3	1	1	1	2	1	1	1	1	3	2	1	2	2	3		
1		6	4	5	5	4	15	12	4	5	4	6	4	4	5	5	15	4	8	8	8	12	143	243
2		6	6	5	5	5	9	9	3	5	4	6	5	4	5	5	15	4	8	8	8	12	137	227
3		6	6	3	3	3	9	9	3	3	4	6	2	4	4	4	15	4	6	8	8	6	116	204
4		12	6	5	5	5	9	9	3	3	4	4	5	4	4	5	9	4	6	8	6	9	125	203
5		12	4	5	5	3	9	9	3	3	4	4	5	4	4	5	9	4	6	8	8	9	123	200
6		6	6	5	5	5	9	9	3	3	4	6	5	4	4	5	15	4	6	8	8	6	126	198
7		12	4	4	4	1	9	9	3	3	3	4	5	2	4	3	9	4	6	8	8	6	111	184

APPENDIX XIV

SITING STUDY L

SITING STUDY L

FINAL SITE SELECTION

Four alternative sites are compared, using 41 impact attributes and 15 cost attributes. A lengthy description of candidate site selection is given in the Environmental Report, but very little discussion of this stage of site selection is presented.

I. ATTRIBUTES

The long list of attributes appears comprehensive, except that socioeconomic impacts are not considered. The attributes are defined only by brief site-specific descriptions, so it is not possible to determine if each attribute is independent. An excerpt is shown on Exhibit L-1. For example, the attribute Habitats may include the attribute Rare, Endangered, and Important Species. Excavating Characteristics may be a subset of Foundation Conditions. These may actually be separate considerations that appear to be dependent because of inadequate definition in the Environmental Report.

II. SCALING

Each site is assigned a "favorability factor" for each attribute, as follows:

0 = not applicable
1 = exceptionally favorable
2 = favorable
3 = questionable-unknowns
4 = unfavorable
5 = exceptionally unfavorable

This is an ordinal scale. Raw impact measurements and transformations are not given. If dollar estimates were prepared for each site, then a significant amount of information is lost in the transformation of ratio-scaled dollars to ordinal-scaled ratings.

III. WEIGHTS

The weights, or "importance factors," are:

0 = unimportant
1 = moderately unimportant
2 = slightly important
3 = moderately important
4 = important
5 = exceptionally important

This is an ordinal scale. The "importance factors" are described as reflecting (1) "The importance of the impact of the station on the environment and (2) the importance of the impact of the environment on the station costs and/or licensability." With respect to the siting methodology used, this definition is meaningless. It is necessary to know whose values the weights

EXHIBIT L-1

SUMMARY DESCRIPTIONS OF SITE CHARACTERISTICS

Site Characteristic	Alternate Sites #1	#2	#3	#4
Geology and Seismology				
Foundation Conditions	Site Elev. 710'-750' 1'-5' residuel soil over Oologah formation. 10'-23' massive crystalline limestone 10'-25' shale and limestone. Possible fractures, solution channels in limestone but not extensive. Generally favorable foundation stability.	Site Elev. 560'-580' 10'-50'± clay and silt terrance deposits over McAlester Formation of interbedded shale, sandstone, and coal. Possible fracture zones and variable bearing capacity. Need further Site investigation to determine acceptability.	Site Elev. 540'-560' 10'-20' clay and silt terrance deposits over McAlester Formation of interbedded shale, sandstone, and coal. Possible fracture zones and variable bearing capacity. Need further Site investigation to determine acceptability.	Site Elev. 560'-580'± 10'-15'± clay, silt, and gravel terrance deposit over Boggy Formation of shale with soft sandstone lenses. Possible fracture zones and variable bearing capacity. Needs further Site investigation to determine acceptability.
Seismicity	Low intensity	Low intensity	Low intensity	Low intensity
Faults and Faulting	Little local faulting. Acceptable	Faulting inferred. Probably inactive.	Faulting inferred. Probably inactive. Some question of acceptability.	Possible faulting. Probably inactive. Over 5 miles to nearest known fault.
Effect on Ground Water on Construction Conditions	Small amounts of ground water.	Some ground water in terrance deposits. Small amounts in sedimentary rocks.	Some ground water in terrance deposits. Small amounts in sedimentary rocks.	Some ground water in terrance deposits. Small amounts in sedimentary rocks.
Excavating Characteristics	Limestone may require blasting. May be difficult to drill because of presence of chert.	Reasonably good. Sandstones may require blasting.	Reasonably good. Sandstones may require blasting.	Reasonably good. Shale and sandstone appear to require blasting.
Surface Erosion	Some surface erosion from construction activity.	Some surface erosion from construction activity.	Some surface erosion from construction activity.	Some surface erosion from construction activity.
Ground Water				
Availability and Interception	Small amounts of poor quality available. Interception limited to that incidental to construction activity.	Fair amounts of good quality. Interception limited to that incidental to construction activity.	Small amounts of poor quality. Interception limited to that incidental to construction activity.	Fair amounts of good quality. Interception limited to that incidental to construction activity.
Depletion	Insignificant.	Insignificant.	Insignificant.	Insignificant.
Chemistry	Insignificant change.	Insignificant change.	Insignificant change.	Insignificant change.

