A TECHNIQUE FOR ENVIRONMENTAL
DECISION MAKING USING QUANTIFIED
SOCIAL AND AESTHETIC VALUES

Battelle

Pacific Northwest Laboratories
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SUMMARY

A four-phase study was designed for the evaluation of social, economic and environmental tradeoffs in the analysis of nuclear plant siting options. The results of the first phase of this work are reported here.

A method was devised for combining social values with techno-economic values. This technique requires that community judgments be measured on the same plant design criteria that are independently quantified by experts on a technical basis. The social values are used as a weighting factor for the techno-economic values.

Social psychologists examined a number of environmental statements, intervenors' statements, and environmental guidelines to determine the significant criteria to be used in analyzing nuclear plant options. Eight criteria were devised in this task: economics, water quality, air quality, animal/plant life, cultural/recreational, health/safety, aesthetics, and land use. Subsequent studies showed that these criteria could be reduced to seven by eliminating land use.

A questionnaire survey was developed using three cooling design options (once-through, natural draft cooling tower, and cooling lake) on each of two sites chosen as test examples.

Slides were prepared to aid in describing the aesthetic impacts; "mini environmental statements" (one page) were prepared to describe the other criteria. Although the respondents were not so informed, the Point Beach and Trojan environmental statements were used to help prepare this material.

The survey was administered to three separate Seattle groups: environmentalists, high school students and businessmen. A total of 192 respondents participated and their responses had remarkably similar patterns. The environmentalists were generally less in favor of nuclear plants than businessmen, and the high school students were between the two.

The survey was designed to measure the respondents direct weighting of the eight criteria by asking respondents to rank each criteria in order of importance. The relative weights of the criteria were also measured indirectly by rating each criterion (on a scale of one to seven) for each option and also making an overall judgment of the acceptability of each design option. First order and multiple correlation analyses were performed on these data to deduce the importance factors. A number of strongly worded questions were also included to help analyze what attitudes of the respondents, if any, could explain their value judgments.

Analysis of the survey results showed no clear preference for the direct over the indirect measurement technique. In the environmentalist group there was a fairly high correlation between the two measurements. This could be attributed to the large size (and better statistics) or the

higher motivation (better understanding of the criteria) of the environmentalist group. Poor correlations were achieved between the two measurements for the businessmen and high school groups. There were several indications that respondents did not differentiate clearly between criteria.

It was concluded that in a follow-on test a) more attention should be devoted to the differentiation between criteria, b) multidimensional scaling should be used to determine the most significant criteria and c) both direct and indirect measurement techniques should again be used.

The ability to perform objective quantification of the criteria discussed above is a basic premise of the derived method. Each of the design/site options must be rated for each of the criteria. Since this analysis is to be done by technologists or economists, the methods can be complex up to the point the methodology becomes burdensome. Two of the criteria, aesthetics and land use, were examined with the goal of deriving a method for quantifying these effects.

In the case of the aesthetics a method was successfully developed. Fundamental equations were derived expressing the relationships between viewscape quality and its basic components: intactness, vividness, and unity. Similarly, the relationships between aesthetic impact, population and change in viewscape quality were described.

The mechanics of making the analysis of a given design on a given site are described. A technique is explained for deciding the number of viewpoints to be used in determining a viewscape, and the structural impact on each viewpoint, and for combining these measurements into an index of aesthetic impact.

The study of the quantification of land use showed that this criterion was accurately defined by the other seven criteria. It was concluded that an index of land use could be derived from factors of suitability and compatibility. Methods for quantifying suitability were derived. In an attempt to quantify the compatibility factor, it became evident that the criteria of health and safety, cultural/recreational, water quality, air quality, and to a lesser degree economics, aesthetics and animal/plant life defined the compatibility of one land use with another. Therefore, it was concluded that land use could be eliminated as a selection criterion.

I. INTRODUCTION

As is evident in today's energy crisis, the present process for evaluating and judging environmental, technical, economic, and social trade-offs has some serious shortcomings. While the AEC and others are making progress on the procedural steps in the process, there are still a number of weaknesses in the ability to analyze alternatives. A corollary deficiency is a difficulty in defending the decisions.

We have concluded that there are three major weaknesses in our present method of analysis:

1. Lack of Quantification of Most Effects. Although costs and some benefits are quantified, most of the environmental and social effects are not.
2. No Measure of Community Social Values. Even though the community must eventually approve of a nuclear plant (or any large construction project for that matter), little or no effort is made in advance to assess the social values on which this judgment is based.
3. No Method for Integrating Social Values with Techno-Economic Ones. Even if the environmental effects have been quantified and the social values have been measured, there is currently no logical method for combining all factors.

There have been some attempts to combine these various factors. One of these is the method used by Northern States Power (NSP) in picking a site

for their coal-fired Sherburne plant. The approach used by NSP was one in which a citizen-government group made the site selection.⁽¹⁾ While the company gave the task forces four possible sites from which to select and reserved the right to make the final selection itself, they abdicated much of the decision making to a citizen vote. This approach undeniably utilizes community judgment (though the sampling must be limited if the committees are of a workable size), but it lacks integration with techno-economic decision criteria. The site selected was not the one favored by NSP. Interestingly enough, the government representatives on the committee disagreed with the citizens group and endorsed the same site favored by the company. Similarly, the company agreed in advance to closed-cycle cooling and sulphur removal. According to Electric Power and Light: "The Sherburne Plant will have the largest stack-gas sulphur cleanup system in the country." Though one can argue with the precision of this decision-making process, it is hard to fault its efficacy, for the plant suffered no delays in obtaining state and local permits.

A more sophisticated approach to planning was developed at Battelle-Columbus.⁽²⁾ While this technique utilizes a hierarchical, quantified subdivision of factors which contribute to environmental quality, it makes no effort to actually measure community values. However, a Delphi technique is used to derive weighting factors for the various elements. While this method reflects the social judgment of a peer group, it is basically an elitist approach. This approach to social problems has not been universally successful as witnessed by the public's acceptance of

radiation standards and school busing decisions. This method does, though, represent a systematic approach to an objective, quantified measurement of environmental impact.

The efforts at Battelle, Pacific Northwest Laboratory (PNL) are designed to combine the social judgments of the community with the techno-economic values of the designers to derive a solution which reflects all of these tradeoffs. The program is planned, on the basis of available funds, manpower and technical requirements, in four phases:

PHASE I ^(a)	<u>Design of System</u>
	A. Combination of Techno-economic Factors
	B. Measurement of Social Values
	C. Quantification of Selected Components
PHASE II	<u>Proof of Principle</u>
	A. Quantification of all Remaining Components
	B. Site Measurement
	C. Analysis
PHASE III	<u>Pristine Site Test</u>
	A. Utility Liaison
	B. Site Measurement

(a) Phase I is completed and the results are reported in this report.

PHASE IV

Time Dependence Measurement

- A. Measure Site before Startup
- B. Measure Site after Startup
- C. Determine Sensitivity of Value Judgments to Time

II. SYNTHESIS OF ANALYTICAL METHODS

Building the methodology for the analysis of the combined social and technical judgments of a plant design/site option entails a number of discrete steps. First is the definition of the pertinent criteria on which the option is to be evaluated. Second comes the measurement of the relative importance the affected community assigns to these criteria in making design/site decisions. And third is the method by which the same criteria may be evaluated on a techno-economic basis. Although these tasks are obviously interdependent, they were separated in order to more efficiently bring maximum expertise to bear on the various aspects. PNL was responsible for designing the overall analytical methodology, for quantifying one of the site criteria (land use), and for coordinating all efforts. Battelle's Human Affairs Research Center in Seattle was assigned the task of developing methodology for the measurement of social values. Jones and Jones, a Seattle-based landscape architect firm was given the task of quantifying one of the "intangible" criteria - aesthetics.

The basic approach for the solution to the problem of integrating social and technical judgments was a decision matrix. In theory a number of independent criteria could be identified. Methods could be developed for quantifying each of these criteria on a technical or economic basis. If this technical rating is designated a , then the i th criteria for the j th site/design option will have a rating a_{ij} . Assuming that a statistically competent sample of the community can be polled on the same criteria,

each of the i criteria will have a social value, for that particular community, of v_i . The product $v_i a_{ij}$ will then be the "socially weighted" score for site/design option j evaluated for the i th criteria. If these scores can be added,

$$\sum_{i=1}^n v_i a_{ij}$$

will be the composite score for option j . This analytical approach has some theoretical validity as well as numerous pitfalls.

Economists have for centuries tried to systematically explain why people will pay more for one commodity than for another. They inevitably concluded that the demand for a given item must be connected somehow with its utility. The "diamond-water paradox" discussed by Baumol⁽³⁾ made it apparent that there was no simple relationship between the price of water, which is essential to man's life, and the price of diamonds, which has little utility.

The classical economists solved this paradox through the invention of the concept of marginal utility. This theory says, in essence, that the price of a commodity is not determined by its total utility but, rather, by the price that a consumer is willing to pay for his next unit of the commodity. Applying this to the paradox, it is easy to explain that a consumer who lives next to a large, pure fresh water supply and who owns generous water rights would be willing to pay considerably more for a unit of diamonds than for his next unit of water. Strand the same man without water in a

vast desert and the inverse would undoubtedly be true. This correctly implies, then, that a unit of water has no absolute price--even to the same user.

This factor, and its application to the problem at hand, can be more easily illustrated by the example of water quality. The "quality" of a given body of water is a complex combination of a large number of factors. To mention only a few, these include such diverse items as coliform count, content of various elements and compounds, and dissolved oxygen. Let us consider for now only the single measure of dissolved oxygen. The saturation limit of dissolved oxygen is dependent on the temperature and pressure of the water. For most common stream conditions, this theoretical limit is about 8.5 parts per million (ppm) of dissolved oxygen. A very high quality natural water body could be expected to have a dissolved oxygen content of 7.5 ppm or less. To raise this body to the theoretical maximum of, for example, 8.5 ppm would be a very costly procedure involving the control of temperature and pressure of the water body and the injection of oxygen gas. To maintain this quality would be a most expensive venture. Since the water at a quality of 7.5 ppm dissolved oxygen (considering only this one measure) is excellent for the support of aerobic life, for the "digestion" of organic materials, etc., the utility of this additional expenditure presumably would be very low. This region of the utility curve is illustrated by the Section A-B of Figure 1.

Now consider the lower range of this curve. Most water quality standards require a dissolved oxygen content of at least 2 ppm (C on the

FIGURE 1. Value of Water Quality as a Function of Dissolved Oxygen Content

curve). As the dissolved oxygen decreases below this level, the water's ability to support aerobic life diminishes rapidly and is, obviously, nil at a zero oxygen content. The value of this water body, by this measure, might be expected to drop rapidly from C to D. If it is assumed that the quality is linear between B and C, the utility function is complete.

The marginal utility of one extra unit of water quality can be measured by taking the slope of this curve. If it is measured in the A-B region (marginal utility 1), it shows a very low marginal utility, in the C-D region a very high one, and an intermediate value in the linear (B-C) range. One could argue that this strong dependence of value on the overall level of water quality being considered rules against the use of any single value (utility) number. In practicality this reasoning does not hold. Economics eliminates from serious consideration any designs in the ultra-high quality region, A-B. The natural levels of a high quality water supply are such that there will never be proposed a design which is to operate in this region between 7.5 to 8.5 ppm dissolved oxygen for reasons previously discussed. The other end (C-D) of the curve is ruled out in practice by the adherence to water quality standards. In theory, a plant could be proposed using water already polluted below acceptable levels, but this is highly unlikely. If this rationale is correct, it should be possible to measure with reasonable accuracy a respondent's assessment of his marginal value of water quality. While it is debatable that the B-C portion of the curve is truly linear, it is demonstrably more likely to be linear (and, hence, more tractable to measurement) than its extremities.

Also, the community will be likely to respond with less variance when considering options in this range. Through the aid of economics on one end and environmental standards at another the respondent is placed neither at the water-rich nor bone-dry extremes of the water-diamond paradox.

The assumption that the values, even confined to region B-C, will be linear is a gross one. Einhorn⁽⁴⁾ demonstrated that three decision makers all given the same multidimensional data each used different cognitive processes to arrive at their overall judgments. In averaging over a number of judges, though, data are best explained by a linear model in which the overall value of a multidimensional alternative is the sum of the values of its components. Yntema and Torgerson⁽⁵⁾ demonstrated that the linear model provides an excellent approximation of data even when interactions or nonlinear relationships exist.

Thus, even though individual respondents may not weight all criteria in a linear, additive fashion, when their cumulative judgment is analyzed, a linear compensatory model will yield the best results in terms of predicting their judgments.

It was recognized that criteria should be limited in number to major areas of importance. The practicality of measuring the community values assigned to a large number of criteria ruled against the technically attractive path of narrow, detailed factors. The criteria should further have the properties of exclusivity to minimize the interactions between

them. For example, if the steam plume emanating from a cooling tower is considered an aesthetic factor, an air quality factor, and a safety factor, then all three of these criteria would be affected by this single feature of a cooling tower alternative. The analysis of such results would show a high interaction between these criteria. If the plume can somehow be "assigned" arbitrarily to a single criterion, this interaction should be diminished if not eliminated.

It is clear that once the various criteria are defined, according to the principles discussed here, they must be evaluated on a consistent basis both in the community and by the technical evaluators. For example, if the cooling tower plume mentioned above is to be considered only as an aesthetic factor by the community, it must also be included only in the aesthetic part of the technical assessment. Furthermore, the various options as described to the community must embrace a range of impacts in each area which is broad enough to span the effects to be expected. It would not be meaningful, for instance, to assess the value of aesthetic quality by describing to the respondents only low-profile plants in a hilly, encroached setting if options being considered were to include a cooling tower on a flat site. Assuming, though, that the respondents were stimulated by effects comparable to those encompassed by the range of design options then their judgments should, hopefully, have the properties of transitivity (transference from one case to another) and linearity. This means that one unit of water quality will have a given value (marginal utility) as long as it lies between the limits B-C, Figure 1.

Last comes the consideration of the evaluation of the various criteria. Let us assume that each of the derived criterion can be technically rated on a linear scale of 0 - 100 between the constraints applied by standards at one end and economic reality at the other. It now can be argued that one unit of aesthetic quality is not equal to one unit of water quality. As this argument is undoubtedly correct, one is tempted to assign some technical weighting factor to make these units of equivalent size. Such manipulation is a mistake, though; for the relative worth of these two units can only be decided by those who must view the structures and use the water. One must trust the measurement of the community social values to assign the relative weight to each of these units.

There are many methods by which this can be done. In a multidimensional problem such as this, the first approach to suggest itself is a ranking technique. Certain variations of this technique can be very effective in deriving a rank ordering of alternatives. In order to be truly effective for these purposes, the respondents must be given the opportunity to make a cardinal judgment. This is comparable in a sense to the measurement Wyler, et al.,⁽⁶⁾ made of the populace's rating of the seriousness of 126 illnesses which ranged from dandruff to leukemia. Respondents were restricted in their rating scale only in that peptic ulcer was arbitrarily assigned a rating of 500. The various techniques considered for the measurement of social values will be discussed in greater detail in the following section.

III. MEASUREMENT OF SOCIAL VALUES

This section will describe the development and testing of a methodology for assessing public attitudes and values associated with nuclear generating stations. The primary focus of this effort is the measurement of the relative importance which people attach to various social and environmental aspects of nuclear power plants.

The topic of nuclear power plant siting is an area of considerable public controversy. It serves as an example of a technology change with a variety of costs and benefits which are passed on to the public. This topic became the focal point for developing a survey approach capable of 1) conveying information and data to a sample of the public, and 2) serving as a basis for gathering reactions from the sample. The intent was to obtain some estimates of the weight or importance which people attach to some of the effects created by nuclear plants. The research design involved presenting information packages about six nuclear power plant design/site options to three groups who might logically be expected to differ in terms of interests, attitudes, and backgrounds of their members. Comparisons of the responses of these three groups would serve as one basis for validating the methodology. A second validation strategy involved the use of different methods of obtaining estimates of importance about environmental effects. Examination of the congruency among methods would serve as a further basis for validation.

The goal of this project was to develop and test a methodology for gathering structured input from respondents about the relative importance which they attach to the social-environmental aspects of nuclear power plants. The main emphasis was on methodological issues, particularly in determining what types of survey research techniques would be effective in gathering public input. The primary uses of the results generated from the data gathered would be in 1) validating the survey research approach, and 2) predicting how various groups of people would weigh the importance of several types of environmental effects created by nuclear plants. The sampling strategy employed was deliberately selective. Consequently, the results do not form the basis for decision-making or policy planning, and generalizations from these data to the general population should be made in a very limited and tentative manner.

A. INSTRUMENT DEVELOPMENT

The development of the survey instrument was performed as a cooperative effort between staff at the Battelle Human Affairs Research Center and Battelle, Pacific Northwest Laboratory (PNL). Due to the technical nature of the project focus, this collaborative effort involved inputs from staff members with backgrounds in the social, life, engineering and physical sciences.

There were three main parts to the survey instrument. (The complete questionnaire, as administered, is included as Appendix C.) Part I consisted of descriptions of six hypothetical nuclear power plant design/site

options and a set of rating scales for evaluating the acceptability of eight characteristics of each option. The six options include the three alternative plant cooling designs which were located in two different geographical settings. The cooling design options are: once-through, cooling tower, and cooling pond. The two hypothetical settings on which each of the three cooling designs was imposed were: a hilly, forested area with a large river as the main source of cooling water; and a flat, open area with a large lake as the water source. The rationale for presenting these six options is to illustrate the differential effects on the environment as a function of nuclear plant design and location. Specifically, this approach allows for a portrayal of the trade-offs between environmental facets such as water quality, air quality and aesthetics.

Eight criteria were chosen as the bases for evaluating the acceptability of each plant option. Selection of criteria reflected a review of material including environmental reports from public utility companies, environmental statements by nuclear power advocates and opponents, and discussions with researchers engaged in studies of the effects of nuclear power plants. The criteria selected were:

Aesthetic: The general appearance of the plant, and the effect it has on the visual quality of the surrounding area.

Economic: The effect of construction and operation costs on consumer power rates and the tax revenues generated by plant.

Water: The changes in the quality of nearby water sources, including the effects due to chemicals and heat.

Land Use: The amount and kind of land taken by the plant; compatibility of area for plant construction and operation in relation to the regional land use plan.

Air: The effects on air quality due to heating and chemical pollutants.

Animal/Plant: The effects on animals and plants, including those in the air or water or on land; the effects on the ecosystem and food chain cycle.

Cultural/Recreational: The recreational opportunities created or eliminated as a result of the plant; potential effects on the historical significance of the area.

Health/Safety: The effects on human health and safety; includes the effects due to: long-term radiation and air pollution exposure; accidental release or leakage of radioactive material; and risks associated with fogging and icing in the area of the plant.

These eight categories became the bases for describing the environmental impacts created by each plant. For each plant option brief paragraphs were included in the questionnaire which described each of the six plant options in terms of the eight environmental impact categories. Respondents were asked to read the descriptions and to make judgments of the acceptability of the plant options. Since the category of *aesthetics* was defined in a visual context, overhead slide projections were shown which presented an artist's conception of each plant option. The judgments of acceptability were made by using 7-point rating scales in which "1" represented *very unacceptable* and "7" *very acceptable*. Finally, respondents

were asked to judge the general or overall acceptability of each plant option. In the analyses of Part I, ratings of the acceptability of the eight environmental impact categories were treated as predictors of the overall rating. Correlational and multiple regression techniques were used to obtain indirect estimates of the relative importance of each impact category.

Part II was a multiple ranking procedure⁽⁷⁾ which presented the eight environmental impact categories from Part I, three at a time. This procedure was included to obtain direct estimates of importance of the eight environmental impact categories through a method which would be partially independent of the estimates obtained from Part I. Respondents were asked to rank each set of three categories "1", "2", and "3" as to their importance. In addition to the eight categories from Part I, a ninth category was included: "The United States' Reputation in the World as a Nation Concerned with Environmental Preservation". This last category served as a dummy variable (i.e., expected on an a priori basis to be of negligible importance) to establish a potential anchor point for evaluating the rankings given to the original eight environmental categories. This ninth category was also included because analysis of the multiple ranking results required an odd number of categories. The multiple ranking procedure presented each category paired with each of the other eight categories once and only once. Each of the nine categories was judged a total of four times. The outcome of this procedure was a rank ordering of the nine

categories which 1) took into account respondent inconsistencies in ranking, and 2) furnished results which met the measurement standards for adequate scaling of comparison judgments.

A special computer program was developed to analyze Part II. In addition to reflecting each subject's rank ordering of the nine variables, the program also yielded the number of intransitive judgments (i.e., inconsistent responses). An intransitive judgment takes the form $A > B > C$, yet $A < C$. Computation of mean rank ordering did not include those respondents with a high number of intransitive judgments.

Part III consisted of 54 attitude statements which dealt with nuclear energy and related topics. The statements fell into the following 12 categories:

- Economics and energy
- Consumption versus conservation
- Role of science and technology
- Idealism versus realism
- Importance of aesthetics
- Safety and risk considerations
- Image of the AEC
- Role of public input
- Distance from nuclear energy plants
- Urgency of energy crisis
- Energy and politics
- Alternatives to nuclear energy.

Statements were phrased in either strongly positive or strongly negative terms to provide respondents with well-defined referents with which to agree or disagree. Responses to the statements were made by checking a 5-point scale which ranges from *strongly agree* to *strongly disagree*. The reasons for including Part III were two-fold. First, the results of Part III could be used as aids in interpreting the estimates of importance from Parts I and II. Second, earlier background research on the topic of public acceptance of nuclear power pointed to a constellation of larger issues which surround the subject of nuclear power. The results of Part III would serve as a basis of exploring some of these issues.

The remainder of the survey questionnaire was devoted to a seven-item multiple choice "test" of knowledge about nuclear power, a brief list of biographical questions about the respondents, and a page for comments. The knowledge test and biographical information sections were used to describe some of the important characteristics of each of the samples. On the page set aside for comments, respondents were encouraged to react to the topic of the study and to offer suggestions and criticisms of the survey approach in a free-response mode. These comments are included as Appendix A.

B. SAMPLING AND DATA COLLECTION

The survey was presented to three groups in the Seattle area. As described earlier, this research was a pilot study and primarily methodological in nature. Consequently, emphasis was not placed on drawing a

random, representative sample of the total population. Rather, samples were chosen as a means of validating and evaluating the methods in the questionnaire. Accordingly, groups were chosen which were expected to differ from one another with respect to interests, attitudes and background. The three samples were: members of Seattle businessmen's organizations; students in a suburban high school; and members of environmental interest groups. Participation was by invitation and on a voluntary basis. A total of 192 people responded to the survey and 177 scorable questionnaires were analyzed. The sample sizes on which the analyses were performed were as follows: businessmen, 29; high school students, 57; and environmentalists, 91.

Questionnaires were administered in a group setting, the nature and purpose of the study was explained, and time was allotted for questions and discussion. Participants then read the introductory material in the questionnaire and proceeded with Part I. Approximately 5 minutes were required to evaluate and judge each of the six plant options described in the questionnaire. During each 5-minute period, the overhead slide projection for that particular site was presented for about 1 minute. The remainder of the survey was self-administered, and respondents were instructed to proceed at their own pace.

C. ANALYSIS OF DATA

Table 1 presents comparisons among the three samples in terms of mean age, educational level, number of elective offices held during the past

TABLE 1. Characteristics of Samples

	<u>Environmentalists</u>	<u>High School Students</u>	<u>Businessmen</u>
Total number of participants - 177	91	57	29
Age in years	$\bar{X} = 37$ S.D. = 10	$\bar{X} = 17$ S.D. = 1	$\bar{X} = 38$ S.D. = 11
Average number of elective offices held in last 5 years	Approx. 2	Approx. 2	Approx. 2
Self rating of knowledge about nuclear energy ^(a)	$\bar{X} = 4.7$ S.D. = 1.0	$\bar{X} = 4.2$ S.D. = 1.2	$\bar{X} = 4.5$ S.D. = 1.2
Average number of correct answers to nuclear energy knowledge test ^(b)	$\bar{X} = 5.0$	$\bar{X} = 2.9$	$\bar{X} = 5.2$

(a) 1 = *Know much less than most people*
7 = *Know much more than most people*

(b) Maximum possible correct = 7

five years, self-ratings of knowledge about nuclear energy, and scores on the seven-item knowledge test.

Responses of the businessmen, high school students, and environmentalists to the six plant options are presented in Tables 2, 3, and 4, respectively. Mean values from these three groups are shown in Figures 2 through 7.

Examination of these tables and figures indicates that, with few exceptions, the businessmen's group perceived the impacts created by nuclear plants as more acceptable than did the group of students or environmentalists. The environmentalists perceived the impact of nuclear plants as less acceptable than did the businessmen and high school students. Across the six plant options, there was a slight trend for the criteria of *economics* and *land use* to be seen as most acceptable by all groups. On the other hand, *water quality* and *animal-plant* impacts were seen as relatively unacceptable, irrespective of the plant option being considered. The overall ratings of acceptability for each plant option should not be interpreted as relative preference judgments or votes. The plant options were not directly compared with each other.