represent and if they measure the correct type of importance. This information is not given.

IV. DECISION RULE

Weighting summation is used. An excerpt of the site comparisons are shown in Exhibit L-2. Weighted "factors" are first summed for the impact attributes and it is stated that differences among sites are negligible. Weighted economic factors are then summed and the proposed site (Site #2) is selected on the basis of economic ranking.

V. DISCUSSION

This siting study is theoretically incorrect in its use of ordinal-scaled attributes and ordinal-scaled weights. Ordinal measures should not be manipulated algebraically, because such manipulation presumes that magnitudes of differences are meaningful.

EXHIBIT L-2

IMPACT CONSIDERATIONS RANKING OF SITES

Site Characteristics	Importance Factors*	Favorability Factors** And Weighted Rankings*** Of Sites			
		1	2	3	4
Geology and Seismology					
Foundation Conditions	4	(2) 8	(3) 12	(3) 12	(2) 8
Seismicity	5	(2) 10	(3) 15	(3) 15	(3) 15
Faults and Faulting	5	(2) 10	(3) 15	(3) 15	(3) 15
Effect of Groundwater on Construction Conditions	3	(1) 3	(2) 6	(2) 6	(2) 6
Excavating Characteristics	4	(3) 12	(2) 8	(2) 8	(1) 4
Surface Erosion	2	(2) 4	(2) 4	(2) 4	(3) 6
Subtotal		47	60	60	54
Subsurface Water					
Interception	3	(1) 3	(2) 6	(1) 3	(2) 6
Depletion	3	(1) 3	(1) 3	(1) 3	(1) 3
Chemistry	3	(1) 3	(1) 3	(1) 3	(1) 3
Subtotal		9	12	9	12
Surface Water					
Availability	5	(1) 5	(2) 10	(2) 10	(2) 10
Cooling Capacity	4	(0) 0	(0) 0	(0) 0	(0) 0
Chemistry	5	(2) 10	(3) 15	(3) 15	(3) 15
Flow Characteristics	5	(0) 0	(2) 10	(2) 10	(2) 10
Sediment Load and Turbidity	3	(1) 3	(3) 9	(3) 9	(3) 9
Capability for Barge Transportation	4	(5) 20	(1) 4	(1) 4	(1) 4
Potential Flooding	5	(1) 5	(2) 10	(3) 15	(2) 10
Radioactive and Chemical Pollutants	3	(2) 6	(2) 6	(2) 6	(2) 6
Subtotal		49	64	69	64
Meteorology					
Transport and Dilution	5	(2) 10	(2) 10	(2) 10	(2) 10
Modification and Removal of Particulates by Fallout and Washout	4	(3) 12	(2) 8	(2) 8	(2) 8
Ambient Background Conditions, Heat and Moisture	3	(2) 6	(1) 3	(2) 6	(1) 3
Storms and Other Extremes	3	(2) 6	(2) 6	(2) 6	(2) 6
Subtotal		34	27	30	27

*Importance Factors: 0 = Unimportant; 1 = Moderately Unimportant; 2 = Slightly Important; 3 = Moderately Important; 4 = Important; 5 = Exceptionally Important.