Tables 5 and 6 present zero order correlation coefficients between the eight environmental impact categories and the overall ratings (see last line, Figure 2) of acceptability for each plant option. The correlations furnish an estimate of the relationship between the rated acceptability of each

TABLE 2. Acceptability of Environmental Impacts Associated with Nuclear Power Plant Options (Businessmen)

	Once-Through River		Cooling Tower River		Cooling Pond River		Once-Through Lake		Cooling Tower Lake		Cooling Pond Lake	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Aesthetics	5.4	1.3	3.5	1.4	5.3	0.9	4.5	1.4	3.0	1.6	4.6	1.6
Economics	6.2	0.9	4.4	1.4	5.4	1.0	6.3	0.8	4.0	1.5	4.9	1.3
Water	3.4	1.4	3.6	1.5	4.1	1.3	3.2	1.6	3.9	1.6	3.9	1.5
Air	6.0	1.2	3.7	1.5	5.8	1.2	6.0	0.9	4.1	1.5	5.8	1.0
Land	5.9	1.0	5.4	1.1	4.0	1.6	5.0	1.4	4.6	1.4	3.2	1.6
Animal/Plant	4.1	1.6	3.0	1.4	4.2	1.5	4.6	1.4	3.6	1.7	3.7	1.3
Cultural/Recreational	5.4	1.0	3.9	1.5	5.1	1.1	5.1	0.9	3.4	1.3	5.1	1.1
Health/Safety	5.5	1.3	3.5	1.6	4.0	1.2	5.2	1.4	4.1	1.5	4.2	1.5
Overall Acceptability	5.0	1.0	3.5	1.2	4.7	0.9	4.7	1.2	3.5	1.3	4.4	1.2

1 = Very Unacceptable

7 = Very Acceptable

TABLE 3. Acceptability of Environmental Impacts Associated
with Nuclear Power Plant Options
(High School Students)

	Once-Through River		Cooling Tower River		Cooling Pond River		Once-Through Lake		Cooling Tower Lake		Cooling Pond Lake	
	<u>X̄</u>	<u>S.D.</u>	<u>X̄</u>	<u>S.D.</u>	<u>X̄</u>	<u>S.D.</u>	<u>X̄</u>	<u>S.D.</u>	<u>X̄</u>	<u>S.D.</u>	<u>X̄</u>	<u>S.D.</u>
Aesthetics	5.0	1.4	2.7	1.6	4.9	1.4	4.1	1.7	2.3	1.6	4.5	1.6
Economics	5.6	1.5	3.7	1.5	4.8	1.3	5.9	1.1	3.9	1.5	4.5	1.3
Water	2.6	1.5	2.6	1.5	3.0	1.5	2.8	1.3	3.1	1.4	3.7	1.6
Air	5.4	1.9	3.1	1.7	5.6	1.5	5.4	1.5	3.3	1.6	5.3	1.6
Land	5.0	1.5	4.4	1.5	3.3	1.6	4.1	1.6	3.9	1.6	2.9	1.7
Animal/Plant	3.8	1.8	2.4	1.7	3.4	1.6	3.9	1.6	2.8	1.5	3.0	1.6
Cultural/ Recreational	4.7	1.7	3.5	1.3	4.9	1.3	4.8	1.4	2.6	1.2	4.9	1.3
Health/Safety	5.1	1.5	3.6	1.7	4.0	1.3	4.9	1.4	3.6	1.6	4.0	1.5
Overall Acceptability	4.5	1.3	3.0	1.2	4.4	1.1	4.5	1.2	3.0	1.2	4.1	1.1

1 = Very Unacceptable

7 = Very Acceptable

TABLE 4. Acceptability of Environmental Impacts Associated with Nuclear Power Plant Options (Environmentalists)

	Once-Through River		Cooling Tower River		Cooling Pond River		Once-Through Lake		Cooling Tower Lake		Cooling Pond Lake	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Aesthetics	4.3	1.7	3.0	1.6	4.3	1.6	3.9	1.6	2.7	1.6	4.0	1.5
Economics	4.9	1.6	4.5	1.5	4.5	1.5	4.8	1.7	4.2	1.5	4.3	1.4
Water	1.9	1.5	2.5	1.3	2.6	1.3	1.9	1.2	2.7	1.4	2.8	1.5
Air	5.4	2.0	3.0	1.6	5.0	2.1	5.0	1.2	3.0	1.7	4.6	2.1
Land	4.7	1.9	4.4	2.0	3.5	1.8	3.6	1.7	3.6	1.8	2.7	1.7
Animal/Plant	2.5	1.8	2.2	1.3	3.1	1.7	2.8	1.7	2.5	1.4	2.3	1.3
Cultural/Recreational	3.4	1.9	3.1	1.9	4.1	1.7	3.9	1.5	2.8	1.5	4.0	1.6
Health/Safety	3.5	2.1	3.0	1.8	3.0	1.6	3.5	1.9	2.8	1.4	3.1	1.6
Overall Acceptability	2.8	1.8	2.8	1.4	3.6	1.6	2.8	1.6	2.7	1.5	3.2	1.6

1 = Very Unacceptable

7 = Very Acceptable

FIGURE 2. Mean Responses, Once-Through Cooling Design, River Location

FIGURE 3. Mean Responses, Cooling Tower Design, River Location

AESTHETICS

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 VERY ACCEPTABLE

ECONOMICS

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 VERY ACCEPTABLE

WATER QUALITY

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 VERY ACCEPTABLE

AIR QUALITY

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 VERY ACCEPTABLE

LAND USE

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 VERY ACCEPTABLE

ANIMAL AND PLANT LIFE

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 VERY ACCEPTABLE

CULTURAL-RECREATIONAL

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 VERY ACCEPTABLE

HUMAN HEALTH-SAFETY

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 VERY ACCEPTABLE

OVERALL RATING

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 VERY ACCEPTABLE

3.6
4.4
4.7

- — — BUSINESSMEN
- — · — · HIGH SCHOOL STUDENTS
- ENVIRONMENTALISTS

FIGURE 4. Mean Responses, Cooling Pond Design, River Location

FIGURE 5. Mean Responses, Once-Through Cooling Design, Lake Location

FIGURE 6. Mean Responses, Cooling Tower Design, Lake Location

FIGURE 7. Mean Responses, Cooling Pond Design, Lake Location

TABLE 5. Correlation Between Acceptability Ratings of Environmental Issues and Overall Acceptability Rating for Each Option

	<u>Once-Through River</u>	<u>Cooling Tower River</u>	<u>Cooling Pond River</u>	<u>Once-Through Lake</u>	<u>Cooling Tower Lake</u>	<u>Cooling Pond Lake</u>
<u>BUSINESSMEN</u>						
Aesthetics	<u>0.70</u>	<u>0.63</u>	0.52	<u>0.66</u>	<u>0.79</u>	<u>0.78</u>
Economics	0.37	0.58	0.29	0.24	<u>0.72</u>	0.42
Water	<u>0.66</u>	<u>0.69</u>	<u>0.58</u>	<u>0.68</u>	0.63	<u>0.67</u>
Air	0.17	0.49	-0.12	0.57	<u>0.68</u>	0.36
Land	0.44	0.35	0.49	0.34	0.47	0.42
Animal/Plant	0.50	<u>0.73</u>	<u>0.61</u>	0.38	0.49	0.45
Cultural/ Recreational	<u>0.51</u>	0.53	<u>0.77</u>	<u>0.65</u>	0.62	0.64
Health/Safety	0.36	0.61	0.52	0.44	<u>0.65</u>	<u>0.67</u>
<u>ENVIRONMENTALISTS</u>						
Aesthetics	0.41	<u>0.57</u>	<u>0.63</u>	0.37	<u>0.60</u>	<u>0.69</u>
Economics	0.43	0.51	0.50	0.29	0.35	0.56
Water	<u>0.73</u>	<u>0.62</u>	<u>0.61</u>	<u>0.72</u>	0.48	<u>0.69</u>
Air	0.33	0.51	0.50	0.48	0.55	0.64
Land	0.49	<u>0.58</u>	0.37	0.41	<u>0.65</u>	0.47
Animal/Plant	<u>0.76</u>	<u>0.66</u>	<u>0.51</u>	<u>0.71</u>	<u>0.69</u>	<u>0.65</u>
Cultural/ Recreational	<u>0.64</u>	0.40	0.42	0.35	0.56	0.64
Health/Safety	<u>0.65</u>	0.54	0.49	<u>0.61</u>	0.51	0.64

TABLE 6. Correlation Between Acceptability Ratings of Environmental Issues and Overall Acceptability Rating for Each Option

	Once-Through River	Cooling Tower River	Cooling Pond River	Once-Through Lake	Cooling Tower Lake	Cooling Pond Lake
<u>HIGH SCHOOL STUDENTS</u>						
Aesthetics	<u>0.58</u>	0.51	0.40	0.48	0.43	0.43
Economics	0.35	0.32	0.15	0.47	0.48	0.35
Water	<u>0.59</u>	0.47	0.26	<u>0.59</u>	0.45	0.37
Air	0.47	<u>0.66</u>	0.15	0.36	<u>0.52</u>	<u>0.45</u>
Land	<u>0.59</u>	0.43	<u>0.47</u>	0.39	0.23	0.38
Animal/Plant	0.48	<u>0.60</u>	0.37	0.54	<u>0.52</u>	<u>0.55</u>
Cultural/ Recreational	0.49	<u>0.63</u>	<u>0.44</u>	<u>0.64</u>	0.51	<u>0.49</u>
Health/Safety	<u>0.58</u>	0.43	<u>0.44</u>	<u>0.56</u>	<u>0.53</u>	<u>0.45</u>
<u>COMBINED SAMPLES</u>						
Aesthetics	0.58	<u>0.60</u>	<u>0.57</u>	0.46	0.55	0.60
Economics	0.48	0.40	0.36	0.51	0.44	0.45
Water	<u>0.71</u>	<u>0.62</u>	0.52	<u>0.68</u>	0.56	0.61
Air	0.34	<u>0.60</u>	0.44	0.46	<u>0.63</u>	0.58
Land	0.53	0.54	0.45	0.46	0.45	0.44
Animal/Plant	<u>0.71</u>	<u>0.60</u>	0.53	<u>0.65</u>	<u>0.63</u>	<u>0.64</u>
Cultural/ Recreational	0.67	0.57	<u>0.56</u>	0.59	0.56	<u>0.65</u>
Health/Safety	<u>0.71</u>	0.55	<u>0.58</u>	<u>0.67</u>	0.56	<u>0.65</u>

impact and the overall rating assigned to the nuclear plant option. Correlation matrices are presented for each sample and for the three samples combined. With only one exception (probably a spurious correlation), all of the coefficients are in a positive direction. This finding indicates, not surprisingly, that higher ratings of acceptability for any impact category are related to higher ratings of overall acceptability and vice versa.

Some indication of the relative importance of the eight categories (as reflected in the size of the correlation coefficient) can be detected, by first locating the highest coefficients within each plant option, and then scanning across the six plant options in search for patterns of high correlations. For each plant option, the highest three or four correlation coefficients are underlined. As an aid to interpretation, the maximum possible correlation is 1.00, which reflects a perfect correspondence between the acceptability rating of an impact category and the overall rating for a plant design. A correlation of 0.00 indicates no relationship between these two ratings. In this manner, the impact categories of prominence for the three samples were as follows: businessmen--*aesthetics*, *water quality*; environmentalists--*water quality*, *animal-plant life*; and high school students--*animal-plant life*, *cultural-recreational*, and *health-safety*. For the three samples combined, the most important impact categories were *animal-plant life*, *health-safety*, and *water quality*. Again, the size of the correlation coefficients indicate how well overall ratings of acceptability of a plant option can be predicted from knowledge of the rating of

each impact category. Predictability is one method of determining the importance or relative weight which the community attaches to an aspect of the environment.

Tables 7 and 8 present the results of the multiple regression analyses which were performed on the data. Results are presented in a similar fashion to the correlational data; matrices are shown for each sample and for the three samples combined. To aid in interpreting these results, it will be useful to briefly describe the multiple regression technique. The basic approach of multiple regression is to produce a combination of independent variables (i.e., impact categories) which will correlate as highly as possible with the dependent variable (i.e., overall acceptability rating for each plant option). The analysis proceeds in a step-by-step fashion. The first step is to choose the single impact category which is the best predictor of the overall rating. The second impact category to be added to the regression equation is that which provides the best prediction in conjunction with the first variable. This procedure continues until no other impact categories will make a significant contribution to the prediction equation. Multiple regression coefficients, or "beta weights," are assigned to each variable or impact category in a manner which maximizes the prediction of the overall acceptability rating. The size of the beta weights assigned to each impact category reflects the importance of that category (in combination with the other categories) in predicting the overall acceptability rating for that plant.

TABLE 7. Multiple Regression Coefficients (Beta Weights)

	Once-Through River	Cooling Tower River	Cooling Pond River	Once-Through Lake	Cooling Tower Lake	Cooling Pond Lake
<u>BUSINESSMEN</u>						
Aesthetics	0.37 (1)	0.24 (4)	-0.05 (6)	0.33 (2)	0.30 (1)	0.44 (1)
Economics	0.16 (5)	0.34 (2)	0.49 (2)	-0.08 (6)	0.28 (2)	-0.13 (5)
Water	0.35 (2)	0.19 (5)	0.10 (5)	0.38 (1)	0.21 (3)	0.08 (8)
Air	-0.04 (8)	0.18 (3)	-0.02 (7)	0.21 (3)	0.16 (6)	0.17 (4)
Land	0.14 (3)	0.07 (6)	0.14 (4)	-0.05 (7)	-0.10 (7)	0.06 (6)
Animal/Plant	0.08 (6)	0.42 (1)	0.48 (3)	-0.23 (5)	0.20 (4)	-0.09 (7)
Cultural/ Recreational	0.22 (4)	-0.04 (7)	0.40 (1)	0.37 (4)	-0.04 (8)	0.31 (3)
Health/Safety	<u>-0.05 (7)</u>	<u>0.02 (8)</u>	<u>-0.02 (8)</u>	<u>-</u>	<u>0.26 (5)</u>	<u>0.38 (2)</u>
R ²	0.73	0.88	0.83	0.71	0.87	0.85
<u>ENVIRONMENTALISTS</u>						
Aesthetics	0.09 (7)	0.32 (3)	0.46 (1)	-0.08 (7)	0.32 (2)	0.24 (1)
Economics	-0.07 (5)	0.08 (7)	-0.10 (6)	-0.02 (8)	-0.13 (6)	-0.06 (7)
Water	0.33 (2)	0.26 (4)	0.47 (2)	0.50 (1)	0.12 (4)	0.37 (2)
Air	-0.03 (8)	0.12 (6)	0.12 (5)	0.16 (3)	0.11 (8)	0.21 (3)
Land	-0.11 (6)	0.04 (2)	-	0.15 (4)	0.11 (5)	0.05 (8)
Animal/Plant	0.34 (1)	0.16 (1)	-0.03 (7)	0.27 (2)	0.32 (1)	0.04 (6)
Cultural/ Recreational	0.19 (4)	0.03 (8)	-0.23 (4)	-0.08 (5)	0.12 (7)	0.16 (4)
Health/Safety	<u>0.33 (3)</u>	<u>0.32 (5)</u>	<u>0.36 (3)</u>	<u>0.10 (6)</u>	<u>0.24 (3)</u>	<u>0.15 (5)</u>
R ²	0.77	0.76	0.65	0.68	0.76	0.77

TABLE 8. Multiple Regression Coefficients (Beta Weights)

	Once-Through River	Cooling Tower River	Cooling Pond River	Once-Through Lake	Cooling Tower Lake	Cooling Pond Lake
<u>HIGH SCHOOL STUDENTS</u>						
Aesthetics	0.19 (4)	0.14 (6)	0.40 (2)	0.16 (4)	0.23 (3)	0.27 (2)
Economics	0.05 (7)	-0.15 (5)	-0.20 (5)	0.16 (5)	0.09 (8)	0.07 (7)
Water	0.22 (2)	0.06 (7)	0.18 (4)	0.27 (2)	0.25 (2)	-0.09 (6)
Air	0.10 (5)	0.41 (1)	-0.04 (7)	-0.05 (8)	0.22 (4)	0.12 (4)
Land	0.26 (1)	0.09 (4)	0.25 (1)	-0.06 (7)	-0.18 (5)	0.10 (5)
Animal/Plant	0.11 (6)	0.23 (3)	0.03 (8)	0.16 (6)	0.11 (7)	0.39 (1)
Cultural/ Recreational	0.02 (8)	0.29 (2)	0.31 (3)	0.24 (1)	0.18 (6)	0.13 (3)
Health/Safety	0.19 (3)	0.05 (8)	0.20 (6)	0.23 (3)	0.04 (1)	0.04 (8)
R ²	0.62	0.70	0.52	0.63	0.50	0.49
<u>COMBINED SAMPLES</u>						
Aesthetics	0.11 (4)	0.21 (4)	0.32 (2)	0.10 (5)	0.26 (2)	0.26 (3)
Economics	0.04 (8)	-	-0.02 (7)	0.10 (6)	0.02 (8)	-0.04 (7)
Water	0.25 (2)	0.12	0.20 (3)	0.34 (1)	0.17 (5)	0.16 (4)
Air	-0.06 (7)	0.18 (2)	0.05 (6)	-	0.24 (3)	0.16 (5)
Land	0.07 (6)	0.13 (3)	0.02 (8)	-	-0.02 (7)	0.02 (8)
Animal/Plant	0.22 (3)	0.32 (1)	0.11 (5)	0.16 (4)	0.20 (1)	0.14 (6)
Cultural/ Recreational	0.14 (5)	0.11	0.16 (4)	0.10 (3)	0.10 (6)	0.24 (1)
Health/Safety	0.31 (1)	0.15 (5)	0.25 (1)	0.27 (2)	0.17 (4)	0.20 (2)
R ²	0.74	0.74	0.60	0.67	0.66	0.71

The size and pattern of beta weights presented in Tables 7 and 8 furnish indirect estimates of the importance of the impact categories in determining overall acceptability of the plant option. The numbers in parentheses indicate the order in the step-wise analysis in which each impact category entered the prediction equation. Generally, the earlier-entering variables are often those with the largest beta weights. Again, it is useful to identify the largest beta weights within each plant option and then scan across the plant options to locate patterns of high beta weights.

Prominent impact categories across plant options for each sample were as follows: businessmen--*aesthetics*, *cultural-recreational*, and *economics*; environmentalists--*water quality*, *aesthetics*, and *health-safety*; high school students--*aesthetics*, *cultural-recreational*, and *water quality*. For the combined samples, *aesthetics*, *animal-plant life*, and *health-safety* issues emerged as the most important predictors of overall acceptability.

The large number of small beta weights is partially due to the nature of the analysis; after the first two or three of the most powerful impact categories are identified by the multiple regression equation, a point of diminishing returns is reached; and the remaining categories contribute relatively little to the overall prediction. This phenomenon may result in the artificial depression of a particular impact category if it is highly correlated with another impact category; more will be said later about the inter-relatedness of impact categories. The R^2 's across the bottom of each beta matrix describe the predictive power of the acceptability

ratings for the combined eight impact categories in estimating the overall acceptability of each plant option. The upper limit of R^2 is 1.00. The size of the R^2 's which are shown indicates rather good prediction of overall acceptability with the eight impact categories which were used. Low R^2 's probably indicate that other factors should be taken into account in addition to the eight factors which are considered.

The highest R^2 's are found for the environmentalist sample, followed by the businessmen and the high school students, respectively. The lower R^2 's for the high school sample may be due to unreliability in the ratings as a result of different motivating conditions, interest in the study, etc. In general, the size of the R^2 's suggests that the combination of the eight impact categories used in this study are quite effective as predictors of overall acceptability. Most of the R^2 's are in the range 0.60 to 0.80, which indicates that 60 to 80% of the variation in the overall ratings of acceptability can be predicted from knowledge of the acceptability ratings for the eight impact categories.

The results of Part III, the multiple ranking procedure (Appendix C, p. C-16), are shown in Table 9. The mean rankings of importance from the triad section (Appendix C, p. C-15) assigned to the eight impact categories are shown, plus the ninth category which was added, U.S. Reputation. In general, the three samples were similar in the importance rankings assigned to the nine categories. *Water quality, animal-plant life, and health-safety* considerations emerged as the environmental categories requiring the most

TABLE 9. Average Rankings of Importance
for Environmental Issues

	<u>High School</u>		<u>Environmentalists</u>		<u>Businessmen</u>		<u>Combined Samples</u>	
	<u>$\bar{X}$</u>	<u>S.D.</u>	<u>$\bar{X}$</u>	<u>S.D.</u>	<u>$\bar{X}$</u>	<u>S.D.</u>	<u>$\bar{X}$</u>	<u>S.D.</u>
Water	7.6	1.2	7.5	1.1	7.3	1.4	7.5	1.2
Animal/Plant	7.5	1.3	7.3	1.0	7.2	1.3	7.4	1.2
Air	7.2	1.6	4.7	1.5	4.7	1.8	4.6	1.6
Health/Safety	6.1	2.1	7.4	1.8	7.6	1.6	7.0	2.0
Land Use	4.5	2.4	6.9	1.4	5.8	2.1	6.8	1.6
Economics	4.1	1.6	3.0	1.6	5.0	1.8	3.8	1.8
Aesthetic	3.3	1.5	3.3	1.7	3.0	1.2	3.2	1.5
Cultural/ Recreational	2.7	1.3	2.9	1.1	3.1	1.2	2.9	1.2
U.S. Reputation	1.1	1.2	1.1	1.1	0.3	1.5	0.9	1.2

0 = Least Important

8 = Most Important

attention. As expected, the category, "The United States' Reputation in the World as a Nation Concerned with Environmental Preservation," received the lowest rank and functions as an anchor point for interpreting the other eight categories.

The 54 attitude items comprising Part III were factor analyzed to determine if some underlying patterns of relationships existed so the items could be rearranged into a smaller set of general factors or dimensions. Four underlying dimensions or factors were found which would encompass a considerable number of the original 54 items. The four factors and the items which comprised them are shown in Tables 10 through 13. The factor loadings indicate the importance of each item in the factor. For example, Question Number 1 received a loading of 0.84, indicating that it was one of the main "definers" of Factor I. The scoring of the responses was such that positive loadings reflect a *disagree* response to the item and negative loadings reflect an *agree* response to the particular item. The four factors and their tentative definitions are: Factor I, Energy Consumption; Factor II, Acceptance of the A.E.C./Belief in Science; Factor III, Intolerance of Nuclear Energy; and Factor IV, Aesthetic, Non-Pragmatic, Idealistic Orientation.

Two of the four factors appear to effectively discriminate between the mean response of the environmentalist and businessmen groups. The means of the two groups differed significantly from one another on the items in Factors I and III (energy consumption and tolerance of nuclear energy). The environmentalists presented a lower tolerance for nuclear energy and

TABLE 10. Factor I: Energy Consumption

<u>Item Number in Questionnaire</u>		<u>Factor Loading</u>
1.	I would be willing to make some real changes in my life-style to conserve electric power.	0.84
2.	The public should be willing to conserve power even if it means changing our way of life.	0.83
3.	Restricting the amount of electricity for industry will do more harm than good.	-0.55
7.	If we don't change our way of life, the environment will be totally destroyed.	0.66
11.	I would be happy to pay 20% more for power if I could be sure it was clean and safe.	0.55
13.	Private citizens will have to change their habits of power consumption if the energy crisis is to end.	0.81
29.	The energy crisis should be solved by restricting the electricity consumed by private citizens.	0.53
31.	Domestic power production must continue to increase if the United States is to remain a major world power.	-0.53
32.	We should be more concerned with conserving energy rather than producing more energy.	0.78
38.	The environment comes first, energy production second.	0.57
42.	Our nation does not need to increase energy production.	0.53
48.	Preserving our environment is more important than creating jobs for the unemployed.	0.52

TABLE 11. Factor II: Image of AEC/Belief in Science

<u>Item Number in Questionnaire</u>		<u>Factor Loading</u>
16.	We would all have a better life if there were more poets and writers and fewer scientists and engineers.	0.52
26.	The United States has been run too long by <i>science and technology</i> .	0.49
33.	The energy crisis is a ploy of politicians to get a vote.	0.61
36.	The AEC is keeping as much information secret about nuclear energy as it did the underground bomb testing.	0.55
39.	The informed public can make much better judgments than the AEC can about nuclear power.	0.50
44.	The AEC is concerned only with the welfare of the public utility companies.	0.76
50.	Much of the publicity about the energy crisis is created by the AEC to encourage more nuclear power plant construction.	0.52

TABLE 12. Factor III: Intolerance of Nuclear Energy

<u>Item Number</u> <u>in</u> <u>Questionnaire</u>		<u>Factor</u> <u>Loading</u>
8.	I wouldn't be concerned about swimming in lake water used to cool a nuclear power plant as long as the AEC says it's safe.	0.57
10.	There must be a better alternative than nuclear energy.	-0.53
18.	All modern conveniences have some risks; the risks of nuclear power aren't any worse.	0.65
27.	Nuclear energy is now the best solution to the energy crisis.	0.59
30.	We don't know enough about long-term radiation effects on health to be able to think in terms of nuclear energy.	-0.55
34.	I would be just as willing to live near a nuclear power plant as any other factory or plant.	0.58

TABLE 13. Factor IV: Aesthetic, Nonpragmatic, Idealistic Orientation

<u>Item Number</u> <u>in</u> <u>Questionnaire</u>		<u>Factor</u> <u>Loading</u>
5.	It's not important that power plants look nice.	0.54
14.	As long as it works, who cares what a nuclear plant looks like.	0.67
23.	A reduction in energy production will make the United States a second rate world power.	0.52
45.	The average person does not have the knowledge to make rational decisions about nuclear energy.	0.50
51.	Issues as complicated as nuclear energy should be decided by the scientists, not the public.	0.57
54.	Unless we continue to fully support scientific and technological efforts, the United States will not survive another 50 years.	0.50

energy conservation orientation than did the sample of businessmen. On the other hand, there were no significant differences in the mean responses of the two groups to the items in Factors II and IV (Acceptance of the A.E.C., and Pragmatism - Idealism).

Appendix A contains a sampling of comments which participants wrote on the final page of the questionnaire. These comments have been classified into two general headings: Methodology Issues and Substantive Issues. Several respondents indicated a preference for more detailed descriptions of the six plant options and/or comparative data about non-nuclear energy sources. A number of comments also point up the difficulties in trying to separate facets of the environment into mutually exclusive categories.

A major problem in designing this study is the identification of categories of environmental impacts which are distinct from one another. Problems here are really two-fold: first, it is necessary to separate categories of environmental impacts on a conceptual level, and then it is important to present these categories in such a fashion that respondents are able to react to them as distinct entities.

One way of estimating the degree to which people regard various aspects of the environment as related or overlapping is to examine the correlations between the categories of environmental impacts. The correlations between the eight environmental impact categories used in this study were computed for each of the six nuclear plant options. The number of relatively strong intercorrelations (greater than 0.50) were totaled within each plant option

and then summed across the six nuclear plant options. This total number of strong correlations furnishes a rough index of the extent to which each sample of respondents see the eight impact categories as interdependent: the larger the number of significant intercorrelations, the greater the interrelatedness (in the eyes of the respondents) of the impact categories. For each group, the total number of intercorrelations was 168. Below is the number of intercorrelations above 0.50, over the maximum possible number of intercorrelations for each group:

Environmentalists = 74/168

Businessmen = 34/168

High School Students = 25/168

Combined Samples = 43/168

Appendix B contains the intercorrelation matrices of impact categories for each plant option, across the three samples and for these three groups combined. In a general way, these data suggest that many of the categories of environmental impacts were regarded as quite interrelated, particularly by the group of environmentalists. This finding tends to support some of the suggestions and criticisms which were offered by members of this group when they participated in the study.

Inspection of the data in Appendix B reveals, for example, that the responses to *animal-plant life* were correlated with the responses to *water*, and that *air quality* and *human health and safety* were also highly

correlated. This means, in essence, that to make these criteria mutually exclusive a greater effort will be required in their definition and explanation to respondents.

D. SUMMARY OF TEST RESULTS

Some tentative conclusions can be drawn from the results just presented. With respect to the acceptability ratings in Part I, *economics* and *land use* considerations were seen as most acceptable, and *water quality* and *animal-plant life* impacts were judged least acceptable. In general, ratings of acceptability for each impact category were positively related to overall acceptability of the plant option.

Correlations between impact categories and overall acceptability also suggested that *water quality* and *animal-plant life* were most strongly related to overall acceptance of a nuclear plant design.

The pattern of beta weights which emerged from the multiple regression analyses suggested that, across the three samples, *water quality*, *aesthetics*, and *cultural-recreational* aspects of the environment tended to be the best predictors of overall acceptability. The predictive power of the eight environmental impact categories, as reflected in the R's, suggests that these eight categories were quite effective in predicting overall acceptability of a plant option.

The importance rankings (Appendix C, p. C-15) indicated a fairly high agreement among the three groups sampled. Specifically, *water quality*,

animal-plant life, and *health-safety* considerations were judged high in importance, while *economics*, *aesthetics*, and *cultural-recreational* issues received less emphasis.

Analysis of the attitude statements revealed four general factors or dimensions which characterized the interrelationships among the 54 items. Two of the dimensions, energy conservation and acceptance of nuclear energy, proved to be good discriminators between the responses of environmentalists and businessmen. These two groups responded very similarly, however, to the statements which comprised the two other factors, image of the AEC and a pragmatism-idealism factor.

Also of interest was the finding that, of the three groups sampled, two of them, businessmen and environmentalists, differed in their acceptance of nuclear energy. In nearly all cases, the businessmen tended to judge nuclear energy plants as more acceptable than the environmentalists. The responses of students generally were intermediate between the two other groups.

E. CONCLUSIONS

The primary objective of this test was to explore several possible methods of measuring the relative importance of environmental impacts as seen by the public. This is both an important and a difficult task: important because technical-social policy decisions, if they are to win

public acceptance, must concentrate on those impacts that are seen as vitally important; difficult because of the very nature of the public values being measured.

The problem is to measure a set of attitudes or values (about the relative importance of several environmental impacts of nuclear generating stations) held by individuals or groups in such a way that they can be expressed on a numerical scale. The numbers on this scale should ideally reflect not only the order of importance but also how much more important one impact is than another. The approach or plan of action one takes to accomplish this task of turning attitudes into numbers can be called the scaling model. In order to measure a table one applies a scaling model built on standard units of length. Standard rulers are readily available to carry out this scaling model. Unfortunately, no such standard ruler is available to determine whether aesthetics or water quality are seen as more important by the public.

Scaling models for use with human respondents involve two broad classes of responses: judgments and sentiments. Judgments involve responses where a correct answer is conceivable. Estimations of distance, weight, and loudness are examples. The respondent's judgments can be compared with the corresponding physical measures as a check on the validity of the scaling model. Sentiments involve personal reactions, interests, preferences, and attitudes. No veridical comparison is possible. It makes no sense to argue that a respondent is incorrect for preferring one cooling design to another, or for saying that aesthetics are more important than

health and safety in the location and design of a nuclear generating station. Since no physical magnitudes are available to validate a scaling model for measuring sentiments, one must fall back on logic and experience. First a scaling model (a measuring approach) is selected that has proved effective in measuring judgments. This model is then applied to measuring sentiments and its long term usefulness is determined by how well the results fit in a system of lawful relations with other variables in that scientific area.⁽⁸⁾ There is no direct way of knowing whether the resulting numbers accurately capture the sentiments of the respondents.

Among the various types of sentiments, measures of the relative importance of elements in a composite are particularly troublesome. For instance, frequent attempts were made to measure the relative importance of different aspects of a work situation (pay versus supervision) in accounting for productivity or work attitudes. Lawler⁽⁹⁾ and Nealey⁽¹⁰⁾ reviewed this literature in detail and concluded that sentiments regarding importance are cognitively complex and difficult to measure directly. The situation is similar to asking someone how his mind works. Such phenomena are beyond the ability of most respondents to report in any direct way.

There is no shortage of scaling models. This area of psychology was highly active before 1880 and by 1900 a dozen or more "psychophysical methods," as they are called, had been tried out. Guilford⁽¹¹⁾ reviewed this work and evaluated many of the methods.

With this long history in mind the choice of scaling models for measuring the relative importance of environmental impacts was not made lightly. In the current project, two general methods were tested; both were shown to be potentially useful tools for obtaining numbers to put into a social value matrix.

The first method was an indirect approach, as recommended by Lawler and Nealey, and involved correlation and regression techniques. The relationships between acceptability of specific environmental impacts of nuclear power plants and the acceptability of the plant in general were examined. When the acceptability of a single impact is highly related to the acceptability of the whole plant, it can be inferred that the impact in question is important; in other words, that people attach a high social value or weight to that impact. When it is acceptable, the plant is acceptable; and when it is not acceptable, the plant is also not acceptable. First order correlations (Tables 5 and 6) between impact categories such as *water quality* or *aesthetics* and overall acceptability of the plant reflect the relative importance of each impact category as measured by this technique. The underlined correlations in Tables 5 and 6 show the most important impacts. These correlations do not take into account the extent to which the several impacts are intercorrelated, i.e., air quality and water quality may not be seen as distinct or exclusive phenomena. In this sense the correlations in Tables 5 and 6 reflect the importance of the impacts as though those impacts occurred in isolation from the other impacts. This is of course, not true and reflects a weakness in this method. If the impacts

could be described so they were really independent of one another in the minds of the respondents, this problem would disappear.

A related method based on multiple regression overcomes the artificiality of considering the impacts as isolated phenomena. The multiple regression coefficients, shown in Tables 7 and 8, enable one to infer the relative importance of the impacts when these are considered jointly. The higher the beta weight, the more important is the impact. The problem here however is that some impacts shown to be important (Tables 5 and 6) drop out of the multiple regression equation because they are highly correlated with other impacts. This technique is designed to predict overall acceptability of a design in the most efficient manner.

Additional analyses not reported here indicate that near-maximum predictability could be achieved using as few as three of the eight impact categories as predictors of overall acceptability. If one takes the view that the eight impact categories are fixed and that a value in each cell of the social values matrix is required, then the multiple regression approach, while mathematically elegant, will not be appropriate. By taking into account the intercorrelation among impacts, some appear to be of negligible importance because they overlap with other important impacts. Again, if the impacts could be described in some different way so that they are genuinely independent, the correlation among impact categories would be minimized. In this case none of the impacts would artificially drop out of the regression coefficients. The results in Tables 5 and 6 would then

agree much better with those in Tables 7 and 8. An approach designed to solve this problem will be discussed at the end of this section.

The second general method for obtaining importance numbers (weighting factors) to put in a social values matrix is to ask respondents to estimate the relative importance of impacts in some direct fashion. As previously mentioned, a great many scaling models are available, including various rating and ranking methods and even techniques whereby respondents make interval and ratio judgments. These require respondents to divide up a total number of points or to indicate how much greater their feeling is for one stimulus than another. Wyler⁽¹²⁾ used this general approach in getting ratings of the seriousness of 126 illnesses which ranged from dandruff to leukemia, and Indow⁽¹³⁾ had students make ratio judgments of their preferences among wristwatches.

Experience with a great number of studies like these leads to the conclusion that a scaling model based on the method of "paired comparisons" is as good as any other method when applied to the scaling of sentiments [see Guilford⁽¹¹⁾ and Torgerson⁽¹⁴⁾]. The paired comparison method requires respondents to make simple preference judgments among all possible pairs of stimuli to be evaluated. The major problem with this method is that it becomes cumbersome with large numbers of stimuli (the number of pairs to be evaluated equals $\frac{N \cdot (N-1)}{2}$, where N is the number of stimuli). Several modifications of the method can be used to reduce the number of judgments required without seriously reducing its accuracy. The present study used

one of these modifications, a multiple ranking approach, that required respondents to rank 12 sets of 3 environmental impacts.

Gulliksen and Tucker⁽⁷⁾ demonstrated that the resulting data can be expressed as paired comparisons and scaled by means of Thurston's law of comparative judgment. Nealey⁽¹⁵⁾ noted that average rankings such as those shown in Table 9 are essentially identical to the scale values that emerge from Thurston scaling. Many psychometricians would argue that such scales have equal interval properties; in other words, that the difference between 3 and 5 is the same as the difference between 6 and 8. Such numbers are more useful mathematically than simple ordinal scales. In summary, a variety of scaling models are available for making direct estimates of importance. They give equally good results in many cases, and the one picked for this study may well be the best available.

The scales of average ranks in Table 9 present the results of this direct method. There is only one scale for each group since the respondents were asked to consider the relative importance of the environmental impacts in general, rather than with respect to any particular design or site.

The important remaining question then is, "How well did these methods work?" Since there is no objective way to judge this, it is interesting to compare results from the different methods. Importance, as measured by the first order correlations (Tables 5 and 6), can be compared with importance, as measured by the multiple regression approach (Tables 7 and 8), by

inspection of the two sets of tables. If high correlations occur in the same places as high beta weights, the two methods agree. Comparison of the results for the combined samples in Tables 6 and 8, for instance, shows that these two methods agree fairly well. The highest correlations in Table 6 tend to occur in the same locations as the highest beta weights in Table 8. These methods should agree quite well since they are based on the same general mathematical approach of inferring importance from the relationship of the several impacts to the overall design.

In order to compare the results from the first order correlations (an indirect approach) with those from the multiple ranking of importance (a direct approach), it is necessary to combine the six design/site options in Tables 6 and 7 into a single number denoting the importance of each impact category. To do this the correlations in Tables 6 and 7 are averaged across the six design/site options by means of a Fisher Z transformation. This gives just one importance score for each impact category. These average correlations are then ranked. The average rankings from Table 9 are also ranked. The resulting two sets of ranks are shown in Table 14. As can be seen there is a good deal of discrepancy in the ranks of importance as inferred from the two methods. The rank order correlation coefficient at the bottom of the table shows the agreement among the two columns of ranks. If agreement is perfect this coefficient will be 1.0. When no agreement exists the coefficient is 0. The two methods agreed fairly well in the environmentalist sample and when the three samples are combined. But no agreement exists for the high school and businessmen samples. Such results are quite typical when direct and indirect methods of measuring importance are compared. (10)

TABLE 14. Comparison of Importance of Environmental Issues
as Inferred from Correlation (Indirect Method)
and Multiple Ranking (Direct Method)

	<u>High School</u>		<u>Environmentalists</u>		<u>Businessmen</u>		<u>Combined Samples</u>	
	<u>Ind.</u>	<u>Dir.</u>	<u>Ind.</u>	<u>Dir.</u>	<u>Ind.</u>	<u>Dir.</u>	<u>Ind.</u>	<u>Dir.</u>
Water	4	8	7	8	7	7	6	8
Animal/Plant	7	7	8	6	4	6	8	7
Air	3	6	3	4	1	3	3	4
Health/Safety	6	5	6	7	5	8	7	6
Land	2	4	2	5	2	5	2	5
Economics	1	3	1	2	3	4	1	3
Aesthetic	5	2	5	3	8	1	4	2
Cultural/ Recreational	8	1	4	1	6	2	5	1
Rank Order Correlation	-0.095		0.643		-0.095		0.560	

1 = Least Important

8 = Most Important

Discrepancies like these may be due to several factors. The environmentalist group was the largest of the three groups. The intercorrelation shown by this group may be a result of high motivation (and have higher reliability). If these methods were applied in a setting where a nuclear station was actually being planned, the sample would be both large and motivated. The multiple regression method in particular is likely to be unreliable with samples less than about 200 when 8 impacts are involved. Past experience, cited above, shows that complex judgments like those required by the direct method are quite difficult for respondents to make.

However, it seems that the most basic difficulty with the current study is with the technical descriptions of the impacts. They do not sufficiently distinguish between the several impacts. As a result the respondents perceive the impacts to overlap and reliable judgments are difficult. The problem of overlap between impact categories shows itself in several ways: 1) by making difficult the interpretation of both the correlation and multiple regression results, 2) by presenting the respondents with a multidimensional task when they are asked to judge the importance of impacts on a unidimensional scale of importance, 3) by detracting from the specificity of the stimuli and thus reducing reliability, and 4) finally in the comments of the respondents which showed they had a difficult time keeping the various impacts separate.

This problem of overlap in impact categories can best be approached by multidimensional scaling techniques. The primary objective is to

discover the important dimensions the public uses to think about environmental impacts. Very likely the eight categories presently used can be reformed so that all the current technical details are included (from technical considerations land use can be dropped, see Section V). The available technical data could then be expressed in a fashion that would communicate more directly and easily to respondents. Thus, their judgments, either direct or indirect, about the relative importance of impact categories would not suffer from the measurement problems currently experienced. The final product will have to maintain the fine balance between psychometric and techno-economic requirements. In that case both the direct and indirect methods could be expected to yield more useful results that agree more closely with each other, and the method easiest to apply could be used. Finally, the role of common sense and expert judgment should not be overlooked in evaluating the results of these approaches to measuring importance.

Both the direct and the indirect method deserve a field test. They are reasonably easy to apply and either might be adequate as a means of generating social value weights given a sample of adequate size, a group of motivated respondents, and added attention to the technical description of the impacts. A recommended preliminary step, if funds permit, would be a multidimensional scaling experiment. Such a study would show how technical data can best be presented considering both the adequacy of technical description and psychometric validity of the impact dimensions.

IV. QUANTIFICATION OF AESTHETIC VALUES

A. APPROACH/METHODOLOGY

This section discusses an approach to predictively evaluate any changes in visual quality of a landscape resulting from the physical introduction of a nuclear facility. Preferably the methodology will 1) allow the evaluation of a range of potential facility types (varying principally by cooling option) on a given site or range of alternative sites; 2) require relatively small numbers of evaluators to be used effectively; and 3) be applicable to any landscape-facility combination.

1. Assumptions and Concepts

Some basic assumptions will clarify the breadth and limitations of the visual evaluation approach used. This evaluation covers only a very narrow frame of experiential response, i.e., visual sensory perception of selected views of the environment. Although many other stimuli affect and alter an observer's perception of the environment (e.g., hearing, touch, joy and anxiety), they are of necessity beyond the scope of this work.

This study must attempt to deal not only with variables within the spatial environment, but with temporal variables as well. An observer's perception of any element of the landscape is constantly being altered by dynamic changes in his position relative to the element, and by the visual interplay of other landscape elements. Some elements are relatively static (landform, vegetation, settlement) while some highly ephemeral (sky

patterns, day/night, seasonal changes). Visual change over time⁽¹⁶⁾ and sequence are important factors contributing to visual perception of the environment. This study uses the concept of visual change over time in its evaluation of the visual quality of a *viewscape* (a scene whose elements may include both the natural landscape and manmade elements) as it appears both *before* and *after* the facility is introduced into it. The change in visual quality of the viewscape as affected by the facility is one index of its visual impact. This change, multiplied by the number of times that viewscape is seen by an observer, is the full measure of visual impact visible from that viewpoint. Sequence is used through the selection of *representative* viewpoints which will fully reveal the facility's visual impact as interpolated over the much wider viewing area.

Within this study, a sight-line analysis procedure is outlined to delimit that surrounding area of land or water from which an alternative facility is visible, and hence which may be visually impacted by the facility's introduction. This surrounding area, termed the facility's *viewshed*^(17,18) is the key to the spatial location of an alternative's potential viewing population and to viewpoint selection. Within the viewshed, viewpoint selection depends upon 1) viewing populations, 2) viewpoint distance from the facility, 3) vertical observer position, 4) direction of view relative to the facility's setting, and 5) visual conditions. Of all these variables, the most important is viewing population, since visual impact must depend on the presence of a viewer. This does not imply, however, that for visual purposes the facility should ideally be located in wilderness or unpopulated areas. We contend that,

through proper design and visual impact evaluation, it is possible to properly and more wisely locate such installations in areas of high population distribution and visual exposure without abusing the invaluable and rapidly disappearing wilderness or semi-wilderness areas.

Prior to any portion of the visual analysis, it is necessary to survey the site for scarce visual resources which would be threatened or destroyed due to the installation of the facility. This is intended to protect any valuable visual resources which might be lost due to physical alteration of the site, regardless of viewing population. Since physical alteration is normally an irreversible process, it is felt that these two considerations, 1) physical impacts to scarce visual resources on the site itself, and 2) the visual relationship between the facility and its setting as viewed from its viewshed, comprise the scope of visual impact.

Three measurement levels or approaches to aid the objective evaluation of visual quality of a viewscape are included. The first gives a direct evaluative measurement of visual quality using familiar *benchmark* landscapes as references. The second applies the numerically-scaled definitions of intactness, vividness, and unity to the viewscape as an overall visual entity. The third applies a similar scale to each individual element of the viewscape, then places their scores into proper perspective by determining the relative visual importance of each viewscape element. Throughout the evaluation, the user is urged and guided in the use of objective visual parameters rather than asked to state preferential biases for or against the viewscape. Objective visual evaluations

show more normative results across different interest groups than do preferential ratings (Ref. 19, p. 128).

This visual quality evaluation approach is consistent with earlier work^(18,20,21) in its application of the concepts of *magnitude* and *importance*. Magnitude is the relative degree to which a viewscape exhibits the qualities of visual intactness, vividness, and unity as measured on numerical rating scales. The importance of each of these qualities (and the viewscape) is expressed through 1) the equations for visual quality and ratio of change in visual quality, 2) the specified selection of representative viewpoints within the facility's viewshed, 3) the weighting factors of viewing population, and 4) (in measurement level 3) the evaluation of the relative degree of visual importance of each major element in the viewscape. The aggregation of these factors of magnitude and importance leads to the final evaluation of visual impact.

This study draws from and owes much to the earlier definitive work of many; in particular, excellent works by Litton,^(22,23) Zube,^(17,19) and Leopold⁽²¹⁾ directly or inadvertently contributed to and enriched this approach. The authors also built upon their own earlier work.^(18,20,24) The last of these utilized a similar technique to evaluate the visual impact of a 6-mile stretch of interstate highway traversing the northern reach of Lake Coeur D'Alene, Idaho.

2. Equations for Visual Impact Assessment

A questionnaire (Appendix D) is employed to assess visual quality of each viewscape before and after the facility is introduced into it. Measurement Level 1 gives a direct score for visual quality on a scale for 1-100, and therefore needs no calculation. Measurements Levels 2 and 3 both depend on the basic formula:

$$VQ = 1/3 (I + V + U)$$

where

VQ = Visual quality of the viewscape

I = Intactness

V = Vividness

U = Unity

The ratio of change in visual quality (R) in a viewscape from before (VQ_b) to after (VQ_a) is expressed as:

$$R = \frac{VQ_a - VQ_b}{VQ_b}$$

Visual impact measured at a given viewpoint is:

$$\text{visual impact} = R \times P$$

where

R = ratio of change in visual quality for viewscape

P = population contact per year at that viewpoint

For further elaboration of the application of these equations, see Subsections B-3, C-1, D and E.

B. DATA PREPARATION/PRELIMINARY ANALYSIS

In order to carry out the visual analysis, the following preparatory data are required:

- Location, topographic maps, and overlapping stereo overhead aerial photographs of the potential site (or sites) to be evaluated.
- Potential facility types to be analyzed (normally varying by cooling system option, either once-through cooling, cooling pond, mechanical draft cooling stacks or natural-draft cooling towers).

While each option has its own visual characteristics, from a distance the major visual difference is the presence or absence of the cooling lake or of the approximately 500-ft-high cooling tower with its steam plume. Normally, the next tallest structure is the approximately 200-ft-high containment silo, which is a visual element common to all facility options considered in this report. The cooling pond or lake may cover a large acreage of land. However, the differing heights of vertical facility elements, cooling tower versus containment silo, lead to the visual distinction between these two cooling systems in this report.

- Schematic site plan(s) which locate the major structures with the site boundaries and convey the base and top elevations of the major facility structures.
- Surrounding population distribution data, both resident and transient, for the area within at least a 5-mile radius from the facility. From this data, and with access to the site and surrounding area for photography, the visual evaluation study may be undertaken.

1. Survey of Site For Scarce Visual Resources

Prior to any other portion of the analysis, the potential site should be thoroughly surveyed in search of scarce or unique visual resources which might be threatened, disturbed or lost by introduction of the facility, either during and/or after construction. The visual survey is best accomplished by investigation or topographic maps and by studying overlapping overhead aerial photographs with stereo viewers, followed by a ground survey to investigate particular areas which appear to contain special visual features. Particular attention should be given areas of the site which will be physically altered by the facility.

The visual survey especially investigates the degree to which the site occupies a visually crucial position in the larger landscape, the degree to which it is visually typical of, or unique from, other areas nearby, and the level of uniqueness (scarcity) of its particular features (waterform, landform and/or vegetation). Waterform features include waterfalls, geysers, glaciers, rivers, streams, creeks or springs; landform features

include distinctive peaks, knolls, ridges, valleys, basins, gorges, or geologic features (such as rock outcrops); vegetative features include rare endemic species or unique combinations, or interfaces between various vegetation types.

To determine the degree of scarcity or uniqueness of visual resources a larger frame of reference is needed. For purposes of comparison, visually-oriented persons familiar with the larger landscape are therefore best qualified for this visual survey. In the absence of naturally-classified physiographic regions, the surrounding area within a 100-mile radius of the site should be used. If individual landscape features or combinations of elements present onsite are sufficiently scarce (unique among five or less places within that area), and are threatened by the introduction of the facility, a "red flag" should immediately be signaled (Ref. 24, p. 13), and a consultation held with officials and/or evaluators to consider the impending loss of unique visual resources, if that site is chosen. A statement of the findings of this initial site survey should accompany the final visual impact analysis report and scores, including slides of those visual resources threatened by the facility.