**Favorability Factors: (0) = Not Applicable; (1) = Exceptionally Favorable; (2) = Favorable; (3) = Questionable-Unknowns; (4) = Unfavorable; (5) = Exceptionally Unfavorable.

***Weighted Ranking = Product of Importance Factor and Favorability Factor.

APPENDIX XV

SITING STUDY M

SITING STUDY M

CANDIDATE AREA SELECTION

Exclusionary screening of 196 sq. miles identifies 11 candidate areas. These areas are then evaluated and compared using 6 attributes.

I. ATTRIBUTES

The list of attributes appears sufficiently comprehensive for this stage of site selection. Three major categories (safety, economics, and environmental concerns) are used and qualitatively justified and defined. Quantitative measures of safety and economic criteria are presented, but environmental attributes are simply defined by high, nominal, or low sensitivity to impact. Those attributes that are the same for all sites are explicitly stated and justified.

II. SCALING

Each attribute is given a rating of 0 to 4, where 4 is best. This appears to be an interval scale because at least one site is given a rating of 4 for each criterion, and the ratings are continuous. That is, a rating of 3.7 or 2.2 is allowed. Transformations from raw impact measurements to ratings are not given; it is therefore not possible to verify the level of measurement.

III. WEIGHTS

No explicit weights are used in this study. It is stated, however, that safety considerations are the most important.

IV. DECISION RULE

No explicit decision rule is used. Individual site ratings are presented as bar graphs (Exhibits M-2 and M-3). Ratings for the three major categories are averaged, and these averaged ratings are used in two scatter diagrams to visually represent relative site rankings (Exhibit M-4 and M-5).

V. DISCUSSION

The report states that "No attempt was made to assign different weights to each parameter, nor to the three principal factors since that process would be extremely subjective." Site ratings for geology/seismology and hazardous operations are averaged to give an overall safety rating, and ratings for land use, cultural resources, and aesthetics are averaged to yield an overall environmental rating for each site. Safety, economic, and environmental ratings are then averaged, and this creates an implied set of weights:

economics = 1
geology/seismology = 1/2
land use = 1/3

The final weighting is then done non-systematically by simply looking at the diagrams. It is possible that the implied weighting contained in the averaging changes the relationships among the sites. This can only be a guess,

EXHIBIT M-1

GEOLOGY/SEISMOLOGY SAFETY EVALUATION FACTORS

		Value
I.	Quaternary Stratigraphy	
A.	Extensive marine terraces (120,000 years or older)	50
B.	Discontinuous marine terraces	30
C.	Relatively continuous alluvial terraces (age to be established)	20
D.	Fragmentary alluvial terraces	10
E.	No stratigraphy present (area probably not feasible for licensing under present criteria).	0

		Value
IIa.	Proximity to Faults Requiring Evaluation for Surface Rupture Hazard	
	Distance from Area	
A.	More than 10 miles from area	1.0
B.	5 to 10 miles from area	0.8
C.	Within 5 miles of area	0.4
D.	Within zone requiring detailed faulting investigation or 1 mile, whichever is greater (ZRDFI as defined in Reference 3)	0.0