2. Viewshed Construction

In order to select viewpoints of a proposed facility on a potential site it is necessary to determine the *viewshed* of that facility. The *viewshed* of a facility on a particular site is that area of surrounding land or water from which the facility is visible. The viewshed is thus

unique to each combination of facility and site and is most accurately constructed with the use of sight-lines from topographic maps of the surrounding area. U.S.G.S. maps at the scale of 1:24,000 are ideal for this purpose, although maps at 1:62,500 scale may be used if the larger scale is not available. These maps should be spliced together so that land within a radius of at least 6 miles surrounding the facility in all directions is represented.

In order to construct the viewshed of a facility, a schematic site plan is required which shows 1) approximate locations of major structures (natural draft or forced-air cooling towers, containment building, turbine building, transmission lines, and switchyards) and 2) any necessary major alterations or existing landforms, waterforms or vegetation (large cuts or fills, cooling lakes for reservoirs, and extensive clearing or reforestation). However, height and bulk of the major structures and the horizontal extent of alterations to the ground surface are of primary concern. These particular items should be located on the U.S.G.S. map, with the recognizable height of the tallest structure related to topographic elevations. Assume that, to recognize or distinguish a structure from a distance when the lower portion is screened from view, at least 10% of its height from the top must be visible. For example, assume that one will not recognize only a small top portion of a 500-ft-high cooling tower, but when the top 50 ft or more is visible, one may readily recognize it.

The viewshed reference elevation = height of tallest structure - $(0.10 \times \text{height})$ + base elevation. For example, a 500-ft-high natural

draft cooling tower to be located on an excavated knoll at base elevation 100 ft will have a viewshed reference elevation of $(500 - 50 + 100 \text{ ft} =) 550 \text{ ft}$ reference elevation. A 200-ft-high containment structure to be located at elevation 50 ft will have a viewshed reference elevation of $(200 - 20 + 50 \text{ ft} =) 230 \text{ ft}$ reference elevation (see Figure 8).

The next step is to look at the configuration of the topography surrounding the facility and seek out prominent landforms which might limit or block out visibility of the facility. On a site with relatively flat or gently rolling topography, there may not be visual screening of the facility by landforms for a radius of several miles. For example, a facility with cooling towers located in the Sacramento Valley is visually exposed to view in all directions for several miles without significant landform screening. On the other hand, in extremely hilly or mountainous landscapes the ridgelines of such landforms will often delimit one side or face of the landform as being visibly exposed to the facility, while the opposite face of the landform may be visibly blocked from facility view exposure. Visibility is frequently blocked at, or very near, a ridge of a relatively steep-sided landform; hence, these ridgelines should be defined on the topographic base map (see Figure 9).

When considering sight-line analysis, it is helpful to think of the viewshed reference elevation point of the facility as an unconfined source of light shining in all directions: the surfaces of land which it would illuminate comprise its viewshed. Certain areas of land may be in the shadows created by landform obstructions; while beyond these shaded areas may be

FIGURE 8. Viewshed Reference Elevation

FIGURE 9. Casting Viewscape, Plan and Section

other land surfaces which emerge again into light. The limit of the land shadowed by an obstructing ridge is the result of a straight beam of light which passes just above the ridge or obstruction and strikes the next available receiving surface, illuminating it above the line of shadow. Accurate location of the next area illuminated behind a ridge obstruction may be made by drawing a section through the point source of light (the viewshed reference elevation of the tallest structure) and the profile of the land radiating out from that point. After locating potential obstructing ridgelines on the topographic map, projection of the shadow lines on receiving landform surfaces behind the ridgelines then may be made.

Topographic contours are lines of equal elevation on land, and as such, they very accurately depict its shape or configuration. When topographic lines descend facing the point source of light, they are apt to be illuminated; when the topographic lines descend away from the point source of light below a blocking ridge, they indicate an area apt to be in shadow. The point at which a contour line on an illuminated landform turns and becomes tangent to a beam of light from the facility is the location of the line of shadow. A straight line projected from the point light source at the facility past this shadow location will locate the shadow on a potential receiving surface behind this landform (see Figures 9 and 10).

The plotting of radial sections through the viewshed reference elevation of the tallest structure (pivoting about this point source of light) and extending for several miles into the surrounding landscape would be an extremely laborious and time-consuming task. An obvious short cut is to

FIGURE 10. Casting Viewscape on Topographic Map

focus only on those critical areas where shadows are formed, at ridges or edges which are tangent to the point source of light, and to determine the line of these shadows on receiving landform surfaces. This may be done entirely in plan view on the topographic map surface by drawing a horizontal red line from the facility reference elevation through or "over" an obstructing ridge to a potential receiving surface beyond. This red line may then be considered to be both the base section line in plan and a horizontal contour line in section at the viewshed reference elevation (as in Figures 9 and 10, at viewshed reference elevation 550 ft). Considering this line to be at a set horizontal elevation of 550 ft, then any ridge point occurring at that same elevation will cast a horizontal shadow to a receiving surface at elevation 550 ft beyond (if such a surface exists).

Similarly, any foreground ridge occurring below 550 ft in elevation will cast a shadow to a receiving surface at an elevation lower than itself, and any ridge occurring above elevation 550 ft must, by geometric necessity, cast a shadow to a receiving surface at an elevation higher than itself. By using the red line both as the section line in plan and as the horizontal line at viewshed reference elevation 550 ft, and reading the ridge elevation directly from the topographic map, then the difference in height between the ridge elevation and reference elevation 550 ft may be plotted above or below the red line. This determines the angle of the light beam passing beyond the ridge and therefore available to illuminate a receiving surface beyond. A blue line may be drawn through this plotted vertical distance from the point-light source (see Figures 9 and 10),

resulting in a triangle of the two colored lines with its apex at the reference point near the top of the facility.

To determine the point of shadow (or light reception) on a potential receiving surface, compare the vertical distance between these two divergent lines (which naturally becomes greater as one moves away from the facility) to the elevations of the contour lines of a potential receiving landform surface. Where the distance between the two colored lines coincides with the relative topographic elevation of the landform surface lies the location of the shadow line, or the point at which the surface emerges into light. From the area of land above this point, the facility is visible and recognizable; below this point, the facility is visually blocked by the landform in front. By connecting the locus of points located at various intervals by the same technique with a smooth line, one accurately defines the "shadow" line, or the line of facility visibility/obscurity.

This analysis may be applied to any combination of facility and site with relative ease. For purposes of viewshed analysis there are normally only two facility alternatives which might be considered: 1) a facility which uses natural draft cooling, which normally makes the tower(s) tallest of the structures on the site, or 2) a facility using another cooling alternative, which will leave the containment building as the tallest facility element. Should both alternatives exist for a given site, construction of the viewshed for the cooling tower alternative leads most easily into modification

for viewshed analysis of the smaller containment building. Therefore, it is recommended that the cooling tower viewshed be constructed first.

Viewshed analysis and construction may be summarized into the following steps:

- Step 1 - Determine locations of major structures on the site and transform the height of the tallest into an approximate topographic elevation to be used as a reference point for the analysis (Figure 8). This horizontal elevation is the red line identified on Figures 9 and 10.
- Step 2 - Identify and define ridgelines or high points of major landforms which might potentially block visibility of the facility beyond.
- Step 3 - Using a straight edge which pivots about a pin stuck into the location of the tallest structure, locate points at which topographic lines become tangent to the straight edge as it is moved across them (Figure 10). This locates the points at which shadows will occur on these surfaces.
- Step 4 - Extend the red line beyond this visibility-obscuring ridge or shadow-point elevation located in Step 3, still using the pin at the facility as the source of the line. Considering this

red line to represent a horizontal line in section at the viewshed reference elevation as found in Step 1, subtract the difference between this red line elevation and the elevation of the ridge or shadow-point. Measure off this vertical distance perpendicular to the red line, and draw a blue line from the facility location pin through that point.

Step 5 - Compare the vertical distance between these two colored lines (measured perpendicular to the red line) to the distance between the viewshed reference elevation and the elevations of ascending contour lines of a potential receiving landform surface; if these two distance measurements coincide at some point, that point is the location of the shadow line on the receiving surface, which should be located on the red line.

Step 6 - Repeat Steps 4 and 5, gradually moving outward from obscuring landforms near the facility to receiving surfaces farther away, moving in a fanning motion and pivoting the straight edge about the facility pin location. Connect the resulting locus of points with smooth lines. Continue the investigation outward to a distance 5-6 miles; color or shade in visible areas, the viewshed.

A completed viewshed of the Trojan facility on the Columbia River is illustrated in subsection E as Figure 40.

3. Estimation of Population Visual Contact With Facility

Both resident and transient population distributions should be considered for their potential views of the facility, leading to viewpoint selection.

Resident population within the viewshed may readily be determined by overlaying the viewshed with a transparency on which population distribution by sector at mile intervals is plotted (see example illustration in Section E, Figure 40). This information is normally prepared as part of the site location study, and may include population counts within equal sectors of 22.5 degrees radiating outward from the facility, girded by concentric circles at mile radius intervals from 1 to 5 miles. Both current and projected populations are frequently given, so that resident population distributions exposed to view of the facility can readily be determined.

Determination of transient population visibility exposure may also be made by considering major transportation corridors which cross within the viewshed, including highways and passenger rail lines. Although aerial views from nearby flight paths might be considered, the actual number of aerial visual contacts with the facility under most viewing conditions will normally be lower than many places on the ground. Railway and highway traffic counts are readily available from state agencies. Also under transient population visibility comes the consideration of seasonal recreation patterns within the viewshed, including both large-group organized recreational patterns and smaller group or individual activity patterns.

For instance, should the viewshed encompass trails or recreational areas, these might be considered as potential viewpoints. Frequently-visited sites of scenic or historic interest within the viewshed are highly eligible as viewpoints, and estimates of transient population for such sites are readily available.

Population visual contact with the facility is the total number of probable visual contacts per year that the facility will be seen by some population from a given viewpoint. For resident population visual contact from a representative viewpoint located in a settlement or community, an average of 75% of the community might see the facility from that viewpoint at some time during the course of a day, year-round. If the facility is 1 mile distant or less, 75% of the community might see it four times a day; if the facility is 1 to 2 miles distant, 75% of the community might see it three times a day; 2 to 3 miles distant, 75% of the community might see it twice a day; 3 to 4 miles distant, 75% of the community might see it once a day; beyond 4 miles distant, 75% of the community might see it 0.5 times a day, or once every two days. For example at a representative viewpoint in a community of 3500 located 2 1/2 miles away from the facility, estimated yearly resident population visual contact would be $3500 \times 0.75 \times 2 \text{ times/day} \times 365 \text{ days/yr} = 1,916,250 \text{ visual contacts per year}$.

Transient population visual contact from transportation corridors must account for the total occupants of a vehicle that might view the facility from a given viewpoint during daylight hours. For instance, at a viewpoint on an interstate highway which has an average daily traffic count of

20,000 vehicles, it can be assumed that each vehicle contains 1.8 passengers and that 65% of the traffic occurs during daylight hours. Then the total yearly facility visual contact from that viewpoint would be $20,000 \times 1.8 \times 0.65 \times 365 \text{ days per yr} = 8,541,000$ visual contacts per year.

The intensity of visual contact is a factor which must be considered. Social psychologists have demonstrated in numerous experiments (the Picasso statue in the Auiago Loop is probably the most striking example of this phenomenon) the ability of a populace to accommodate to aesthetic changes. Hence, the visual impact, per contact, on the resident population should be less than that on a transient. The total aesthetic impact will, of course, be a function of the total contacts appropriately weighted for this intensity factor. Little or nothing is known about this factor; these values will clearly require some research before they can be used with any confidence.

The term "visual impact" of any alterations of the landscape presupposes that people are (or will be) present to view the alteration. Since there can be no visual impact if there is no viewer (see discussion in Subsection A-1), population distribution within the viewshed of the facility is the most important criteria for viewpoint selection. No combined selection of viewpoints is sufficient which does not reflect views seen from major concentrations of resident and transient populations within the facility's viewshed. However, the following considerations are also very important, because they attempt to clarify the selection of representative viewpoints.

4. Viewpoint Selection

Once the viewshed of a facility on a site is determined, and an estimation of population visual contact with the facility made, it is necessary to select representative viewpoints from which to photograph the proposed facility. Viewpoint selection is primarily related to population visibility contact with the facility under varying conditions. It should be obvious from looking at the size and configuration of the viewshed that an infinite number of views of the facility are possible by varying groups of people (see Trojan viewshed, Figure 40, Subsection E). Therefore, criteria must be developed to guide viewpoint selection so that it will not be necessary to finally evaluate more than eight to twelve views for any one site-facility alternative, although photographs from at least twenty viewpoints should be considered initially. This necessitates consideration of two variable conditions in addition to population distribution within the viewshed:

- 1) Distance and observer position,
- 2) Direction of view and visual conditions.

Distance and observer position: The visual impact of the facility is closely related to the distance the observer is from the facility and the vertical position of the observer relative to the facility. (See Figure 11 for observer distance zones and Figure 12 for observer position.) For descriptive purposes, Litton (Ref. 23, p. 3) proposes three landscape distance zone designations:

<u>Zone</u>	<u>Near Boundary, Miles</u>	<u>Far Boundary, Miles</u>
Foreground	0	1/4 - 1/2
Middleground	1/4 - 1/2	3 - 5
Background	3 - 5	∞

When the facility is seen as an element in each of these zones, its degree of participation in the viewscape may change. Obviously, the facility occupies a larger portion of the viewscape as one gets closer to it (Figure 11). However, its perceptual relationship to the viewscape changes in other ways as well. In the background (more than 3-5 miles distant), the facility appears as a two-dimensional pattern or shape (see

FIGURE 11. Observer Distance Zones

FIGURE 12. Observer Position

Figure 13). Since all colors appear subdued in the background due to atmospheric conditions, the increasing similarity of color value for all viewscape elements may make the facility very difficult to distinguish from its surroundings, unless it interrupts the skyline. The facility itself, as a background element, may be concealed by trees in the near or middle-ground, or obscured by atmospheric conditions. If natural draft or mechanical draft cooling is used by the facility, the plume (when present) will be the primary identifying feature, locating the facility in the viewscape.

FIGURE 13. Background, +5 Miles, Observer Normal

Observer position, or the vertical location of the observer relative to the facility, is another important consideration in viewpoint selection.

Litton (Ref. 23, pp. 5-10) suggests three categories of observer position: observer inferior, observer normal, and observer superior (Figure 12). In an inferior position, the observer is essentially below or near the base level of the object or landscape he is viewing (Figures 14, 15, 16, 17, 18, and 19). Views of distant elements may be obscured or blocked by screening elements nearer the observer, and their detail competes for his attention. The observer inferior viewing position will often focus the viewer's attention on the foreground.

FIGURE 14. Middleground, 2-1/4 Miles, Observer Inferior

In the observer normal position, the viewer's level line of sight basically coincides with a dominant landscape element, and the observer tends to focus on the middleground (Figures 13, 20, 21, 22, 23, 24 and 25). Litton states that the normal observer position is very comprehensive, retaining some familiarity with foreground detail and also allowing a

certain level of overview which is characteristic of an observer superior position, making observer normal an ideal combination for recognition of landscape space.

FIGURE 15. Middleground, 2-1/4 Miles, Observer Inferior

FIGURE 16. Middleground, 1-1/2 Miles, Observer Inferior

The observer superior viewing position (Figure 26) is most easily characterized as an overview from a mountain or ridge in which the overall landscape structure may be seen, though perhaps with little detail. Attention is most frequently drawn to the distant landscape.

It is in the middleground of the viewscape (1/2 to 3-5 miles distant) that the facility establishes itself as a strong visual element. Litton (Ref. 23, p. 4) says that the middleground is that zone of the landscape where simple landform and vegetative shapes, patterns and textures become distinct and recognizable in relationship to each other. Therefore, the middleground zone clearly shows the degree of visual success or failure of

FIGURE 17. Middleground, 1-1/4 Miles, Observer Inferior

man-made alterations within the overall landscape pattern. In the middle-ground, distance and atmospheric conditions generally have less success muting visual contrasts than in the background, and color chroma contrasts as well as value contrasts are more readily apparent. The facility as a middleground viewscape element may often be clearly seen in relationship to its setting. However, an absence of comprehensible detail or texture in this distance zone often causes visual confusion as to the exact size of the facility. The apparent distance is usually reduced and sometimes the setting appears "dwarfed" or smaller than it actually is.^(23,25) If present, the steam plume may add its pattern, color and texture to that of the sky, depending upon their mutual degree of contrast. Although detail is absent, the larger, unscreened ancillary structures may also be seen in relation to their setting.

FIGURE 18. Middleground, 1 Mile, Observer Inferior

As a foreground element (1/2 to 0 miles distant), the facility complex may appear so large that it completely dominates the viewscape, blocking from view any sense of the larger setting beyond (Figures 24 and 25). Detailed contrasts in surface color and texture are readily distinguishable, revealing the true size of the facility complex. The detail of unscreened smaller adjunct structures may be very apparent.

Litton's study of distance and observer position is of relevance to this analysis as it helps specify a possible selection of viewpoints. Given a viewshed with existing and future population distribution patterns, it is possible to develop criteria to standardize the distribution of viewpoints in the viewshed into an optimal pattern of distance and observer position which will best display all visual aspects of the facility.

FIGURE 19. Foreground/Middleground; 1/2 Mile,
Observer Inferior

Normally, there are two inverse phenomena occurring within the viewshed: 1) visibility of the facility decreases with distance, 2) while the

FIGURE 20. Middleground, 3 Miles, Observer Normal

FIGURE 21. Middleground, 2-1/2 Miles, Observer Normal

population available to view the facility increases with distance from the facility (see Figure 27). Since the facility is often set away from nearby

FIGURE 22. Middleground, 2-1/4 Miles, Observer Normal

FIGURE 23. Middleground, 1-3/4 Miles, Observer Normal

settlements or roads, the viewing population which sees the facility as a foreground viewscape element will be limited to facility workers and visitors to the site. Their primary concern is the facility itself, and their ability to view the facility in relation to the large landscape is restricted by the dominant presence of the facility complex. The viewing position within one-half mile of the facility is most often observer inferior.

The larger population which views the facility as a middleground element includes both residents and transients within the viewshed from one-half mile to 3 to 5 miles of the facility. In this zone visual comprehension of the facility's relationship to the larger landscape is more

FIGURE 24. Middleground, 1-1/4 Miles, Observer Normal/Superior

complete. The population's visual concerns are probably less oriented toward the facility than are those who visit the site or work there. Depending upon local topography, the viewing position in this zone may range from observer inferior through observer normal, and even to observer superior if there are significant landforms, overlooks or flight paths in this zone. Since visual comprehension of the middleground is very high in the observer normal position, if such locations exist within a relatively uniform population distribution pattern they should be considered as potential viewpoints, along with observer normal and observer superior positions. Since the middleground is the zone more closely balanced (see Figure 27), and since this zone is noted for potential visual comprehension of landscape alteration impacts, the majority of viewpoints should probably be within this zone, if in basic agreement with population distribution.

FIGURE 25. Foreground, 1/8 Mile, Observer Normal

From beyond 3 to 5 miles, the facility appears as a background element in the viewscape until it apparently becomes so small as to vanish from

FIGURE 26. Middleground, 2-1/4 Miles, Observer Superior

FIGURE 27. Viewshed Phenomena

view. A steam plume, however, may be visible from greater distances than the facility itself. Visual comprehension of the facility as a background element is greatest from an observer superior position if in agreement with topography or flight paths and population distribution; otherwise, observer normal or observer inferior viewpoints may be used.

One other variable exists which is pertinent to distance considerations in the viewshed: a facility using a 500-ft-high natural draft cooling tower(s) will be visible for considerably greater distances than a facility using another cooling alternative, and its viewshed will normally encompass a much larger area as well. Other factors being equal, it may only be necessary to evaluate eight representative viewsapes of the latter, while a natural draft cooling tower alternative might require 12 viewsapes to fully represent its visual qualities.

In summary, an idealized distribution of viewpoints based on distance and observer position for facilities with or without natural draft cooling towers might appear as shown in Tables 15 and 16.

It must be stressed that Tables 15 and 16 are idealized distribution of viewpoints for example or guideline purposes only. Each viewshed is entirely unique in shape and area, and actual topographic conditions may be restrictive to both observer position and viewing distance distribution. Most importantly, population distribution is the major criterion; Tables 15 and 16 are useful in selecting viewpoints given a large number of choices.

TABLE 15. Idealized Viewpoint Distribution: Natural Draft Cooling Tower Alternative (12 Final Viewscapes Required).

<u>Distance</u>	<u>Observer Inferior</u>	<u>Observer Normal</u>	<u>Observer Superior</u>
Foreground 0-1/2 Miles	1	.	.
Middleground 1/2-5 miles	1	6	1
Background >5 miles	.	2	1

TABLE 16. Idealized Viewpoint Distribution: Mechanical Draft Cooling Towers, Cooling Reservoirs or Once-Through Cooling Alternatives (8 Final Viewscapes Required).

<u>Distance</u>	<u>Observer Inferior</u>	<u>Observer Normal</u>	<u>Observer Superior</u>
Foreground 0-1/2 Miles		1	.
Middleground 1/2-3 miles		4	.
Background >3 miles	.	1	1

Direction of view and visual conditions: The directional distribution of viewpoints within the viewshed should reveal the facility in all of its basic visual relationships with the major elements of its setting. For example, a facility located in the foothills of a large mountain range would appear against a mountain backdrop as seen from one viewpoint, while from another viewpoint the facility might appear with a valley behind, or with no major landform backdrop at all (Figures 21 and 22). Similarly, a facility located at the edge of a large body of water should be viewed both from its landward side and from across some portion of the waterform to put it in representative relationship to these elements. The various elements of the setting, both natural (major landforms, waterforms or vegetative patterns) and man-made development (major structures nearby to distant skylines of cities) should ideally be in visual alignment with the facility, if such alignments agree with population distribution, distance and observer position as discussed above. One way to meet these criteria would be to require that at least one viewpoint be located in each quadrant as defined by major compass points; ideally the facility would appear as a middle-ground viewscape element (from 1/2 to 3-5 miles distant), even if population distribution in that quadrant is very low. However, this selection may also be made (more accurately) by locating prominent man-made or natural elements of the surrounding area on a map and drawing a straight axis line from them through the facility and extending in both directions to locate potential viewpoints (Figure 28). The element may lie between or behind the facility and the potential viewpoint in the viewshed.

① PEAK AS BACKDROP

② VALLEY AS BACKDROP

③ UPRIVER TOWARD POINT

④ CONFLUENCE NEAR ISLAND

FIGURE 28. Directions of View as Considered for Viewpoint Selection

Visual conditions include considerations of seasonal changes in vegetative cover and color, the presence or absence of snow, rain, haze, or clear skies, and the changing angles of sunlight, both seasonally and through each day (see "Seasonality" in Ref. 18 and Ref. 22). Once a potential viewpoint is determined, a day and time representative of maximum population visual contact with the facility should be chosen to photograph the viewscape. Photos should usually be taken between 9:00-11:00 a.m. and 1:00-4:00 p.m., to avoid long concealing shadows. A day representative of "typical" sky conditions for the area (clear or overcast) when the population visual contact will be greatest is best. Photos should be taken during two seasons, if practical and deemed necessary to fully reveal visual impact. If a viewscape is evaluated in two seasons, the visual impact for the two seasons should be averaged together.

5. Viewscape Photography-Before and After

After the potential viewpoints are selected within the viewshed using the considerations described in Subsection B-4 (including visual conditions to determine proper time, light and weather conditions), the viewscape from each potential viewpoint toward the facility may be photographed. Viewscapes from at least twenty viewpoints should be photographed, and the final eight or twelve viewscapes selected from these. The products of two alternative color photographic techniques may be considered: 1) Two 8 x 10 in. color photographs of each viewscape, one before the facility is installed, the second one touched up with the facility (and plume, if potentially present) added to represent the after condition.

This technique is fairly easy to control and touch up, but may be time-consuming and variable according to the artist's ability. Also it is relatively small in size for a display. 2) Two color slides of each view-scape, one before and the second after slide mounted together with an additional transparent image of the facility combined into one slide. The additional transparency of the facility would be one of a series of standard transparent facility images made available to the visual quality evaluator. These standard transparent images would illustrate the facility and plume from 1/2 mile distant intervals at various vertical observer positions. They would illustrate different directions relative to the direction of sunlight and represent hourly intervals from 9:00-11:00 a.m. and 1:00-4:00 p.m. The appropriate facility image would be mounted within the frame of a second before slide to depict the after visual image of a facility in that location. The slide alternative has the advantage of being quickly and directly prepared, and is capable of being projected as a large image which more closely resembles actual viewing conditions.