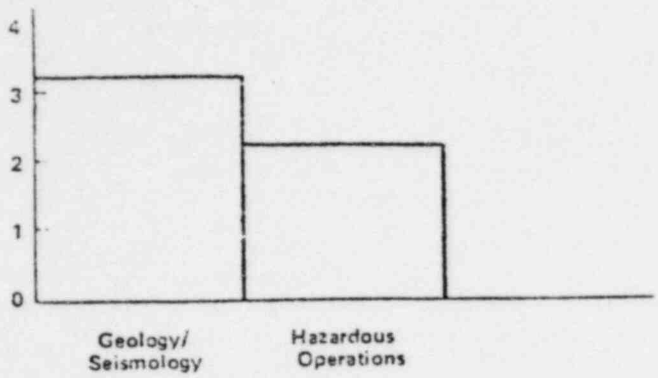
		Weighting Factor
IIb.	Faults and Suspected Faults Requiring Additional Evaluation	
A.	Santa Monica-Baja California Zone of Deformation	11
B.	Las Flores lineament (suspected Quaternary fault, possibly longer than 10 miles, further investigation may be inconclusive)	9
C.	Las Pulgas fault (suspected Quaternary fault maximum length 5 to 10 miles, most of length not accessible for exploration)	7
D.	Stuart Mesa fault (suspected Quaternary fault maximum length 5 to 10 miles)	5
E.	Postulated onshore extension of Rose Canyon fault (probable pre-Quaternary fault, possibly longer than 10 miles)	5
F.	Minor breaks in marine terrace deposits (total length not known)	4
G.	Cristianitos fault (pre-Quaternary fault more than 20 miles long)	3

		Value
III.	Proximity to Photolineaments (Longer than 1,000 Feet) Expressed on Quaternary Deposits	
A.	None within 5 miles	15
B.	Five or fewer within 5 miles	12
C.	More than 5 within 5 miles	6
D.	More than 5 within potential area	3