For viewscales in which the facility appears as a foreground element, or in viewscales in which major alterations to the surrounding landscape are visible, it may be necessary to use slides taken of 8 x 10 in. touched-up color photographs to accurately depict the facility's visual impact.

Regardless of the type of photographic technique and evaluator presentation format used, it is critically important that 1) the photographer

approximately center the potential facility horizontally in the viewscape, and 2) that the image of the facility is accurately located in the after viewscape photograph or transparency. Both of these criteria may be met by careful alignment of the viewpoint with the facility location and with key landscape features immediately in front of or behind the facility which may act as photographic reference points. The colored viewshed topographic map is ideally suited for this purpose. After a viewpoint has been selected, a line drawn from the viewpoint through the facility location will locate landscape reference points in a plane which may be used during viewscape photography; this will allow the first consideration (centering the facility in the viewscape) to be easily met (see viewpoint selection sketches, Figure 28).

The second consideration, accurately locating the facility in the after viewscape, then becomes easier, since the horizontal placement of the facility image may be traced back to the photographic reference points discussed above. The vertical placement of the facility image in the viewscape is a function of observer position relative to the facility and the location of the viewpoint horizon. An observable visual phenomenon (frequently used when constructing perspective drawings) is that all horizontal lines of objects in any view "vanish" to points located on one single horizontal line called the "horizon," which represents the line at which a theoretically level ground plane meets the sky. In any viewscape the horizon always lies at the horizontal level of an observer's eye, or at the viewing point elevation of a camera.

The key to locating the facility in any viewscape, therefore, is to locate the horizon in the viewscape, and determine the elevation of the viewpoint in relation to the elevation of the facility. Locate the observer distance from the facility (and hence, its physical size relative to the size of the photographic frame) and the point on (or above or below) the facility which is the same elevation as the observer viewpoint. This point on the facility, if placed on the horizon line of the viewscape, will accurately place the facility vertically within the viewscape.

The section and four viewscales (Figure 29) seen or photographed from viewpoints at varying elevations illustrate this principle. In Viewscale A, photographed from a viewpoint 150 ft above the top elevation of the cooling tower, the top of the cooling tower is located 150 ft below the horizon as measured in proportion to the tower's height of 500 ft. (The actual size of the tower in relationship to the photographic picture frame is determined by the observer distance in miles, as discussed above.) In Viewscale B, taken at 500 ft elevation, the horizon is placed at that same elevation on the facility. Viewscales C and D illustrate the facility similarly located, with the horizon passing through or below reference point elevations on the facility itself. All that is needed for this placement of the facility is the elevation and height of the facility (read directly off the viewshed topographic map), and the viewpoint elevation, through which the horizon line passes. If the horizon is not readily apparent in the viewscale photograph (i.e., blocked by landforms or vegetation), it may be closely approximated by finding a reference

FIGURE 29. Vertical Placement of the Facility Into the Viewscape

point on an object or landform in the viewscape which is the same elevation as the viewpoint itself. A horizontal line through this point is the horizon of the viewscape.

C. EVALUATION OF VISUAL QUALITY

Evaluation of visual quality of each before and after viewscape should be made by at least five evaluators, who will be asked to view colored slides and record their visual evaluations on a questionnaire (see Appendix D for questionnaire). The viewscape slides should be viewed in a darkened room, with the narrow dimension of the slide frame projected (ideally) to at least 30 in. wide. Portions of this section of the report would be given to each evaluator prior to the visual evaluation to help define and illustrate the concepts of intactness, vividness, unity and importance, which will be rated and recorded on the questionnaire for each viewscape.

Subsection C-1 explains the three levels of visual quality measurement, which together comprise the questionnaire. Subsections C-2 to C-5 define and illustrate the visual attributes of intactness, vividness, unity, and importance, which are required to complete measurement Levels 2 and 3 of the visual quality evaluation questionnaire.

1. Three Levels of Visual Quality Measurement

As discussed briefly in Section IV-A, the questionnaire actually consists of three levels of visual measurement for each viewscape:

Level 1 - Pre-evaluation Measurement

Level 2 - Overall Visual Attribute Measurement

Level 3 - Elemental Visual Attribute Measurement.

These three measurement levels were derived during the course of this study as three slightly different approaches to the evaluation of a viewscape's visual quality. Although these three approaches are not mutually exclusive, all three were used successfully by a special-competence group in the evaluation of three viewscales (Section IV-E). Of the three measurement levels, agreement in scores was closest between Level 1 and Level 3. The visual impact scores derived from Level 3 are consistently between Levels 1 and 2, and Level 1 depends more upon the evaluator's familiarity with a wide range of landscapes than Levels 2 and 3 (and is therefore more susceptible to bias). Therefore, it appears that Level 3 could be used alone in the assessment of visual impact. The Visual Quality Evaluation Questionnaire (Appendix D) could thus be shortened to include only those questions pertinent to Level 3. However, further testing and comparison between the approaches is necessary.

Level 1 - Pre-evaluation Measurement: This approach allows the evaluator to directly record his immediate visual response to the viewscape, rating its visual quality from 1 (very high visual quality) to 100 (very low visual quality) through Item A of the questionnaire (see Appendix D). The evaluator is reminded to be objective and impartial in his judgment. Consideration is given to the degree the viewscape is

scenic, distinctive, memorable, stimulating, and overall visually harmonious. A scale of comparison is implied, suggesting that viewscales of the Grand Canyon, Yosemite Falls, or the Grand Tetons might be scored close to 1, while viewscales of unrestored strip mines, active landfill operations, or highly polluted wastelands might be given scores nearer 100. Level 1 requires that the evaluator be familiar with a wide range of landscapes, and is considerably less specific in its requirements than Levels 2 and 3. Since it does not force the evaluator to objectively analyze the visual attributes of the elements which comprise the viewscape, Level 1 is more susceptible to bias than Levels 2 or 3.

Level 2 - Overall Visual Attribute Measurement: In this approach, the evaluator's responses to the intactness, vividness, and unity of the overall viewscape (Items B.1, C.1, D.1, and D.2 of the questionnaire, Appendix D), are combined into a total visual quality rating for the viewscape. The evaluator is given definitions and illustrations of the concepts of intactness, vividness, and unity in Subsection C-2 to C-4, which would accompany the questionnaire. The before and after viewscape ratings thus recorded may be combined by use of the formula:

$$VQ = 1/3 (I + V + U)$$

Where: VQ = Visual quality of the viewscape

I = Intactness from Question B.1

V = Vividness from Question C.1

U = Unity, as average from questions D.1 and D.2, i.e.,

$$U = \frac{D.1 + D.2}{2}$$

Of the three measurement levels, special-competence group scores derived from Level 2 do not appear to agree closely with scores from Levels 1 and 3. Therefore, this measurement level may prove to be the least representative of visual impact. For an example of numerical application of the overall visual attribute technique, see Section IV-E.

Level 3 - Elemental Visual Attribute Measurement: This approach combines the evaluator's responses to the intactness, vividness, and importance of each major element of the viewscape (Items B.2, C.2, and E of the questionnaire, Appendix D) with that of unity (Items D.1 and D.2) into a total visual quality rating for the viewscape. Level 3 may be seen to vary from Level 2 in its application of two visual attributes (intactness and vividness) to each major viewscape element instead of to the overall viewscape. This is accomplished by graphically subdividing the viewscape into its major elements of sky, landform and waterform (see Figures 41-43, Section IV-E) and rating them individually rather than collectively. Also, the visual importance score for each major viewscape element (Item E,

Questionnaire, Appendix D) is required to put the elements into proper context with each other. These scores are then numerically combined by use of the formula:

$$VQ = 1/3 (\bar{I} + \bar{V} + U)$$

Where: VQ = Visual quality of the viewscape

$\bar{I}$ = Summation of the intactness scores for each major element (from Question B.2) individually multiplied by the importance scores for each major element (from Question E), divided by the summation of the importance scores of each major element, i.e.,

$$\bar{I} = \frac{I_A (IMP_A) + I_B (IMP_B) + I_C (IMP_C) + \dots + I_Z (IMP_Z)}{IMP_A + IMP_B + IMP_C + \dots + IMP_Z}$$

Where the subscripts A, B, C, etc., represent each major viewscape element identified in Question B.2.

Similarly: $\bar{V}$ = summation of the vividness scores for each major element (from Question C.2) individually multiplied by the importance scores for each major element (from Question E), divided by the summation of the importance scores of each major element, i.e.,

$$\bar{V} = \frac{V_A(IMP_A) + V_B(IMP_B) + V_C(IMP_C) + \dots + V_Z(IMP_Z)}{IMP_A + IMP_B + IMP_C + \dots + IMP_Z}$$

Where the subscripts A, B, C, etc., represent each major viewscape element identified in Question C.2; and

U = Unity as averaged from Question D.1 and D.2, i.e.,

$$U = \frac{D.1 + D.2}{2} .$$

Level 3 appears to be the most reliable of the three measurement levels presented, judging from special-competence group analyses of three viewscales (Section IV-E). Although further testing is required for statistical verification, an unbiased evaluation of visual quality may prove to be most accurately undertaken through Level 3, the elemental visual attribute measurement.

2. Intactness Evaluation

The intactness of a viewscape is a measure of its apparent degree of natural condition as judged by its level of urbanization and the degree to which encroachment is present. Comprehension of each of these two factors is essential to a proper understanding of intactness.

Level of Urbanization: This is a measure of the apparency or presence of man-made development in the viewscape. If this were to be evaluated by scores, seven levels might be identified:

- 1 Very highly natural, no apparent man-made development
 - 2 Highly natural, little apparent man-made development
 - 3 Moderately highly natural, some apparent man-made development
 - 4 Moderately natural, moderate degree of development
 - 5 Moderately low degree of naturalness, moderately high degree of man-made development
 - 6 Low degree of naturalness, high degree of man-made development
 - 7 Naturalness nearly absent, very high degree of man-made development
- (See Figure 30).

The two extremes are immediately recognizable: (1) views of apparently undisturbed landscapes devoid of roads, structures or any sign of human settlement or activity, as opposed to (7) views of highly urban centers and dense industrial complexes. A score of (2) might be given to views of occasional clearings or low-density farmscapes carved out of highly natural surroundings; (3) might include moderate-density farmscapes with scattered woodlots, or very sparsely scattered homesites; (4) might include more intensely cultivated lands with obvious signs of mechanization and development; (5) might be given views of moderate-density housing or low-density industrial development; and (6) could indicate a viewscape of high-density housing or moderate-density industrial development.

Degree of Encroachment: This is a measure of the presence or absence of undesirable, visually disturbing elements in the viewscape. Encroachment

- (1) Very highly natural, no apparent man-made development.

- (3) Moderately highly natural, some apparent man-made development.

- (5) Moderately low degree of naturalness, moderately high degree of man-made development.

FIGURE 30. Level of Urbanization

includes such visual disturbances as: garbage heaps, junk yards, trash and/or litter, confusing and inharmonious signs and billboards, mazes of overhead wires, the sources or visual results of air or water pollution, as well as the apparent level of man's physical alteration or visual obscurity of sky, land, or waterforms, as by strip mining, clear cutting, road cuts/fills, wetland or shoreline filling or alterations, diking, rip-rapping or culverting of streams or rivers, or visual intrusions and unhealed scars in the viewscape. Also included are any obvious effects of natural catastrophies such as the visual disturbances caused by fire, flood, or earthquake. Although the degree of encroachment by each element (or by combinations of them) will vary widely, seven levels of encroachment might be distinguished in order of increasing severity within the viewscape (see Figure 31):

- 1 Pristine viewscape, visual disturbances absent
- 2 Very little visual disturbance/physical alteration
- 3 Moderately little visual disturbance/physical alteration
- 4 Moderate degree of visual disturbance/physical alteration
- 5 Moderately high visual disturbance/physical alteration
- 6 High degree of visual disturbance/physical alteration
- 7 Very high degree of visual disturbance/physical alteration.

Overall Intactness: This will be the only one of these considerations scored on the questionnaire. This is a combination of level of urbanization and degree of encroachment. It should be apparent that one viewscape may display a very high degree of man-made development with very little

- (1) Pristine Viewscape,
Visual Disturbance
Absent

- (3) Moderately Little Visual
Disturbance/Physical
Alteration

- (6) High Degree of Visual
Disturbance/Physical
Alteration

FIGURE 31. Degree of Encroachment

visual disturbance (as in a well-designed, carefully maintained urban setting), while another may display a very high degree of visual disturbance and alteration with little apparent man-made development (as in a forested area recently devastated by fire). Hence, it is important to gauge the intensity of development along with the severity of visual disturbance and alteration when measuring the overall intactness of a viewscape.

In general, overall intactness is likely to be scored somewhere between the scores for level of urbanization and degree of encroachment. Seven levels of overall intactness are to be distinguished when scoring this category:

- 1 Very highly intact
- 2 Highly intact/little alteration
- 3 Moderately highly intact/moderately little alteration
- 4 Moderately intact/moderately altered
- 5 Moderately low intactness/moderately highly altered
- 6 Low intactness/highly altered
- 7 Very low intactness/very highly altered.

3. Vividness Evaluation

Vividness is the memorability of the visual impression received from the viewscape or its elements. Vividness relates to the level of distinction or prominence resulting from contrast or mutual accentuation of diverse viewscape elements. To aid the evaluator in scoring the overall vividness of the before and after viewscape or its elements, eight complementary effects might be isolated and discussed: 1) definition of viewscape boundary, 2) diversity of spatial enclosure, 3) degree of topographic relief, 4) diversity of vegetative pattern, 5) prominence of natural features, 6) prominence of waterforms, 7) vividness of sky, and 8) vividness of man-made elements. (See Litton⁽²²⁾ for further discussion of Items 1 - 6.) While the importance of each of these considerations will vary greatly between viewsapes, it is worthwhile to discuss and illustrate each one to better convey the concept of vividness.

1) Definition of viewscape boundary: The viewscape boundary is the furthest visible limit of landform, waterform or vegetation which acts as the skyline boundary for the viewscape. The strength or weakness of definition of the viewscape skyline elements may enhance or detract from the vividness of the viewscape. In general, viewsapes with strongly defined visual walls, with distinct or irregular skyline profiles which are clearly legible and memorable, may often be more vivid than viewsapes whose skyline boundary is poorly defined, indistinct and hazy. Jagged ridgelines and mountain peaks often form highly distinct and legible middleground and background boundaries of

the viewscape, while skyline edges of forest or lower vegetation may clearly and distinctly define the viewscape boundary in the foreground and middleground. Smooth, regular skyline profiles are often less distinct. Skyline boundary definition is very low where there is no legible distinction of skyline at all. Man-made elements may reduce the definition of a viewscape boundary by removing a portion of the boundary element, or by blocking a portion of the element from view. Evaluation of the definition of viewscape boundary for a viewscape includes consideration of one of seven levels: (see Figure 32).

- 1 Boundary very highly distinct/legible
- 2 Boundary highly distinct/legible
- 3 Boundary moderately highly distinct/legible
- 4 Boundary moderately distinct/legible
- 5 Boundary moderately highly indistinct/illegible
- 6 Boundary highly indistinct/illegible
- 7 Boundary very highly indistinct/illegible.

2) Diversity of spatial enclosure: The skyline boundary may be only one of many elements in the viewscape which encloses space. There may be other viewscape spaces whose overlapping walls are partly visible, e.g., observer normal or observer superior views of consecutive ridges and valleys, or views with glimpses of several clearings within a wooded valley. A high diversity of spatial enclosure normally enhances the visual quality of a viewscape. This type of

Boundary 1

Spatial 2

Boundary 3

Spatial 3

Boundary 5

Spatial 6

FIGURE 32. Definition of Viewscape Boundary and
Diversity of Spatial Enclosure

viewscape takes on another dimension, holding the observer's visual interest for longer periods of time than viewsapes in which every element and every space is immediately and readily seen and understood. Spatial enclosure is often more diverse as the number and configuration of vertical elements increases, as the overlapping vertical or sloping planes weave space between elements of the viewsapes. [For a discussion of planal zones see Jones.^(18,26)] Overlapping planes may be formed by vegetation, landform and/or by man-made elements. However, man may also simplify or remove spatial definitions of landform and vegetation in order to convert the land to his own purposes. Evaluation of the diversity of spatial enclosure in a viewscape could include the following scale: (see Figure 32).

- 1 Very highly diverse spatial enclosure
- 2 Highly diverse spatial enclosure
- 3 Moderately highly diverse spatial enclosure
- 4 Moderately diverse spatial enclosure
- 5 Moderately low diversity of spatial enclosure
- 6 Low diversity of spatial enclosure
- 7 Very low diversity of spatial enclosure.

3) Degree of topographic relief: The visual perception of topographic relief will often enhance the quality of a viewscape, adding to its vividness. The visual stimulation received from viewsapes of mountains, hillsides, or canyons is often higher than that received from viewsapes of nearly flat terrain; however, contrasts between flat and high, steep or

deeply incised terrain may also add to the visual perception of topographic relief. As mentioned in Subsection B-4, man-made elements seen in the middleground (or foreground) may effect the observer's perception of the true size of landscape elements. They can block the observer's view and/or make landforms or differences in topographic relief seem smaller than they really are. Evaluation of topographic relief could be measured on a scale of one to seven as follows (see Figure 33):

- 1 Very high degree of topographic relief
- 2 High degree of topographic relief
- 3 Moderately high degree of topographic relief
- 4 Moderate degree of topographic relief
- 5 Moderately low degree of topographic relief
- 6 Low degree of topographic relief
- 7 Very low degree of topographic relief.

4) Diversity of vegetative pattern: Pattern is formed at the edge between two major types of vegetation (see Ref. 22) as between forest/shrubland/grassland/barren surfaces. Pattern may also exist within a major vegetation type and may be expressed as variations of form, color and texture of vegetation. Vegetative pattern may result from degrees of contrast and distinction or irregularity of vegetative edge and profile. Man's alterations nearly always influence vegetative pattern, sometimes increasing its diversity (e.g., increasing the length and configurations of vegetative edges, when creating alternate clearings, woodlots and hedgerows) and

(1) Very high degree of topographic relief

(4) Moderate degree of topographic relief

(7) Very low degree of topographic relief

FIGURE 33. Degree of Topographic Relief

sometimes decreasing vegetative diversity (e.g., removing or simplifying the existing patterns, when totally clearing forests and planting one single crop throughout, or by paving once-vegetated land). The following scale might apply to diversity or vegetative pattern:

- 1 Very highly diverse vegetative pattern
- 2 Highly diverse vegetative pattern
- 3 Moderately highly diverse vegetative pattern
- 4 Moderately diverse vegetative pattern
- 5 Moderately low diversity of vegetative pattern
- 6 Low diversity of vegetative pattern
- 7 Very low diversity of vegetative pattern.

5) Prominence of natural features: Prominent natural features and natural landmarks nearly always increase the vividness of a viewscape. Prominent natural features may include those of landform (distinctive mountain peaks, volcanic cones, gorges and canyons, or striking rock outcrops), vegetation (distinctive groupings of rare or specimen trees, a single majestic oak or a lonely, tenacious, windswept tree atop a rocky bluff), or water (waterfalls, geysers, glaciers, rapids or springs), or combinations of these. These striking and memorable natural features may owe their prominence to their uniqueness, isolation, distinctive profile, size/scale domination, or contrast with the surrounding viewscape elements. Man-made elements may visually compete with these natural features for attention, or may visually attract attention by complementing them. The

vividness of natural features may be visually obscured or physically altered by man's actions, or their vividness may be enhanced through careful design restraint. The prominence of natural features of a viewscape might be evaluated on this scale (see Figure 34):

- 1 Very highly prominent natural features present
- 2 Highly prominent natural features present
- 3 Moderately highly prominent natural features present
- 4 Moderately prominent natural features present
- 5 Moderately low prominence of natural features
- 6 Low prominence of natural features
- 7 Very low prominence of natural features.

6) Prominence of waterforms: Water prominently displayed nearly always enhances the vividness and visual quality of a viewscape (see Ref. 18, 22). Prominence as used here refers not only to the actual amount of water that is visible, but also to the degree which water enhances the viewscape by its color, value and texture; by the steepness, height, clarity and definition of the shoreline edge; and by the complexity of the waterform pattern as woven into the overall viewscape elements. Man's alterations to the viewscape may enhance or degrade the vividness of waterforms, depending upon the degree and design sensitivity of the alteration. Prominence of waterforms in the viewscape might be evaluated in this manner (see Figure 35):

(1) Very highly prominent natural features present

(2) Highly prominent natural features present

(4) Moderately prominent natural features present

FIGURE 34. Prominence of Natural Features

(1) Waterforms very highly prominent

(3) Waterforms moderately highly prominent

(5) Waterforms of moderately low prominence

FIGURE 35. Prominence of Waterforms

- 1 Waterforms very highly prominent
- 2 Waterforms highly prominent
- 3 Waterforms moderately highly prominent
- 4 Waterforms of moderate prominence
- 5 Waterforms of moderately low prominence
- 6 Waterforms of low prominence
- 7 Waterforms of very low prominence/absent.

7) Vividness of sky: Since the sky is the most highly ephemeral natural element of the viewscape, its visual quality is difficult to evaluate. Yet, in most viewsapes, the sky is among the largest visual elements present. Although constantly changing, various moods or types of skies are frequently associated with particular regions or areas of the country; e.g., cloudy, drizzling skies of the Pacific Northwest; clear, crisp skies of Eastern Washington and Oregon; silent fogs of San Francisco; or hazy orange smogs of Los Angeles. Assuming that each viewscape sky represents a relatively consistent condition, evaluation of vividness should take into consideration its clarity, depth, contrasts of color and cloud pattern textures, and its prominence or memorability in the viewscape. Man's effects on the vividness of the sky may include visual competition, visual blockage or the results of air pollution. The vividness of the sky might be evaluated on the following scale (see Figure 36):

- 1 Sky very highly vivid
- 2 Sky highly vivid

(1) Sky very highly vivid

(3) Sky moderately highly vivid

(7) Sky of very low vividness

FIGURE 36. Vividness of Sky

- 3 Sky moderately highly vivid
- 4 Sky moderately vivid
- 5 Sky of moderately low vividness
- 6 Sky of low vividness
- 7 Sky of very low vividness.

8) Vividness of man-made elements: Buildings, bridges, dams, water towers, power lines, roads, and parking areas may or may not be highly vivid in the viewscape, depending more upon their contrast, diversity, prominence and level of visual distinction within the overall viewscape than by their size or number (as measured by intactness). The visual memorability of man-made elements in a viewscape could be evaluated using the following scale:

- 1 Man-made elements very highly vivid
- 2 Man-made elements highly vivid
- 3 Man-made elements moderately highly vivid
- 4 Man-made elements moderately vivid
- 5 Man-made elements of moderately low vividness
- 6 Man-made elements of low vividness
- 7 Man-made elements of very low vividness/absent.

Vividness of the overall viewscape, or of its elements, may be evaluated from considerations of all or some of the above considerations (see Figure 37). They should be frequently referred to by the viewscape

evaluator. In summary, vividness is a measure of: memorability, level of distinction, prominence, diversity, contrast, and mutual accentuation of elements in the viewscape. Vividness in the viewscape should be rated on the following scale, before and after the facility is introduced:

- 1 Very highly vivid
- 2 Highly vivid
- 3 Moderately highly vivid
- 4 Moderately vivid
- 5 Moderately low vividness
- 6 Low vividness
- 7 Very low vividness.

FIGURE 37. Overall Vividness

4. Unity Evaluation

Unity is a measure of the degree to which individual elements in the viewscape join together to form a single, coherent, harmonious visual unit (see Ref. 22 for further discussion.) Unity refers to the compositional harmony or intercompatibility of the individual elements which comprise the viewscape. Unity does not require similarity or blandness of inter-related elements; rather, it may depend on an organized balance between visually dominant and subordinate viewscape elements. Vividness depends upon visual contrasts and distinction between diverse viewscape elements, while unity quantifies their visual coherence and compositional integrity. A viewscape of high visual quality is often likely to possess richness and diversity, making it highly vivid, while at the same time possessing a high degree of visual unity (see Figure 38).

The overall unity of a viewscape may be distinguished at seven levels:

- 1 Very high overall unity between viewscape elements
- 2 High overall unity between viewscape elements
- 3 Moderately high overall unity between viewscape elements
- 4 Moderate overall unity between viewscape elements
- 5 Moderately low overall unity between viewscape elements
- 6 Low overall unity between viewscape elements
- 7 Very low overall unity between viewscape elements.

FIGURE 38. Very High Overall Unity Between Viewscape Elements.
(See Ref. 22 for further discussion.)

Overall unity and the unity between man-made and natural elements are not necessarily the same as the level of urbanization or degree of encroachment, which together comprise viewscape intactness. Intactness is the relative degree of natural condition of the viewscape, while unity is indifferent to the degree of natural condition and is only concerned with visual integration of the viewscape composition. The degree of unity between man-made and natural elements in the viewscape may be distinguished at seven levels (see Figure 39):

- 1 Man-made elements very highly unified with natural/absent
- 2 Man-made elements highly unified with natural
- 3 Man-made elements moderately highly unified with natural
- 4 Man-made elements moderately unified with natural
- 5 Man-made elements of moderately low unity with natural
- 6 Man-made elements of low unity with natural
- 7 Man-made elements of very low unity with natural.

- (1) Man-made elements very highly unified with natural

- (3) Man-made elements moderately highly unified with natural

- (6) Man-made elements of low unity with natural

FIGURE 39. Unity Between Man-made and Natural Elements

5. Elemental Visual Importance Evaluation

The visual importance of an element in the viewscape is an evaluative rating of its level of visual contribution to the overall viewscape. Visual importance may be related to size, number, singularity, contrast or position. The element of highest visual importance in a viewscape is the one which, if removed from the viewscape (or severely altered), would change the viewscape to the greatest degree. Using this simple guideline, each "after" viewscape element may be assigned a score for visual importance from the following scale:

- 1 Element very high in visual importance to viewscape
- 2 Element high in visual importance to viewscape
- 3 Element moderately high in visual importance to viewscape
- 4 Element of moderate visual importance to viewscape
- 5 Element of moderately low visual importance to viewscape
- 6 Element of low visual importance to viewscape
- 7 Element of very low visual importance to viewscape.

D. DETERMINATION OF VISUAL IMPACT

In Section IV-B parameters were given to determine population visual contact and to select representative viewpoints of the proposed facility location by analysis of the facility's viewshed. In Section IV-C questionnaire scoring criteria were given to evaluate the visual quality of the viewscape from each representative viewpoint before and after the facility is introduced. This section describes the final determination of visual impact using the results of the questionnaire.

1. Visual Quality - Summation of Measurement Levels

Scores for visual quality obtained from the three measurement levels described in Subsection C-1 (Pre-evaluation, Overall Visual Attribute and Elemental Visual Attribute Measurements) for before and after viewsapes of each site-facility combination should be compared. Where close agreement exists, the three scores might be averaged for visual quality before and after (see Table 18, Section IV-E). Since the scores from the three levels may not be in basic agreement, it may be necessary to depend solely on scores derived from Level 3, because these appear to be the most reliable and indicative of visual quality (see discussion in Subsection C-1). For purposes of comparison and scaling, visual quality scores obtained from measurement Levels 2 and 3 must be converted from a 1 to 7 scale to a scale from 1 to 100.

2. Ratio of Change in Visual Quality

The change in visual quality (Delta VQ) of a viewscape before (VQ_b) and after (VQ_a) the facility is introduced is the difference between these two scores:

$$\text{Delta VQ} = VQ_a - VQ_b.$$

In order to record the severity of change relative to original visual quality, it is not adequate to merely express the difference in visual quality before and after the facility is introduced. For example, a facility to be constructed on a pristine lake shore might change a view-scape's visual quality score from 10 to 26; the same facility, built on a

semi-developed lakeshore, might change the visual quality score from 22 to 36; while if constructed at a more intensively developed lake site, the change in a viewscape's visual quality score might be from 44 to 56. Although the numerical change in visual quality would be 16, 14, and 12 points, respectively, no acknowledgement of the relative degree of original visual quality of each site is expressed by these scores. However, through the use of a ratio, an expression of the relative degree of original visual quality can be retained. This ratio, called the Ratio of Change in Visual Quality (R), is represented as:

$$R = \frac{VQa - VQb}{VQb} = \frac{\text{DELTA } VQ}{VQb} .$$

The value of R will vary according to the relative severity of change in visual quality. If there is no change in visual quality, R will equal zero. In the three lake site examples given above, the ratio of change would be expressed as:

$$R = \frac{26 - 10}{10} = 1.60$$

Pristine lakeshore site, 16-point loss of visual quality.

$$R = \frac{36 - 22}{22} = 0.64$$

Semi-developed lakeshore site, 14-point loss of visual quality.

$$R = \frac{56 - 44}{44} = 0.27$$

Intensively-developed lakeshore site, 12-point loss of visual quality.

Therefore, R expresses the severity of change relative to original visual quality, and is a more useful and revealing expression than the mere numerical difference between before and after scores (Delta VQ).

3. Total Visual Impact Determination

Visual impact is partially a function of the number of people who are present (or may be present in the future) to view the landscape alteration from the surrounding viewshed, and partially a measure of the loss or destruction of scarce visual resources present at the site itself. In order to compare visual impacts of two or more site-facility alternatives, it is necessary to compare the ratios of change in visual quality (designated as R) from representative viewpoints of each alternative, multiplied by some factor which accounts for the different viewing populations at each viewpoint (designated as P). By summing the products of $P \times R$ and averaging them between the eight or twelve viewscales evaluated, the visual impacts of each site-facility alternative may be compared.

Table 17 illustrates a tabulated comparison between two theoretical site-facility alternatives. Visual quality scores for before and after would be those derived by averaging scores from the three measurement levels (or solely derived from Level 3 as discussed in Subsection C-1), after all were placed on a scale from 1 to 100. The ratio of change in visual quality is derived by subtracting VQ_b from VQ_a and dividing the difference by VQ_b . Instead of multiplying the ratio of change in visual quality by the total population visual contacts per year, the seventh root of visual contacts per year is used (arbitrarily) to reduce the size of the product of $R \times P$; this nonetheless maintains the proportional integrity of the visual impact scores.

TABLE 17. Comparison of Visual Impacts Between Two Theoretical Alternatives

Viewscape name	Viewpoint distance, miles	VQ _b (Visual quality before)	VQ _a (Visual quality after)	R (Ratio of change in visual quality)	P (Population visual contacts per year)	$\sqrt[3]{P}$ (Population contact factor)	$R \times \sqrt[3]{P}$ (Visual Impact)
A	0.5	20	45	1.25	2,000,000	8	10.0
B	1	25	50	1.00	4,000,000	8.7	8.7
C	1.5	30	50	0.67	3,000,000	8.4	5.6
D	2	20	50	1.50	8,000,000	9.7	14.6
E	2	45	60	0.33	500,000	6.6	2.2
F	3	60	70	0.16	10,000,000	10	1.6
G	4	40	60	0.50	2,000,000	8	4.0
H	5.5	35	50	0.43	4,000,000	8.7	3.7
Average Visual Impact, Alternative 1							6.3
A'	0.5	30	60	1.00	500,000	6.6	6.6
B'	1	25	40	0.60	5,000,000	9.1	5.5
C'	2	45	55	0.22	8,000,000	9.7	2.1
D'	2.5	40	60	0.50	400,000	6.3	3.2
E'	3	20	45	1.25	10,000,000	10	12.5
F'	3.5	15	35	1.33	8,000,000	9.7	12.9
G'	4	20	35	0.75	7,000,000	9.5	7.1
H'	5	35	55	0.57	10,000,000	10	5.7
Average Visual Impact, Alternative 2							7.0

In comparing the visual impacts scores by viewscape between the two site-facility alternatives, two considerations should be mentioned which may only be resolved by extensive testing of the evaluation procedure as it is applied to a wide variety of alternatives. First, some normalizing of average visual impact scores may be required to account for the varying viewpoint distances from the facility within the idealized viewpoint distribution (Tables 15 and 16, Section IV-B). This would prevent unfair comparisons between two alternatives, one for which viewpoints were very close to the facility and the other for which viewpoints were more distant. Second, the acceptable level of visual impact might be experimentally determined. This would set a numerical threshold beyond which an alternative would be designated with a "red flag" in a manner similar to that used for scarce visual resources threatened by the facility, as discussed in Subsection B-1. Although it is tempting to address each of these considerations in greater detail, extensive testing is required. For the present, this evaluation procedure is most effectively applied to determine the relative severity of visual impacts from a number of site-facility alternatives.

E. SPECIAL-COMPETENCE GROUP ANALYSES OF THREE VIEWSCAPES

The visual quality questionnaire (Appendix D) and equations for visual impact assessment evolved through many trial stages. The results and findings presented here are derived from visual quality analyses of three viewsapes by five members (See Appendix E) of the design professions, whose backgrounds include the practice of architecture, urban design, and

landscape architecture. Two nuclear facilities (then under construction) were photographed and used as example case studies: the Trojan Nuclear Facility, sited on the Columbia River 8 miles southeast of Longview, Washington, and the Rancho Seco Nuclear Facility, sited on the Sacramento Valley, 25 miles southeast of Sacramento, California.

The viewshed and location of the two viewpoints analyzed for the Trojan site are presented as Figure 40. Drawings of the three viewscales before and after (with a sketch outlining and identifying the major view-scale elements as required for measurement Level 3 of the visual analysis) are presented in Figures 41-43. Viewscales A (Figure 41) and C (Figure 43) are of the Trojan facility, at 3/4 and 2 1/4 miles, respectively. Viewscape B is of the Rancho Seco site as seen from one mile (Figure 42). In all viewscales the plume was graphically approximated on the sketch and imagined to be part of the viewscale by the evaluators, since neither of the two facilities were operational at the time of photography.

Visual quality of each viewscale was evaluated using the criteria outlined in Section IV; the questionnaire used by the special-competence group was substantially longer. The shortened viewscale questionnaire presented in Appendix D requires only that information pertinent to the final evaluation procedure. Visual quality scores determined by each measurement level for the three viewscales analyzed are presented on Table 18. The visual quality scores are comparable by comparing viewshed scores among the three techniques. However, agreement appears to be

FIGURE 40. Trojan Facility Viewshed and Viewpoints A and C

Before

After

Major viewscape
elements

FIGURE 41. Trojan,
3/4 Mile, Viewscape A

Before

After

Major viewscape
elements

FIGURE 42. Rancho Seco,
1 Mile, Viewscape B

Before

After

Major viewscape
elements

FIGURE 43. Trojan, 2-1/4
Miles, Viewscape C

TABLE 18 Analyses of Three Viewscapes by Special-Competence Group

<u>VIEWSCAPE A (Figure 41)</u>		<u>Visual Quality</u>		<u>Ratio of</u>
		<u>Before</u>	<u>After</u>	<u>Visual Change</u>
1	Pre-Evaluation Measurement	32	63	0.96
2	Overall Visual Attribute	38	62	0.63
3	Elemental Visual Attribute	34	65	0.91
	Average of Measurement Levels	35	63	0.80

<u>VIEWSCAPE B (Figure 42)</u>		<u>Visual Quality</u>		<u>Ratio of</u>
		<u>Before</u>	<u>After</u>	<u>Visual Change</u>
1	Pre-Evaluation Measurement	39	60	0.53
2	Overall Visual Attribute	46	55	0.20
3	Elemental Visual Attribute	35	51	0.45
	Average of Measurement Levels	40	55	0.37

<u>VIEWSCAPE C (Figure 43)</u>		<u>Visual Quality</u>		<u>Ratio of</u>
		<u>Before</u>	<u>After</u>	<u>Visual Change</u>
1	Pre-Evaluation Measurement	25	48	0.92
2	Overall Visual Attribute	35	47	0.34
3	Elemental Visual Attribute	29	47	0.62
	Average of Measurement Levels	30	47	0.56

closest between Levels 1 and 3, as derived from special-competence group analysis. Much more extensive testing is needed to derive statistically sound results from the evaluation techniques presented here. When sufficiently large test cases have been evaluated, it is hoped that any hidden weighting factors will be discovered and quantified. Then, if possible, the three evaluation measurement levels may be singled down to one (most likely, Level 3, as discussed in Subsection C-1).

V. LAND USE QUANTIFICATION

The eight categories (economics, water impact, land use, air impact, ecologic impact, aesthetics, health-safety, and culture) selected for technical evaluation were felt to possess certain mutually exclusive features that could be identified and reduced, through a systematic evaluation process, to a normalized score. The normalized score for each category would express the impact as assessed by technical experts. In the investigation of land use quantification it was finally concluded that there is no possibility of generically analyzing this problem.

Under the classic approach to land use planning, i.e., discrete zones for heavy industry, light industry, etc., it seemed apparent that land use could be numerically rated on the basis of suitability and compatibility. In the modern context of land use planning, however, most land uses are compatible with each other. The following discussion describes the investigative process by which it was concluded that the other seven site selection criteria, when completely developed, define the elements of land use. When the political and social aspects of this problem are measured in the quantification of social values (see Section III), then land use is in essence quantified.

Management of land as a basic resource to meet the physical, environmental, and economic needs of society is a relatively new concept. The evaluation of the land use management concept was stimulated through

the public's changing perception of the importance of land use to environmental quality. Symptomatic of this changing perception of land use is the increasing demand that more thorough evaluation be done before large projects are approved. The public has ways (i.e., the National Environmental Policy Act and other Federal and State legislation) for their concerns about land use to be heard. Utilities are aware of these concerns and are looking for guidance in matters of land use in the areas of 1) central station power plants site selection, 2) facility engineering, and 3) management of the utility owned lands not required for the plant proper.

With this as background a review was made of the factors that are known to directly influence the final decisions on land use in a region. In the case of a nuclear power plant a wide variety of factors were considered during the site selection process. The factors that appear to hold the most importance are:

- Amount and type of land required
- Proposed use of the exclusion area
- Physical suitability of the land for the proposed uses
- Compatibility of proposed land uses with existing regional land use plans
- Effect on other potential uses such as agriculture and forestry.

Examination of these influencing factors lead to the conceptualization of a program to evaluate each factor in detail.

Based upon the factors (listed on page 149) that were found to have a profound influence in land use determinations, the following six-step evaluation program was initiated:

- 1) Identify important land usages to be included in evaluating land use
- 2) Identify the facility region (that area to be investigated in detail for land use)
- 3) Identify the physical characteristics to be used in evaluating land use suitability
- 4) Develop land suitability ratings for each land use
- 5) Review the region's land use plan, if one exists. (If a land use plan is not available, evaluate use of a simplifying method for land use determination based on physical suitability and compatibility.)
- 6) Develop a measurement scale for rating site location and site land uses.

A. LAND USES

The classification of land uses may be simple with only a few broadly defined classes; or it may be highly detailed and specific starting with broad classes, then subclasses, each of which may be further subdivided, etc. There are, however, certain activities that are most often used. Agriculture, residential, recreation, manufacturing, forestry, and retail trade are a few examples of major land uses that are widely accepted.

The review of major land uses by the study team resulted in the selection of 12 broad categories of land use that are particularly appropriate in evaluating the impact of nuclear power plants land use:

- Wildlife habitat
- Timber (forestland)
- Open space
- Historical/cultural
- Dry-land farming
- Irrigation agriculture
- Recreation (natural setting)
- Rural residential
- Urban residential
- Commercial
- Light industry
- Heavy industry

(Nuclear power plant facilities are classified within the above listing as heavy industry.)

B. FACILITY REGION

The study team found that at least three different descriptions of facility region are needed in assessing nuclear plant siting land use factors. Each facility region is important for a different reason.

- For radiation dose calculations the facility region is the area within a 50-mile radius of the plant. Land use within a 10-mile radius of the plant is more intensively evaluated than in the remaining area within the 50-mile radius.
- For evaluating aesthetic impact, the facility region becomes the area from which the plant can be seen.
- For identification of suitable sites for heavy industry by a regional planning agency, the facility region and the planning region are the same and may be identified by political boundaries, e.g., county and/or state, or by a topographic boundary, e.g., river basin.

Each of the above definitions is useful in a different aspect of land use evaluation.

C. LAND USE SUITABILITY AND RATINGS

It is important that land usage considers the capability or suitability of the land for various purposes so that land use determinations can take place without costly economic and environmental mistakes. Although, as was previously stated, it was found that land use quantification is not mutually exclusive of the other criteria, the methodology discussed below for determining the suitability of available land could be useful to utilities and land planners (see Table 19).

TABLE 19. Matrix for Compatibility Ratings

Proposed Use to be Introduced	Existing Use of Land									
	Wildlife Habitat	Forestland	Open Space	Historical/Cultural	Dry-Land Farming	Irrigated Agriculture	Recreation (Natural Setting)	Rural Residential	Urban Residential	Commercial
	Wildlife Habitat									
	Forestland									
	Open Space									
	Historical/Cultural									
	Dry-land Farming									
	Irrigated Agriculture									
	Recreation (Natural Setting)									
	Rural Residential									
	Urban Residential									
	Commercial									
	Light Industry									
	Heavy Industry									

- 0 = Negligible Negative Impact
 1 = Small Negative Impact
 2 = Moderate Negative Impact
 3 = Significant Negative Impact
 4 = Major Negative Impact

The six physical factors of primary importance in most areas are the land characteristics of:

- Topography
- Soils
- Drainage
- Depth to bedrock
- Geologic hazard
- Flooding hazard.

Suitability ratings developed for the above factors apply only to the physical characteristics of land. They do not include consideration of existing developments such as the location of highways, railroads and utility lines, or other environmental factors such as fog, smoke and noise.

Categories of land use for which suitability ratings are developed in this report encompass:

- Urban residential
- Rural residential
- Heavy industry
- Light industry/commerce
- Irrigation agriculture
- Dry-land farming
- Timber
- Recreation/open space/wildlife habitat/cultural.

Interpretative ratings are made for ranges in each physical characteristic of land according to the following descriptive classification of suitability for each use:

- Optimum - site conditions do not present any significant limitations for this use
- Satisfactory - site conditions do not present any serious limitations for this use, and any limitations presented can be readily overcome
- Marginal - site conditions present serious limitations for this and the limitations would be difficult to correct
- Unsatisfactory - site conditions present such severe limitations for this use that development would be undesirable.

Table 20 summarizes suitability ratings of land characteristics for each use category. This is a generalized table for universal application with such modifications as might be necessary to fit the characteristics of the region in question. Once the ratings for a given area are adopted, application of Table 20 requires development of a series of overlay maps, each describing a physical characteristic, from which suitability maps for different land uses can be prepared. The procedure, detailed in the following sections, is an adaptation of an approach originally developed by Kiefer.⁽²⁷⁾

1. Project Area

To illustrate the application of this methodology, a real area was selected for which much of the basic data needed to describe physical land

TABLE 20. Land Use Suitability Ratings

1	2	3	4	5	6	7	8
Use	Rating (a)	Slope %	Soil Class (b)	Drainage (c)	Depth to Bedrock ft.	Flood Hazard	Geologic Hazard
Urban Residential	O	0-5	GW,GP,SW,SP	e	8+	No hazard	No hazard
	S	5-10	GM,GC,SM,SC,ML,CL	g	5-8	No hazard	erosion w/controls
	M	10-20	MH,CH,OL,OH	f	2-5	--	drainage w/controls
	U	20+	Muck and Peat	p to vp	0-2	occasional & seasonal	sliding
Rural Residential	O	2-5	GW,GP,SW,SP	e	10+	no hazard	no hazard
	S	0-2 & 5-10	GM,GC,SM,SC,ML,CL	g	7-10	no hazard	no hazard
	M	10-20	MH,CH,OL,OH	f	5-7	--	erosion w/controls
	U	20+	Muck and Peat	p to vp	0-5	occasional & seasonal	sliding & drainage
Heavy Industry	O	0-2	GW,GP,SW,SP	e	8+	no hazard	no hazard
	S	2-5	GM,GC,SM,SC,ML,CL	g	3-8	occasional w/flood proofing	erosion w/controls
	M	5-10	MH,CH,OL,OH, Muck and Peat	f,p,vp	0-3	seasonal w/flood proofing	drainage w/controls
	U	10+		-	-	occasional & seasonal wo/ flood proofing	sliding
Light Industry/ Commerce	O	0-5	GW,GP,SW,SP	e	8+	no hazard	no hazard
	S	5-10	GM,GC,SM,SC,ML,CL	g	5-8	no hazard	erosion w/controls
	M	10-20	MH,CH,OL,OH	f	2-5	--	drainage w/controls
	U	20+	Muck and Peat	p to vp	0-2	occasional & seasonal	sliding
Irrigation Agriculture	O	accounted for	determined from	accounted for in	accounted for in	not a limiting	no hazard
	S	in irrigation	detailed soil	irrigation suit-	irrigation suit-	factor for crop	erosion w/controls
	M	suitability	mapping irrigabil-	ability classifi-	ability classifi-	agriculture dur-	sliding
	U	classification	ity survey for the	cation under	cation under	ing flood-free	drainage
Dry-Land Farming	O	0-5	determined from	e	10+	not a limiting	
	S	5-10	detailed soil	g	5-10	factor for crop	
	M	10-20	mapping for the	f	2-5	agriculture dur-	not a limiting
	U	20+	specific area in	p to vp	0-2	ing flood-free	factor
Forestland	O	not a limit-	varies with	varies with	varies with	not a signifi-	
	S	ing factor	species of trees	species of trees	species of trees	cant factor for	
	M					most forest	not a limiting
	U					lands	factor
Recreation/Open Space/Wildlife Habitat/Cultural	O	not a limit-	not a limiting	not a limiting	not a limiting	not a limiting	
	S	ing factor	factor	factor	factor	factor	
	M						
	U						

(a) O = Optimum
S = Satisfactory
M = Marginal
U = Unsatisfactory

(b) Soil class designations from
Unified Soil Classification
System (USCS). See Table 2.

(c) e = excellent
g = good
f = fair
p = poor
vp = very poor

characteristics was readily available. The area covers 6 miles in a north-south direction and 9 1/2 miles in a east-west direction for a total of 57 square miles (approximately 36,500 acres). The area was not selected with any one preferred land use in mind.

There is considerable topographic relief in the area. Elevations range from 150 ft above mean sea level on the flood plain of the major river that meanders across the west side to over 1,100 ft on the nearby ridges. The steeper slopes are forested while much of the remaining land is currently used for agriculture.

The temperature, marine-type climate is well suited for agriculture. Although annual precipitation averages about 40 in., seasonal distribution is such that there are periods of 60 to 90 days without rainfall during the growing season. For this reason, irrigation is necessary to obtain the yield and quality of crops suitable for use by the major food processing industries located nearby.

Rural farm population in the region encompassing the project area dropped 40% in the last 25 years. Rural non-farm population doubled and urban population increased 127% during the same period. This represents an average population increase of about 3.2% per year.

Movement from urban to rural areas is encouraged by the well-developed transportation system and road network. Single family, non-farm rural homes are especially noticeable along the roads radiating from the

nearby, major metropolitan area. These are shown along with present commercial, industrial, urban, and recreational land use in the existing land use plot of Figure 44.

2. Physical Land Characteristics

a. Geology

Geologic data should include information on parent material, depth to bedrock, and geologic hazards such as faults and landslide prone areas in sufficient detail to be consistent with the scope and detail of overall planning objectives. Figure 45 delineates the bedrock or parent material geology for the project area. Depth to bedrock is shown on the soils map of Figure 47 discussed later. No known geologic hazards exist in the project area.

b. Slope

Slope is the determinant factor in many cases for different land uses. Figure 46, therefore, is a focal point for most of the evaluation steps that follow. It is important that the scale and accuracy of topographic data from which the slope map is prepared be consistent with the needs. Slopes in the area vary from the wide, flat flood-plain to ribbons of ridge tops exceeding 30%.

c. Soil

Soil association reports provide most of the information needed to construct a map such as the one shown in Figure 47. Table 21 describes the soil groups in accordance with the symbols shown on Figure 47. The numbers below the soil symbols indicate the depth to bedrock using a 3 for

FIGURE 44. Existing Land Use

FIGURE 45. Geology: Bedrock and/or Parent Material

FIGURE 46. Slope Map

SEE NARRATIVE FOR LEGEND

FIGURE 47. Soils

TABLE 21. Soils Description

Soil Series	Soil Symbol	Subsoil Description	Shrink-Swell Potential	Ranges in Slope (%)	Drainage Classification	Frequency of Flooding	Irrigation Suitability
Amity	Am	Firm, silty clay loam	Low	0- 7	Imperfect	None	Excellent
Camas	Ca	Mixtures of gravel, cobbles, and sand	Low	0- 3	Excessive	Seasonal	Fair
Chehalis	Ch	Friable silty clay loam	Low	0- 3	Good	Occasional	Excellent
Clackamas	Cl	More than 50 percent gravel and cobbles	Low	0- 7	Imperfect	None	Good
Cloquato	Cq	Friable silt loam	Low	0- 3	Good	Seasonal	Excellent
Courtney	Ct	More than 50 percent gravel and cobbles	Low	0- 3	Poor	None	Poor
Dayton	Da	Silty clay loam	Medium	0- 3	Poor	None	Fair
Hazelair	Ha	Clay	Low	3-12	Moderately good to imperfect	None	Fair
				20-30			Not suited
Jory	Jo	Very firm clay	Low	3- 7	Good	None	Good
				7-12			Fair

TABLE 21. (cont.)