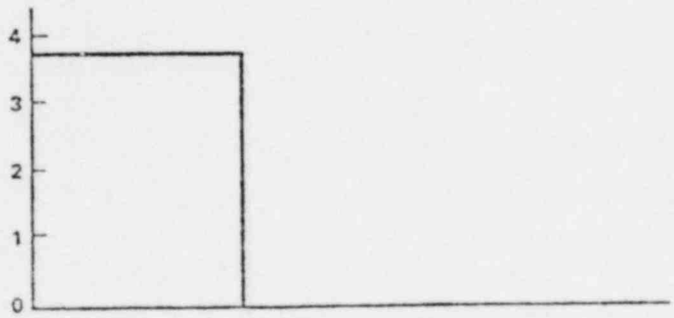
EXHIBIT M-2

IMPACT CHARTS - SITES 1 AND 2

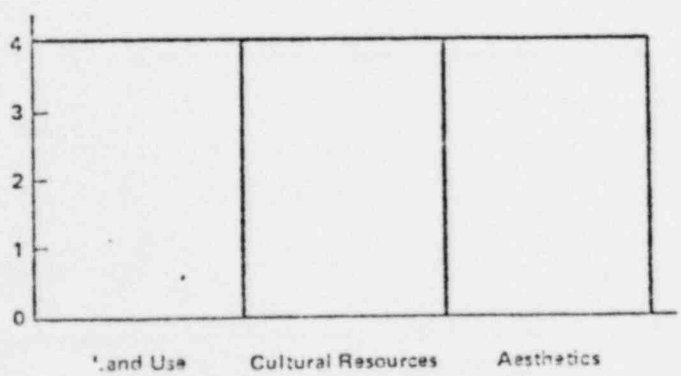
SITE 1



SAFETY

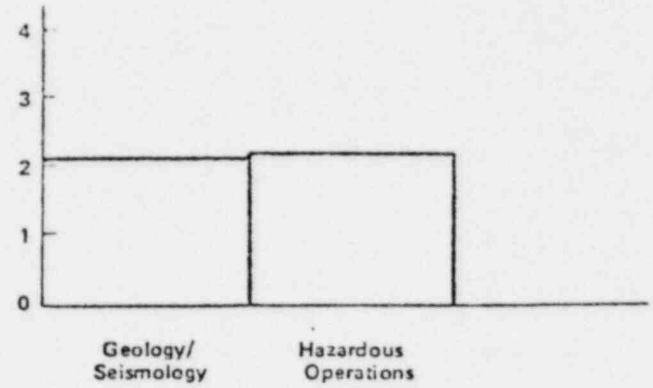


ECONOMICS

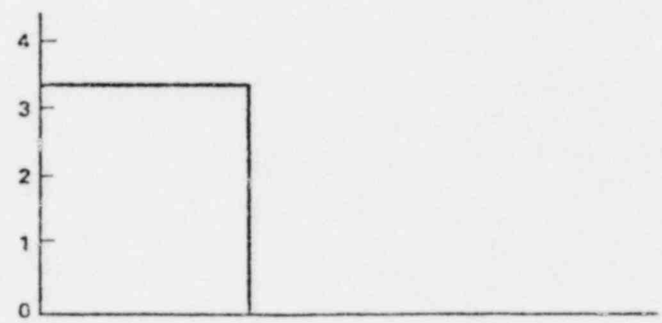


ENVIRONMENT

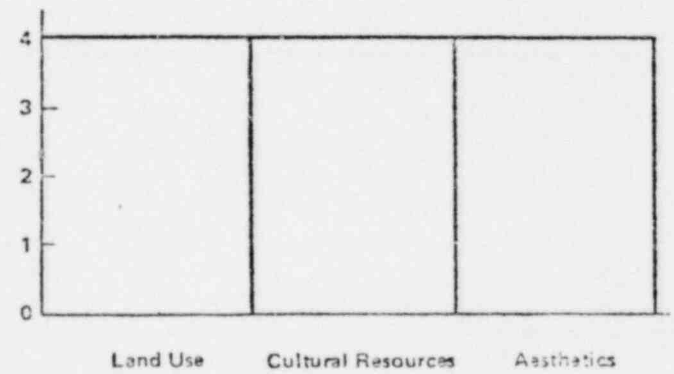