Soil Series	Soil Symbol	Subsoil Description	Shrink-Swell Potential	Ranges in Slope (%)	Drainage Classification	Frequency of Flooding	Irrigation Suitability
Jory	Jo	Very firm clay	Low	12-20 20-30	Good	None	Poor Not suited
Maytown	Ma	Friable silty clay loam	Low	0-3	Imperfect	Occasional	Excellent
McAlpin	Mp	Firm silty clay	Low	0-3	Moderately good to imperfect	Occasional	Excellent
Nekia	Ne	Firm clay; 30" to bedrock	Low	3-7 7-12 12-20 20-30 30-60	Good	None	Good Fair Poor Not suited Woodland
Newberg	Nb	Very friable sandy loam	Low	0-3	Somewhat excessive	Seasonal	Excellent
Salkum	Sk	Firm silty clay	Low	3-12 12-20	Good	None	Good Poor
Sifton	Sf	More than 50 per-cent gravel and cobbles	Low	0-7	Excessive	None	Fair
Silverton	Sv	Gravelly clay	Low	3-12	Good	None	Fair

TABLE 21. (cont.)

Soil Series	Soil Symbol	Subsoil Description	Shrink-Swell Potential	Ranges in Slope (%)	Drainage Classification	Frequency of Flooding	Irrigation Suitability
Silverton	Sv	Gravelly clay	Low	12-20	Good	None	Poor
Steiwer	St	Friable silty clay loam; 20" to bedrock	Low	3-12	Good	None	Fair
				12-20			Poor
				20-30			Not suited
Waldo	Wa	Firm clay	Medium	0- 3	Poor	Occasional	Fair
Wapato	Wp	Firm porous, silty clay loam	Low	0- 3	Poor	Occasional	Excellent
Woodburn	Wo	Silt loam or very fine sandy loam	Low	0- 7	Moderately good	None	Excellent
				7-12			Good

*Adapted from Willamette Basin General Soil Association Map & Report, Segment 1, Dept. of Soils, Oregon State University.

0 to 3 ft and a 7 for 3 to 7 ft. If no number is shown, the soil depth is greater than 7 ft. Lower case letters below the soil symbols are abbreviations for the drainage classifications listed in Table 21.

d. Terrain Map

Land suitability for uses such as industry and residential depends upon the engineering characteristics of both the transported and residual soils. For this purpose, the Unified Soil Classification System (USCS), as detailed in Table 22, was used.

Using data on liquid and plastic limits, Table 23 was prepared to relate agricultural and engineering characteristics of the soils. This result was combined with the geologic map (Figure 45) to produce the composite terrain map shown in Figure 48.

Note that all of the soils in the project area fall into one of four USCS classes: ML, CL, SC, or GP. Referring to Figure 48, the first symbol identifies the origin of the parent material: FP (flood plain) for transported soils; RSS (residual sandstone) and RIB (residual igneous basalt) for soils formed in place. Where the soil is greater than 7 ft deep, the parent material notation is immediately followed by one of the engineering soil class symbols (ML, CL, SC, or GP).

Where bedrock is from 3 to 7 ft below the surface, the parent material notation is followed by a slash (/) which, in turn, is followed by the bedrock notation such as SSR (sandstone rock) or IBR (igneous basalt rock).

**TABLE 22. Soil Identification and Description
(Unified Soil Classification System)**

MAJOR DIVISIONS		SYMBOL	COLOR	DESCRIPTION	DRAINAGE
COARSE GRAINED SOILS (more than half re-tained by No. 200 sieve)	GRAVEL & GRAVELLY SOILS	GW	RED	Well-graded gravels or gravel-sand mixtures, little or no fines.	Excellent
		GP		Poorly graded gravels or gravel-sand mixtures, little or no fines.	Excellent
		GM	YELLOW	Silty gravels, gravel-sand-silt mixtures.	Fair to poor
		GC		Clayey gravels, gravel-sand-clay mixtures.	Poor to practically impervious
	SAND & SANDY SOILS	SW	RED	Well-graded sands or gravelly sands, little or no fines.	Excellent
		SP		Poorly graded sands or gravelly sands, little or no fines.	Excellent
		SM	YELLOW	Silty sands, sand-silt mixtures.	Fair to poor
		SC		Clayey sands, sand-clay mixtures.	Poor to practically impervious
FINE GRAINED SOIL (more than half passes No. 200 sieve)	SILTS & CLAYS (liquid limit less than 50)	ML	GREEN	Inorganic silts & very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	Fair to poor
		CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Practically impervious
		OL		Organic silts and organic silt-clays of low plasticity.	Poor
	SILTS & CLAYS (liquid limit greater than 50)	MH	BLUE	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Fair to poor
		CH		Inorganic clays of high plasticity, fat clays.	Practically impervious
		OH		Organic clays of medium to high plasticity, organic silts.	Practically impervious
HIGHLY ORGANIC SOILS		Pt	ORANGE	Peat & other highly organic soils.	Fair to poor

TABLE 23. Terrain Map Classification System

Soil Group Characteristics			Terrain Map Symbols				
Group	Depth to Bedrock (ft)	Drainage	Transported and/or Residual Soil Classification	Bedrock Depth Notation	Bedrock Classification	Unified Soil Classification	Drainage Classification
Wo Am	Greater than 7	Moderately good	FP	No notation for depths greater than 7 feet.	Bedrock not identified if at a depth greater than 7 feet.	ML	f
Am Wo Da	Greater than 7	Imperfect	FP			CL	P
Wo Am Da	Greater than 7	Moderately good to imperfect	FP			ML	P
Da Am Wo	Greater than 7	Imperfect	FP			CL	P
Ch Wp Ma	Greater than 7	Moderately good to Imperfect	FP			ML	P
Cq Nb	Greater than 7	Good	FP			ML	Ge
Ca Nb	Greater than 7	Excessive	FP			GP	Gé
Nb Ca	Greater than 7	Somewhat excessive	FP			SC	.Ge
Ca	Greater than 7	Excessive	FP			GP	Ce
Nb Ca Wp	Greater than 7	Somewhat excessive	FP			SC	Ge

TABLE 23. (cont.)

Soil Group Characteristics			Terrain Map Symbols			
Group	Depth to Bedrock (ft)	Drainage	Transported and/or Re- sidual Soil Classification	Bedrock Depth Notation	Bedrock Classi- fication	Unified Soil Classi- fication Drainage Classi- fication
Ch Wp Ma	3-7	Moderately good to imperfect	FP	/	SSR	ML P
St	0-3	Good	RSS	-	SSR	ML ge
St Ne Sv	0-3	Good	FP	-	SSR	ML ge
Ne St Ha	0-3	Good	RSS	-	SSR	CL ge
Jo Ne	3-7	Good	RIB	/	IBR	CL ge
Ne Sk	3-7	Good	RIB	/	IBR	CL ge
Ne Sv	3-7	Good	RIB	/	IBR	CL ge
Sf Cl Ct	3-7	Moderately good	FP	/	IBR	GP f
Cl Ct	3-7	Imperfect	FP	/	IBR	GP f
Ne	3-7	Good	RIB	/	IBR	CL ge
Wa Mp	3-7	Poor	FP	/	IBR	CL Vp
Ne Jo	3-7	Good	RIB	/	IBR	CL ge

This is then followed by the applicable USCS symbol. For shallow bedrock, 0 to 3 ft below the surface, the bedrock notation is preceded by a dash (-).

The final symbol identifies the drainage conditions as listed in the last column of Table 23. The symbols are abbreviations for good to excellent (ge), fair (f), poor (p), and very poor (vp).

The terrain map notation RIB/IBR-CL-ge would be read

RIB residual igneous basalt parent material

/ 3 - 7 ft to bedrock

IBR igneous basalt bedrock

CL USCS engineering class

ge good to excellent drainage

e. Suitability Maps

Table 20, which listed land use suitability ratings, can now be used in conjunction with the slope and terrain maps to develop suitability maps for the land uses to be considered. For illustrative purposes, suitability maps are included in this report for rural residential, urban residential, industrial, and irrigation land uses. Determining the suitability for

irrigation also required use of the soils map. The results are shown in Figures 49-52. Although printed on opaque paper for this report, in actual application these would be prepared as transparent overlays to facilitate the determination of a composite land use plan.

No areas were found to be optimum for any use in the project area. Wherever the suitability was determined to be either marginal or unsatisfactory, the most serious limiting factor is indicated.

Figure 49, rural residential suitability, shows that no land in the project area is rated satisfactory. This is because the shallow depth to bedrock over much of the area makes the use of septic tanks and wells a hazard for other than very low density development. Satisfactory conditions for rural residential use require that the land be capable of handling a density of 12 persons per acre in single family dwellings.

The other rated uses (urban residential, industrial, and irrigation) all have sizable blocks of land in the satisfactory category. Nuclear plant sites would fall in the heavy industry category from the standpoint of determining the physical land suitability.

D. COMPOSITE LAND USE PLAN

Examination of all of the land use possibilities, shown by the suitability maps, in light of anticipated future needs led to the composite land use plan for the region shown in Figure 53.

FIGURE 49. Rural Residential Suitability

FIGURE 50. Urban Residential Suitability

FIGURE 51. Industrial Suitability

FIGURE 52. Irrigation Suitability

FIGURE 53. Composite Land Use Plan

Rural residential development, other than of very low density, was ruled out for the reasons cited earlier. The project area is not suited to a residential growth of any magnitude that is dependent upon the use of septic tanks and wells.

The area designated for urban residential development covers about 2,000 acres which would accommodate 40,000 persons at a density of 20 persons per acre. This would satisfy the present growth rate of the nearby municipality to the year 1995. If the city's needs expand beyond the initial designated area, an additional 2,000 acres adjacent to the first block are delineated that would be suitable for residential development and could be utilized for agriculture in the interim.

An industrial strip near the main transportation links is delineated for initial expansion. Two additional areas suitable for industrial park type of developments are indicated within areas that could be used for agriculture in the interim. Likewise, a fourth area is identified for long-range industrial expansion within an area suitable for recreation use in the interim.

Three potential locations within land suitable for industrial development are deemed environmentally acceptable for nuclear plant siting, assuming they are properly engineered from a waste management, safety, and aesthetic standpoint. These are marked, A, B, and C on Figure 53. Other considerations in final site selection from alternative locations are discussed in the next section.

Much of the remaining land is suitable for irrigation agriculture as indicated. The major exception is along the large river where the plan calls for maintenance of a recreation and conservation strip to help meet the growing demand for outdoor recreation opportunities. When added to the steeper land that is unsatisfactory for any rated purpose, a scenic recreation and conservation strip is created that wanders in a nearby continuous ribbon throughout the project area.

E. RATIONALE FOR LAND USE QUANTIFICATION

Before it was discovered that land use quantification was not mutually exclusive of the other site criteria a system was outlined for this evaluation. The tentative approach taken was to set up a hierarchical system as shown in Figure 54. The total region is considered in the evaluation. Areas within the region that could not be considered as possible nuclear sites on the basis of high population density or legal restrictions such as wilderness areas were first dropped from further consideration. The second level of the hierarchy became the land areas acceptable for nuclear power plant location on the basis of population density or legal restrictions. Next, the remaining area of the region was screened for land suitability and all the areas having geologic hazards and other physical characteristics not suitable to nuclear power plant siting were dropped from further consideration. The third level of the hierarchy then becomes the remaining lands that meet health, safety, legal and land suitability requirements for a nuclear power plant.

FIGURE 54. Hierarchial Screening for Land Use Determinations

The detailed methodology for the suitability analysis was already described. To this point the evaluation is mainly generic. The remaining two levels of the hierarchy are more complex and enmeshed with intangibles that do not necessarily have generic transferability from region to region. In attempting to define these levels it was discovered that they are specified by the measurements of the other seven criteria and the social values.

In its abstract form there appears to be some feeling by the general public that certain types of land uses are inherently more compatible than others. The study team approached the problem of assessing compatibility in several ways. An interactive matrix of the 12 categories of land use was set up with each land use in both the row and column position as shown in Table 19. A peer group was formed and asked to rate each compatibility on the basis of 4 to 0, with 4 being very compatible and 0 very incompatible. The compatibility of each proposed land use was evaluated on the basis of locating within a larger area having the existing land use; for example, What is the compatibility of heavy industry placed within an area currently having a land use of wildlife habitat?

When the peer group attempted to make the assessment, they found that generic statements no longer were necessarily helpful. The special situations of the site and local region became very important. They needed to know the impact of each of the other seven evaluation criteria (i.e., economics, water impact, air impact, ecologic impact) before they could determine the compatibility of one type of land use with another.

They wanted to know exactly what activities within the broad class of land use are being considered. What can be done to reduce the negative economic, social or environmental impact that may arise? What are the characteristics of the natural systems present in the area? Thus, evaluation becomes very site oriented and the special considerations of the situation become important. General statements of land use compatibility become less meaningful.

At the governmental level where land use planning and zoning takes place, the planners and government officials need to know in fairly precise terms the environmental impact, the aesthetic impact, etc., before they are willing to pass judgment on land use compatibility. There is also general recognition of interregional variations that influence site selection so that what may be the desired land use pattern in one region may not be so highly valued in another region. For example, the attitudes of rural residents about the environment often differ from residents within large metropolitan areas. Even between metropolitan areas there are cultural differences. San Francisco Bay residents tend to relate to their surroundings and region's pattern of land use differently than do New York City or Newark, New Jersey residents. Furthermore, families in different stages of the family life cycle search out and interact with different environments. Desired land use patterns, therefore, are perceived from a multitude of viewpoints because of a wide diversity of value orientations and life styles.

Regional differences also arise out of different political structures and institutional constraints. Customarily, the guardianship of the public

interest in land use and other land development matters is vested in a planning commission. The commission is established by the governing body of a given political jurisdiction on the basis of power conferred by state legislation. Institutional constraints on regional land use derive from Federal, State and local laws, statistics, ordinances and regulations.

Other factors that influence regional differences in land use determinations are present land uses and long-term societal goals for the region such as "regional growth" or "quality living in a quality environment." Land use patterns of a region are the result of a number of factors all acting concurrently. After the study was almost complete, it was concluded that the social-political aspects discussed above are measured in the analysis of social values, assuming the questionnaire includes examples of land use alternatives.

Our discussions with university personnel in geography and landscape architecture indicate that the emphasis in planning today is concerned with achieving a proper mix and interaction between the various land uses. No longer is heavy industry necessarily isolated from other land uses. Natural areas for recreation are being placed near large metropolitan areas. Neighborhoods are being designed to include a mix of residential, open space, recreational, commercial and industrial land uses. Emphasis is on controlling man's activities through engineering design so that incompatibilities are reduced to acceptable levels.

There is no generic standard that can be applied in determining at the local or regional level what land uses will be accepted as compatible and desirable by the citizenry. And it is becoming very difficult to gain acceptance of large projects without community support.

Today, there is increasing recognition that the determination of land use must be done for an entire region. Not only is regional planning being proposed by professional planners, it is being demanded by the public. There are a number of bills currently before Congress to establish a National Land Use Policy, authorizing the Federal government to assist states in developing and implementing state land use programs.

Land use planning is a continuing process. It involves identification and evaluation of the scientific, technical, societal and aesthetic aspects of each environmental problem and each land use alternative. It involves planning at the regional level for any problem or alternative that could affect the region's objective of maximizing the current and future social, economic, environmental and physical benefits from land.

Thus, planning seeks to effectively use some land resources while conserving other land resources for future use. To be effective, regional land use planning needs to be comprehensive. Pollution problems of air and water cannot be treated separately from land use, nor can environmental quality problems of the city be divorced from those of the surrounding area. Land use determinations must be viewed in the context of a broad

planning approach against the backdrop of direct public participation in working out objectives of social, economic and environmental conditions. Thus, in each of the other study categories, i.e., *aesthetics, economics, water impact, air impact, cultural, health and safety, ecologic and land-use*, suitability considerations are determinants in determining land-use.

Nuclear power plant land use may be compatible adjacent to a wide variety of land uses. It depends on the particular engineering design applied at that site, regional attitudes, and the complex interaction of economic activities, ecological systems and societal values.

F. SUMMARY

There is a great deal of appeal in developing a land use methodology that is based entirely on generic standards, and thereby determining without prior clearance where nuclear power plants can be alternatively sited. The determination of land use is very complex and requires assessment at the local level to allow for specific site details and local societal values. The history of land-use zoning in this country suggests that total reliance on generic standards for the location assessment of the acceptability of a nuclear power plant site is all but impossible. Even for the relatively simple task of preserving neighborhood level amenities in a suburban residential development, generic standards are found to have severe limitations.

It should not be either the responsibility or prerogative of a utility desiring to site a nuclear plant to develop a regional land use plan. Rather, the utility should be responsible for developing detailed construction plans and assessment of environmental impacts at sites where nuclear power development is deemed compatible with surrounding land use by a regional or local land planning authority. This does not preclude encouragement and support of land use planning by the utility, which would benefit the region as well as the utility.

It is important that land use takes into consideration the compatibility or suitability of the land for various purposes, so that land use determinations can take place without costly economic and environmental mistakes. The suitability rating methodology discussed in this report is not a quantification of the land use criterion, but is a helpful guide to utilities and planners in developing information on potential sites.

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APPENDIX A
WRITE-IN COMMENTS

Appendix A Write-In Comments

Methodological Criticisms and Comments

Your options do not include direct questions about areas where technical controversy exists. E.g., actual effect of radiation dose to population, genetic effects, existence or non-existence of thresholds, and how these might affect the options you give.

I feel totally unable to make the judgment asked of me in regard to the 6 proposed plans. The information given does not convince me I have enough accurate knowledge on which to make my own judgments.

This might be more meaningful after a panel discussion presenting opposite views-environmentalist vs. economist.

For a serious assessment of this kind, I think it would be necessary to present the responding group with a less hypothetical and more concrete, specific, factual background with respect to the questions being raised. This might conceivably be done by means of an adversary kind of presentation by each side-as before a judge in a court.

This survey was very interesting and informative. It produced some valid points to consider about nuclear plants. The directions were very explicit and it was very well put together.

Not enough information supplied to make many of the judgments called for.

Much of the information presented (as under health-safety, water, air and animal-plant) is inaccurate.

I appreciate the difficulty of constructing this document and attempting to evaluate public opinion concerning nuclear power.

I cannot work with this format. Lack of a comparison with alternatives and "acceptability".

I feel not enough data is available on your design descriptions to make an informed decision. The descriptions appear to be biased toward the eventual public approval of nuclear power plants.

A short 10-12 minute movie on this subject tonight would have been interesting and informative.

You cannot separate land use, plants-animals, water, aesthetics. You cannot make an environmental trade off with one without affecting the others. They are affected simultaneously.

The issues cannot be isolated in this manner. They cannot be reduced to the level necessary to answer these questions.

More seminars of this nature should be planned. Basically, most people are ill-informed and do not see fit to learn anything new. Educational T.V. shows on this subject should be widely shown.

Nuclear energy cannot be evaluated apart from other possible energy sources.

I hope that if the results of this survey are used in any way to influence decision-making, that the data provided us on the 6 sites is included and emphasized as the basis for our decisions. There is such a mass of conflicting data given us on nuclear plants from all sides, that it should be very difficult for the general public to make valid judgments at this time. The judgments in the results of this survey should only be aligned with the data provided on the 6 sites.

I'm wondering if the effects on "water and animal-plant" wouldn't be constantly increased over a period of time. It sounds like a short-term statement in the options, particularly in the "lake option".

All 6 designs under health-safety ignore consideration of biological magnification in the food chain. This renders all 6 designs totally unacceptable as presented.

This study, which I was pleased to be able to participate in, seems too hypothetical to be very helpful, but I hope I'm wrong. Anything which increases public awareness and knowledge is all to the good. Until people know more they cannot contribute intelligently to the needed discussion.

This seems to be a better means of public survey than simple yes and no questions.

Very open-ended questions, define your terms. When you ask about change in life style, what kind? How much of a change?

Much better is the approach used in multiple choice, last half of questionnaire, where an attempt is made to explore the nuances of public opinion on the whole question of energy, living standards, our culture, etc. This, it seems to me, is the real question, not where we are going to site our nuclear plants.

Substantive Comments

If one feels as I do that the real solution to the energy crisis... lies not in further development, but in learning to live within our resources, then one must find all the alternatives contained herein unacceptable. To answer no to all the questions would indicate I do not believe there are lesser evils among the alternatives, obviously not true.

I wish you might have had my reaction to the defects of other systems as well. None are highly acceptable, but I know some of them must exist. I need them as much as anyone and will accept some for the advantages they offer.

Nuclear power plants will probably be more necessary as time goes on. They must not be implemented at the expense of either safety or the environment.

I'm not opposed to nuclear power as such, but do favor using less power.

My personal conviction is that generation of electrical power by nuclear plants is the most acceptable of the presently available alternatives. Fossil fuel burning plants not only create an unacceptable impact on the quality of the environment, but contribute to the exhaustion of irreplaceable resources.

The question of whether or not to proceed with nuclear power plants supercedes the question of whether one or another design is better.

This reaffirms the dilemma I face in considering nuclear power plants. None of the 6 alternatives is very acceptable. Atmospheric changes, significant alterations in climate, would conceivably follow the erection of cooling towers in the desert for example.

I am concerned with the secrecy and seeming lack of concern on the part of the A.E.C., lack of knowledge by the public, lack of public input into decisions on siting, whether we want nuclear power plants at all, etc.

Information comes to us from such diverse sources and is often so confusing that judgment is difficult, to say the least. So many pressures from political and citizen groups do not help us with the true facts. Facts are so almost impossible to identify.

...If these things are too dangerous for Edward Teller to accept, they are too dangerous for me..."