SITE 2



SAFETY



ECONOMICS



ENVIRONMENT

EXHIBIT M-3

IMPACT CHARTS - SITES 3 AND 4

SITE 3 SITE 4

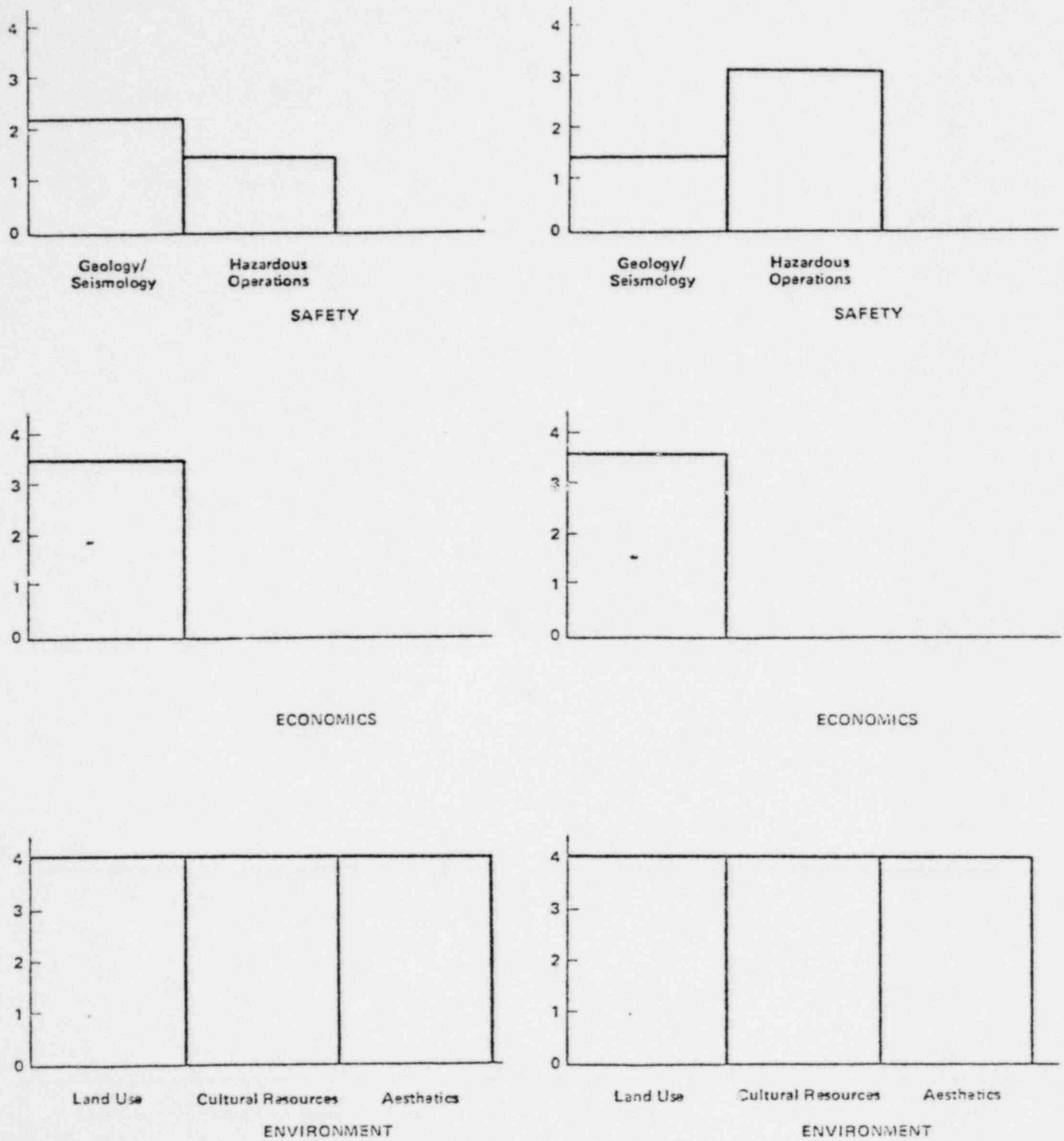


EXHIBIT M-4

SITE EVALUTATION

SAFETY AND ECONOMICS

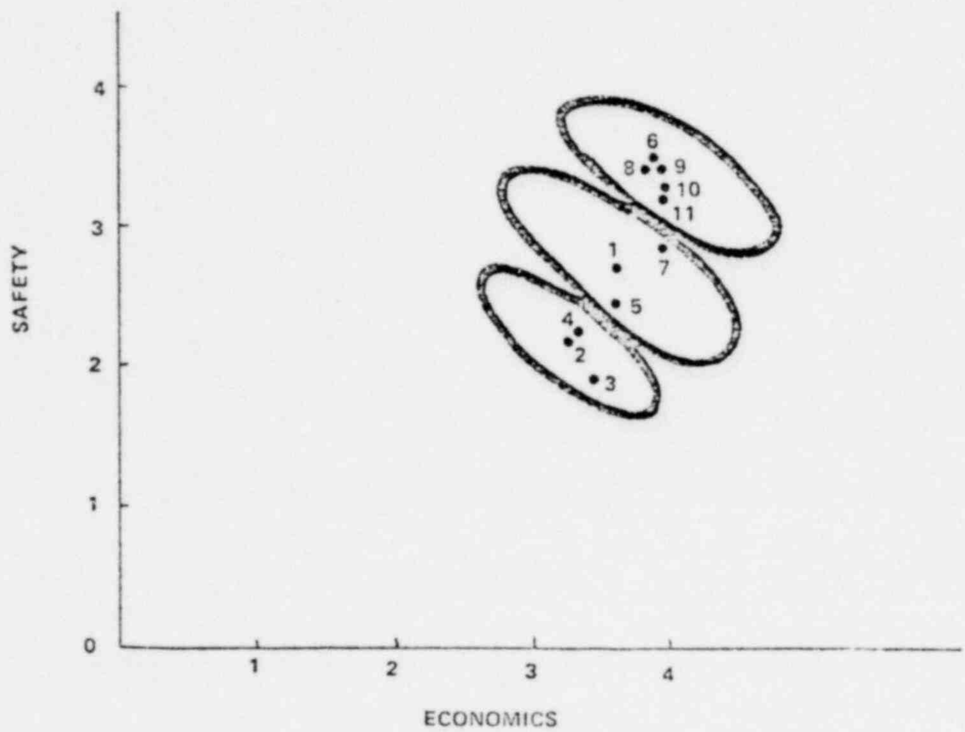
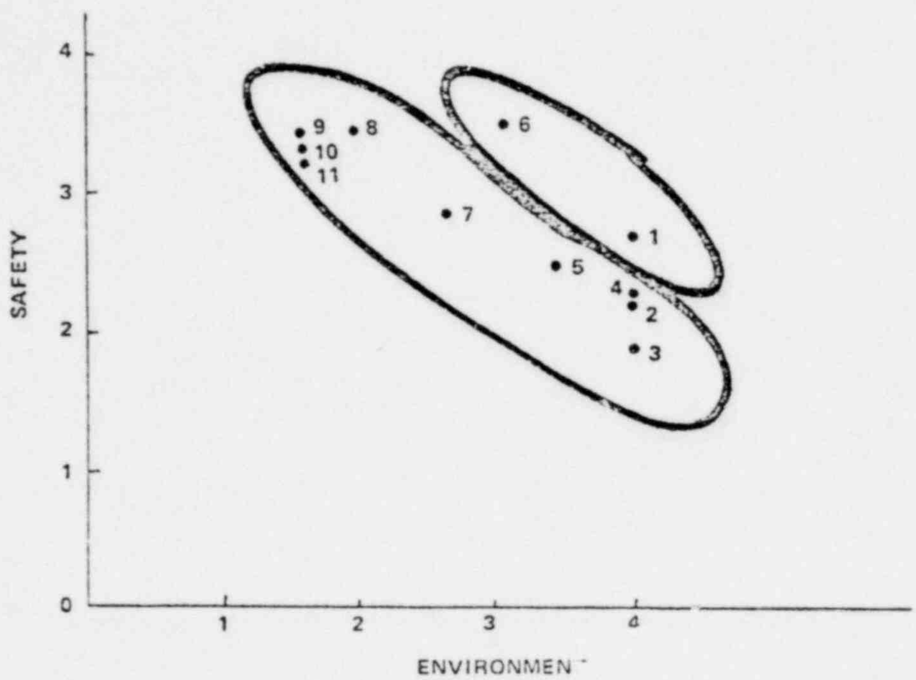


EXHIBIT M-5

SITE EVALUTATION

SAFETY AND ENVIRONMENT



however, because it is difficult to determine exact values from bar graphs. Exhibit M-6 shows the changes in site rankings that occur when the ratings are summed without averaging.

The area recommended for further study is a combination of two areas, sites #6 and #8. The rationale for this selection is not the overall rankings, but safety and particularly geology/seismology considerations. This appears to negate the entire siting exercise and implies that no other attributes are important. Although appearing to consider several attributes, the final result does not acknowledge tradeoffs and the decision is based on only one attribute.

EXHIBIT M-6

EFFECTS OF AVERAGING

A. Rating Summation

Site #1	Geology/ Seismology	Hazardous Operations	Economics	Land Use	Cultural Resources	Aesthetics	Sum	Rank
1	32.	2.2	3.7	4.0	4.0	4.0	21.1	1
2	2.1	2.2	3.4	4.0	4.0	4.0	19.7	4
3	2.2	1.4	3.4	4.0	4.0	4.0	19.0	6
4	1.4	3.2	3.6	4.0	4.0	4.0	20.2	3
5	0.8	4.0	3.8	2.6	4.0	4.0	19.2	5
6	3.7	3.4	3.9	4.0	2.7	2.7	20.4	2
7	3.5	2.2	4.0	1.3	4.0	2.6	17.6	7
8	3.4	3.6	3.9	2.0	2.6	1.2	16.7	8
9	4.0	2.8	4.0	0.7	4.0	0.2	15.7	9
10	3.8	2.9	4.0	0.7	4.0	0.2	15.6	10
11	3.8	2.6	4.0	0.8	4.0	0.2	15.4	11

B. Summation of Averages

Site #	Safety	Economics	Environmental	Sum	Rank
1	2.7	3.7	4.0	10.4	2
2	2.15	3.4	4.0	9.55	5
3	1.8	3.4	4.0	9.2	8
4	2.3	3.6	4.0	9.9	3
5	2.4	3.8	3.53	9.73	4
6	3.55	3.9	3.13	10.58	1
7	2.85	4.0	2.63	9.48	6
8	3.5	3.9	1.93	9.33	7
9	3.4	4.0	1.63	9.03	9
10	3.35	4.0	1.63	8.98	10
11	3.2	4.0	1.67	8.87	11