APPENDIX B

INTERCORRELATIONS BETWEEN RATINGS OF
EIGHT ENVIRONMENTAL IMPACT CATEGORIES

Appendix B: INTERCORRELATIONS BETWEEN RATINGS OF
EIGHT ENVIRONMENTAL IMPACT CATEGORIES

ENVIRONMENTALISTS

Once-Through Cooling/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health Safety
Aesthetics	1.00							
Economics	.52	1.00						
Water	.33	.33	1.00					
Air	.55	.47	.27	1.00				
Land	.73	.53	.47	.57	1.00			
Animal/ Plant	.37	.45	.58	.26	.38	1.00		
Cultural/ Recreational	.48	.44	.51	.26	.58	.61	1.00	
Health/ Safety	.41	.58	.50	.54	.60	.51	.42	1.00

Cooling Tower/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health/ Safety
Aesthetics	1.00							
Economics	.34	1.00						
Water	.24	.20	1.00					
Air	.08	.55	.30	1.00				
Land	.44	.61	.41	.47	1.00			
Animal/ Plant	.36	.26	.71	.31	.25	1.00		
Cultural/ Recreational	.35	.51	.24	.20	.49	.25	1.00	
Health/ Safety	.19	.47	.13	.59	.45	.32	.24	1.00

ENVIRONMENTALISTS

Cooling Pond/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health, Safety
Aesthetics	1.00							
Economics	.52	1.00						
Water	.38	.40	1.00					
Air	.47	.60	.32	1.00				
Land	.58	.65	.27	.35	1.00			
Animal/ Plant	.48	.63	.64	.35	.61	1.00		
Cultural/ Recreational	.59	.44	.40	.41	.56	.41	1.00	
Health/ Safety	.37	.60	.21	.50	.42	.36	.54	1.00

Once-Through Cooling/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health/ Safety
Aesthetics	1.00							
Economics	.47	1.00						
Water	.34	.11	1.00					
Air	.57	.58	.25	1.00				
Land	.63	.46	.23	.56	1.00			
Animal/ Plant	.40	.43	.60	.55	.41	1.00		
Cultural/ Recreational	.67	.49	.33	.45	.61	.45	1.00	
Health/ Safety	.51	.55	.46	.66	.58	.70	.49	1.00

ENVIRONMENTALISTS

Cooling Tower/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health Safety
Aesthetics	1.00							
Economics	.30	1.00						
Water	.26	.25	1.00					
Air	.23	.39	.40	1.00				
Land	.49	.54	.33	.50	1.00			
Animal/ Plant	.28	.21	.49	.53	.51	1.00		
Cultural/ Recreational	.54	.37	.33	.18	.60	.38	1.00	
Health/ Safety	.23	.56	.12	.49	.50	.36	.27	1.00

Cooling Pond/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health Safety
Aesthetics	1.00							
Economics	.62	1.00						
Water	.42	.37	1.00					
Air	.57	.58	.34	1.00				
Land	.55	.66	.22	.44	1.00			
Animal/ Plant	.48	.47	.68	.40	.45	1.00		
Cultural/ Recreational	.58	.52	.41	.51	.53	.52	1.00	
Health/ Safety	.50	.56	.44	.57	.36	.58	.51	1.00

BUSINESSMEN

Once-Through Cooling/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health Safety
Aesthetics	1.00							
Economics	.37	1.00						
Water	.48	-.06	1.00					
Air	.04	.34	.12	1.00				
Land	.26	.64	.12	.43	1.00			
Animal/ Plant	.40	.01	.59	.13	.29	1.00		
Cultural/ Recreational	.21	.14	.41	.22	.40	.16	1.00	
Health/ Safety	.28	.37	.20	.30	.60	.16	.41	1.00

Cooling Tower/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health/ Safety
Aesthetics	1.00							
Economics	.39	1.00						
Water	.31	.22	1.00					
Air	.33	.35	.43	1.00				
Land	.23	.49	-.02	.17	1.00			
Animal/ Plant	.32	.18	.67	.29	.13	1.00		
Cultural/ Recreational	.35	.39	.41	.08	.56	.52	1.00	
Health/ Safety	.41	.45	.51	.20	.20	.49	.40	1.00

BUSINESSMEN

Cooling Pond/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health/ Safety
Aesthetics	1.00							
Economics	.14	1.00						
Water	.36	.04	1.00					
Air	-.08	-.08	.02	1.00				
Land	.50	-.10	.44	.02	1.00			
Animal/ Plant	.49	-.41	.50	-.07	.48	1.00		
Cultural/ Recreational	.43	.01	.46	-.09	.42	.60	1.00	
Health/ Safety	.06	.34	.32	-.05	.33	.24	.47	1.00

Once-Through/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health/ Safety
Aesthetics	1.00							
Economics	.29	1.00						
Water	.47	.04	1.00					
Air	.40	.41	.41	1.00				
Land	.35	.29	.35	.20	1.00			
Animal/ Plant	.28	.12	.57	.36	.15	1.00		
Cultural/ Recreational	.46	.43	.60	.55	.45	.67	1.00	
Health/ Safety	.37	.35	.48	.48	.11	.32	.38	1.00

BUSINESSMEN

Cooling Tower/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health Safety
Aesthetics	1.00							
Economics	.56	1.00						
Water	.45	.33	1.00					
Air	.51	.64	.41	1.00				
Land	.39	.50	.53	.33	1.00			
Animal/ Plant	.27	.29	.47	.47	.30	1.00		
Cultural/ Recreational	.49	.49	.50	.38	.27	.63	1.00	
Health/ Safety	.62	.45	.43	.22	.39	.07	.46	1.00

Cooling Pond/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health Safety
Aesthetics	1.00							
Economics	.56	1.00						
Water	.68	.38	1.00					
Air	.22	.32	.08	1.00				
Land	.29	.14	.33	.17	1.00			
Animal/ Plant	.38	.07	.72	-.08	.53	1.00		
Cultural/ Recreational	.45	.30	.29	.33	.43	.36	1.00	
Health/ Safety	.52	.30	.72	.00	.29	.51	.23	1.00

HIGH SCHOOL STUDENTS

Once-Through Cooling/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health Safety
Aesthetics	1.00							
Economics	.22	1.00						
Water	.39	.22	1.00					
Air	.29	.38	.35	1.00				
Land	.58	.29	.34	.39	1.00			
Animal/ Plant	.37	.05	.62	.22	.20	1.00		
Cultural/ Recreational	.30	.18	.51	.42	.34	.66	1.00	
Health/ Safety	.36	.50	.46	.46	.37	.40	.48	1.00

Cooling Tower/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health Safety
Aesthetics	1.00							
Economics	.61	1.00						
Water	.26	.31	1.00					
Air	.59	.47	.35	1.00				
Land	.44	.52	.34	.43	1.00			
Animal/ Plant	.37	.14	.45	.29	.14	1.00		
Cultural/ Recreational	.26	.26	.44	.31	.39	.61	1.00	
Health/ Safety	.23	.38	.33	.55	.33	.20	.31	1.00

HIGH SCHOOL STUDENTS

Cooling Pond/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	He Sa
Aesthetics	1.00							
Economics	.28	1.00						
Water	-.08	.06	1.00					
Air	.13	.18	.44	1.00				
Land	.17	.40	.16	.03	1.00			
Animal/ Plant	-.06	.10	.48	.35	.38	1.00		
Cultural/ Recreational	.09	.19	.04	.02	.28	.37	1.00	
Health/ Safety	.07	.38	.39	.38	.59	.54	.25	1.

Once-Through Cooling/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	He Sa
Aesthetics	1.00							
Economics	.28	1.00						
Water	.35	.30	1.00					
Air	.25	.47	.35	1.00				
Land	.48	.32	.44	.34	1.00			
Animal/ Plant	.31	.23	.51	.45	.28	1.00		
Cultural/ Recreational	.43	.36	.43	.37	.41	.63	1.00	
Health/ Safety	.32	.47	.37	.29	.37	.23	.46	1.0

HIGH SCHOOL STUDENTS

Cooling Tower/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health Safety
Aesthetics	1.00							
Economics	.58	1.00						
Water	.15	.39	1.00					
Air	.22	.39	.44	1.00				
Land	.41	.39	.41	.32	1.00			
Animal/ Plant	.34	.34	.50	.44	.29	1.00		
Cultural/ Recreational	.42	.46	.23	.50	.34	.59	1.00	
Health/ Safety	.43	.56	.36	.56	.39	.67	.70	1.00

Cooling Pond/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health Safety
Aesthetics	1.00							
Economics	.33	1.00						
Water	.21	.27	1.00					
Air	.27	.30	.47	1.00				
Land	.44	.29	.30	.24	1.00			
Animal/ Plant	.12	.23	.66	.46	.25	1.00		
Cultural/ Recreational	.19	.39	.27	.45	.21	.58	1.00	
Health/ Safety	.37	.44	.34	.35	.37	.49	.36	1.00

COMBINED SAMPLES

Once-Through Cooling/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Hea Saf
Aesthetics	1.00							
Economics	.45	1.00						
Water	.49	.34	1.00					
Air	.38	.43	.33	1.00				
Land	.60	.52	.44	.47	1.00			
Animal/ Plant	.46	.28	.65	.22	.34	1.00		
Cultural/ Recreational	.44	.41	.57	.33	.49	.64	1.00	
Health/ Safety	.47	.57	.52	.42	.50	.54	.55	1.0

Cooling Tower/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	He Sa
Aesthetics	1.00							
Economics	.45	1.00						
Water	.36	.22	1.00					
Air	.40	.36	.44	1.00				
Land	.46	.50	.36	.40	1.00			
Animal/ Plant	.42	.18	.63	.38	.29	1.00		
Cultural/ Recreational	.35	.33	.44	.27	.49	.52	1.00	
Health/ Safety	.29	.35	.35	.51	.38	.36	.37	1

COMBINED SAMPLES

Cooling Pond/River Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health Safety
Aesthetics	1.00							
Economics	.39	1.00						
Water	.24	.23	1.00					
Air	.36	.36	.36	1.00				
Land	.42	.42	.29	.23	1.00			
Animal/ Plant	.31	.27	.58	.34	.51	1.00		
Cultural/ Recreational	.40	.28	.38	.32	.40	.48	1.00	
Health/ Safety	.32	.46	.40	.45	.46	.44	.48	1.00

Once-Through Cooling/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health/ Safety
Aesthetics	1.00							
Economics	.38	1.00						
Water	.36	.28	1.00					
Air	.38	.53	.32	1.00				
Land	.50	.47	.37	.49	1.00			
Animal/ Plant	.35	.44	.60	.49	.40	1.00		
Cultural/ Recreational	.49	.52	.46	.48	.54	.62	1.00	
Health/ Safety	.39	.59	.49	.52	.46	.55	.53	1.00

COMBINED SAMPLES

Cooling Tower/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health/ Safety
Aesthetics	1.00							
Economics	.47	1.00						
Water	.28	.25	1.00					
Air	.30	.40	.48	1.00				
Land	.41	.42	.42	.41	1.00			
Animal/ Plant	.31	.26	.57	.55	.36	1.00		
Cultural/ Recreational	.49	.41	.36	.39	.46	.51	1.00	
Health/ Safety	.35	.47	.33	.50	.44	.43	.44	1.00

Cooling Pond/Lake Location

	Aesthe- tics	Econo- mics	Water	Air	Land	Animal/ Plant	Cultural/ Recreational	Health/ Safety
Aesthetics	1.00							
Economics	.51	1.00						
Water	.37	.32	1.00					
Air	.39	.44	.38	1.00				
Land	.42	.40	.31	.33	1.00			
Animal/ Plant	.30	.29	.72	.41	.37	1.00		
Cultural/ Recreational	.42	.42	.41	.50	.40	.57	1.00	
Health/ Safety	.44	.44	.50	.47	.39	.56	.46	1.00

APPENDIX C
NUCLEAR SITING QUESTIONNAIRE

The first part of this survey deals with the various kinds of impacts created by present day nuclear generating plants, often referred to as "light water reactors". Electricity is produced in these plants by steam-driven turbines, the heat for the steam being created by a nuclear core. All steam plants, whether nuclear or coal burning, require cooling water to condense the excess heat. Waste heat in the cooling water can be treated in one of several ways.

Three methods of cooling will be described briefly. Each has certain advantages and disadvantages in terms of the way it affects the environment.

1. Once-through cooling: This method involves a continuous pumping of river, lake, or ocean water through the plant's condensers and back into the water source.
2. Cooling tower: Compared to the once-through design, this method draws a smaller amount of water from the water source. This water is recirculated in a closed system between the condensers and the tower. Part of the water is lost through evaporation (which is the major cooling mechanism), and the rest is returned to the original water source.
3. Cooling pond: This method also draws a smaller amount of water from the water source. This water is recirculated in a closed system between the condensers and the cooling pond. A small amount of water is continuously returned to the original water source.

These three cooling designs will each be presented in two different geographical settings, making a total of 6 design/location options. The two hypothetical settings are: a hilly, forested area with a large river as the main source for water; and a flat, open area with a large lake as the water source.

Nuclear power plants can affect the environment in several ways. On the next page, eight categories of effects or environmental impacts are described. These eight categories will be used as a basis for describing each of the six nuclear power plant alternatives.

ENVIRONMENTAL EFFECTS

Below is a list of 8 impacts or environmental effects to use in evaluating the acceptability of each of the 6 nuclear plant alternatives.

- AESTHETIC-----the general appearance of the plant, and the effect it has on the visual quality of the surrounding area
- ECONOMIC-----the effect of construction and operation costs on consumer power rates and the tax revenues generated by the plant
- WATER-----the changes in the quality of nearby water sources, including the effects due to chemicals and heat
- LAND USE-----the amount and kind of land taken by the plant; compatibility of area for plant construction and operation in relation to the regional land use plan
- AIR-----the effects on air quality due to heating and chemical pollutants
- ANIMAL-PLANT-----the effects on animals and plants, including those in the air or water or on land; the effects on the ecosystem and food chain cycle
- CULTURAL-RECREATIONAL--the recreational opportunities created or eliminated as a result of the plant; potential effects on the historical significance of the area
- HEALTH-SAFETY-----the effects on human health and safety; includes the effects due to: long-term radiation and air pollution exposure; accidental release or leakage of radioactive material; and risks associated with fogging and icing in the area of the plant

In describing the effects of nuclear power plants, we have attempted to furnish as recent and valid information as possible concerning the impacts created by nuclear power. This information represents a survey of material including environmental impact statements, books and articles by nuclear power advocates, concerned scientists, and environmentalists, and many discussions with scientists who have studied the effects of nuclear power stations. It should be noted that controversy does exist in this area, particularly with respect to the evaluation of radioactivity risks.

DESIGN 1 ONCE-THROUGH COOLING OPTION, RIVER LOCATION

AESTHETICS	As shown in the slide, the surrounding area is rolling hills and forest. The reactor building is 200 feet high (about the height of a 16 story building) and would be readily visible at eye level for one mile.
ECONOMIC	Power generated by this plant design will be less expensive than any other type of new power plant which could be added to the service area. The plant would employ 80 people and would add \$3 million per year to the local tax base.
WATER	In the once-through design, the water which is discharged back into the river would be as much as 20°F warmer than the inlet temperature. After mixing, the temperature of the entire river would be raised 0.3 of 1°F. This design would also put three tons of chemical matter into the river each day. This figure is very close to what a once-through cooled coal or oil burning power plant would discharge into the river. The impact of heating and chemicals would adversely affect the water quality of the river, particularly at the point of discharge. After dilution with the river water, it would be very difficult to detect any chemical or heating effects one-half mile below the point of discharge.
AIR	The effect of chemicals, pollutants, or heat on the air would be negligible. This should be contrasted to the air impacts created by a fossil fuel burning plant, which would add 200 tons of noxious gases per day and 11 tons of particulates per day.
LAND USE	The power plant would commit 100 acres of land, valued at \$100 per acre, and zoned for commercial-industrial use.
ANIMAL- PLANT	The large water withdrawal would destroy less than 1% of the young fish life in the river. Some minor effects upon lower organisms in the food chain cycle could be expected.
CULTURAL- RECREATIONAL	Opportunities for sport and commercial fishing would actually be enhanced in the area near the discharge point, as the fish would be attracted to the warmed water. The land area surrounding a plant is of no major historical significance.
HEALTH- SAFETY	The total radioactivity released to the air and water by this design causes a total exposure of 4 man-rems per year to the population within a 50 mile radius. This can be compared to 600,000 man-rems the same population receives from the sun, cosmic rays, and naturally radioactive elements in the earth. The risks from accidental leakage or release of radioactivity have been calculated to be 0.1 to .01 of the risk from the continuous exposure described above.

DESIGN 1

ONCE THROUGH COOLING DESIGN, RIVER LOCATION

On the preceding page, information is furnished which describes some of the environmental effects created by a once-through cooling design, river location. After reading the descriptions of the 8 types of impacts, judge the degree of acceptability of each impact using the rating scales below. Circle the number which best describes your feeling.

1. How acceptable is Design 1 to you with respect to the AESTHETIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
2. How acceptable is Design 1 to you with respect to the ECONOMIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
3. How acceptable is Design 1 to you with respect to the effects on WATER quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
4. How acceptable is Design 1 to you with respect to the effects on AIR quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
5. How acceptable is Design 1 to you with respect to the effects on LAND USE considerations?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
6. How acceptable is Design 1 to you with respect to the effects on ANIMAL AND PLANT life?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
7. How acceptable is Design 1 to you with respect to the effects on CULTURAL-RECREATIONAL features of the region?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
8. How acceptable is Design 1 to you with respect to the effects on HEALTH-SAFETY?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

Taking all factors into consideration, how acceptable is Design 1 to you?

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

DESIGN 2 COOLING TOWER OPTION, RIVER LOCATION

AESTHETICS	As shown in the slide, the surrounding area is rolling hills and forest. The dominant feature is the cooling tower, which is 500 feet tall (compare to Space Needle, which is approximately 600 feet). At eye level, the tower would have a dominant visual impact for three miles. In addition, the steam vapor trail, or plume, would extend downwind and would be visible up to 20 miles from the plant under adverse weather conditions.
ECONOMIC	The costs involved in building and operating this plant would cause an increase of about \$10 per year in the amount paid for electrical energy by an average family (four people). The plant would employ 80 people and would add \$3 million per year to the local tax base.
WATER	The increase in temperature of the river water would be minor compared to that created by the once-through design. However, this design would discharge five tons of chemicals per day in a more concentrated form into the water. Again, by the time the chemicals were one-half mile downstream, their effects would be difficult to detect.
AIR	About one-half ton of chemicals (biocides and corrosion inhibitors) would be added to the air each day and would be distributed over a wide area. This can be compared to the impacts of a comparable fossil fuel burning plant which would discharge 200 tons per day of noxious gases and 11 tons a day of particulates.
LAND USE	The power plant and towers would commit 105 acres of land, valued at \$100 per acre and zoned for commercial-industrial use.
ANIMAL- PLANT	The fish life in the river would be largely unaffected by this design. Less water would be drawn into the plant and thus fewer fish and small organisms would be affected by the heat. However, the constant recirculation of water through the pumps and condensers would kill all of the entrained food chain organisms. The impact of 5 tons of concentrated chemicals per day would have a definitely larger effect on the food chain system in the water. To date, clear-cut data does not exist which would specify the effects of these chemicals on aquatic life. Under adverse conditions, the steam vapor trail from the tower could kill some domestic and migratory birds flying through the steam plume.
CULTURAL- RECREATIONAL	This design would have the effect of slightly decreasing the total number of fish in the river. The area surrounding the plant is of no major historical significance.
HEALTH- SAFETY	Radioactive risks are identical to those described for the once-through cooling design. The steam vapor plume would create ground fogging and icing under unusual weather conditions. This fogging and icing would create a serious driving hazard over several square miles on an average of one day per year.

DESIGN 2

COOLING TOWER DESIGN, RIVER LOCATION

On the preceding page, information is furnished which describes some of the environmental effects created by a cooling tower design, river location. After reading the descriptions of the 8 types of impacts, judge the degree of acceptability of each impact using the rating scales below. Circle the number which best describes your feeling.

1. How acceptable is Design 2 to you with respect to the AESTHETIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
2. How acceptable is Design 2 to you with respect to the ECONOMIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
3. How acceptable is Design 2 to you with respect to the effects on WATER quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
4. How acceptable is Design 2 to you with respect to the effects on AIR quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
5. How acceptable is Design 2 to you with respect to the effects on LAND USE considerations?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
6. How acceptable is Design 2 to you with respect to the effects on ANIMAL AND PLANT life?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
7. How acceptable is Design 2 to you with respect to the effects on CULTURAL-RECREATIONAL features of the region?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
8. How acceptable is Design 2 to you with respect to the effects on HEALTH-SAFETY?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

Taking all factors into consideration, how acceptable is Design 2 to you?

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

DESIGN 3 COOLING POND OPTION, RIVER LOCATION

AESTHETICS	As shown in the slide, the surrounding area is rolling hills and forest. The dominant feature is the reactor structure, which is 200 feet high (comparable to a 16 story building) and readily visible at eye level for one mile. The cooling pond would be partially hidden and visible only at close distances.
ECONOMIC	The costs involved in building and operating this plant would cause an increase of \$5 per year in the amount paid for electrical energy by an average family (four people). The plant would employ 80 people and would add \$3 million per year to the local tax base.
WATER	The increase in temperature of the river water would be minor compared to that created by the once-through design. However, this design would discharge 5 tons of chemicals per day in a more concentrated form into the water. Again, by the time the chemicals were one-half mile downstream, their effects would be difficult to detect.
AIR	The chemicals added to the air from this type of plant design would be almost negligible. This can be compared with the previously described air impacts created by a comparable fossil fuel burning plant.
LAND USE	The power plant and cooling pond would commit 2100 acres of land valued at \$100 per acre and zoned for commercial-industrial use.
ANIMAL- PLANT	The aquatic life in the river would be largely unaffected by this design. There would be fewer fish and small organisms drawn into the plant and there would be less of a heating effect than would be expected from the once-through cooling design. However, the constant recirculation of water through the pumps and condensers would kill all of the entrained food chain organisms. There would be an impact on the food chain and ecosystem as the result of the 5 tons of chemicals added per day to water. 2100 acres of natural habitat for animal and plant life would be eliminated, but the pond and surrounding forest would provide a resting place for migratory water birds.
CULTURAL- RECREATIONAL	The cooling pond could have a potential for use as a fishery for warm water species. Similarly, the pond would have some potential for water sports. The surrounding area would be of no major historical significance.
HEALTH- SAFETY	Radioactive risks are identical to those described for the once-through and cooling tower designs. A ground fogging and icing condition would be created by the cooling pond and would create a driving hazard as follows: Fogging and icing would extend one mile downwind for two days/year; fogging and icing would extend five miles for one day/year; fogging and icing would extend 10 miles approximately five hours/year.

DESIGN 3

COOLING POND DESIGN, RIVER LOCATION

On the preceding page, information is furnished which describes some of the environmental effects created by a cooling pond design, river location. After reading the descriptions of the 8 types of impacts, judge the degree of acceptability of each impact using the rating scales below. Circle the number which best describes your feeling.

1. How acceptable is Design 3 to you with respect to the AESTHETIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
2. How acceptable is Design 3 to you with respect to the ECONOMIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
3. How acceptable is Design 3 to you with respect to the effects on WATER quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
4. How acceptable is Design 3 to you with respect to the effects on AIR quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
5. How acceptable is Design 3 to you with respect to the effects on LAND USE considerations?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
6. How acceptable is Design 3 to you with respect to the effects on ANIMAL AND PLANT life?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
7. How acceptable is Design 3 to you with respect to the effects on CULTURAL-RECREATIONAL features of the region?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
8. How acceptable is Design 3 to you with respect to the effects on HEALTH-SAFETY?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

Taking all factors into consideration, how acceptable is Design 3 to you?

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

DESIGN 4 ONCE-THROUGH COOLING OPTION, LAKE LOCATION

AESTHETICS	As shown in the slide, the surrounding area is flat, open land, with few wooded areas. The reactor building is 200 feet high (about the height of a 16 story building) and would have a major visual impact within 2 miles.
ECONOMIC	Power generated by this plant design will be less expensive than any other type of new power plant which could be added to the service area. The plant would employ 80 people and would add \$3 million per year to the local tax base.
WATER	In the once-through design, the water which is discharged back into the lake would be as much as 20°F warmer than the inlet temperature. This design would also put 3 tons of chemical matter into the river each day. This figure is very close to what a once-through cooled coal burning power plant would discharge into the lake. The impact of heating and chemicals would adversely affect the water quality of the lake, particularly at the point of discharge. After dilution with the lake water, it would be very difficult to detect any chemical or heating effects 1/2 mile beyond the point of discharge.
AIR	The effect of chemicals, pollutants, or heat on the air would be negligible. This should be contrasted to the air impacts created by a fossil fuel burning plant, which would add 200 tons of noxious gases per day and 11 tons of particulates per day.
LAND USE	The power plant would commit 100 acres of land, valued at \$400 per acre, zoned for rural-agricultural use.
ANIMAL- PLANT	The large water withdrawal could be expected to destroy a very low percentage of the lake fish life (approximately 1/10 of 1 percent). Some minor effects upon lower organisms in the food chain cycle could be expected.
CULTURAL- RECREATIONAL	Opportunities for sport and commercial fishing could be enhanced in the area near the discharge point, due to the attraction of fish toward the warmed water. There are two major historical landmarks within a 10 mile radius of the plant. The reactor structure would not be visible from these landmarks.
HEALTH- SAFETY	The total radioactivity released to the air and water by this design causes a total exposure of 4 man-rems per year to the population within a 50 mile radius. This can be compared to the 600,000 man-rems the same population receives from the sun, cosmic rays, and naturally radioactive elements in the earth. The risks from accidental release or leakage of radioactivity have been calculated to be 1/10 to 1/100 of the risk from the continuous exposure described above.

DESIGN 4

ONCE-THROUGH COOLING DESIGN, LAKE LOCATION

On the preceding page, information is furnished which describes some of the environmental effects created by a once-through cooling design, lake location. After reading the descriptions of the 8 types of impacts, judge the degree of acceptability of each impact using the rating scales below. Circle the number which best describes your feeling.

1. How acceptable is Design 4 to you with respect to the AESTHETIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
2. How acceptable is Design 4 to you with respect to the ECONOMIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
3. How acceptable is Design 4 to you with respect to the effects on WATER quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
4. How acceptable is Design 4 to you with respect to the effects on AIR quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
5. How acceptable is Design 4 to you with respect to the effects on LAND USE considerations?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
6. How acceptable is Design 4 to you with respect to the effects on ANIMAL AND PLANT life?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
7. How acceptable is Design 4 to you with respect to the effects on CULTURAL-RECREATIONAL features of the region?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
8. How acceptable is Design 4 to you with respect to the effects on HEALTH-SAFETY?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

Taking all factors into consideration, how acceptable is Design 4 to you?

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

DESIGN 5 COOLING TOWER OPTION, LAKE LOCATION

AESTHETICS	As shown in the slide, the surrounding area is flat, open land, with few wooded areas. The two cooling towers are each 450 feet tall (compare with Space Needle, which is approximately 600 feet high). At eye level, the towers would have a dominant visual impact for 15 miles. The steam vapor plume would extend downwind and would be visible up to 20 miles from the plant under adverse weather conditions.
ECONOMIC	The costs involved in building and operating this plant would cause an increase of about \$10 per year in the amount paid for electrical energy by an average family (four people). The plant would employ 80 people and would add \$3 million per year to the local tax base.
WATER	The increase in temperature of the lake water would be minor compared to that created by the once-through design. However, this design would discharge 5 tons of chemicals per day in a more concentrated form into the water. By the time the chemicals were one-half mile beyond the point of discharge, their effects would be difficult to detect.
AIR	About one-half ton of chemicals (biocides and corrosion inhibitors) would be added to the air each day and would be distributed over a wide area. This can be compared to the impacts of a comparable fossil fuel burning plant which would discharge 200 tons per day of noxious gases and 11 tons per day of particulates.
LAND USE	The plant and towers would commit 105 acres of land, valued at \$400 per acre and zoned for rural-agricultural use.
ANIMAL- PLANT	The fish life in the lake would be largely unaffected by this design. Less water would be drawn into the plant and thus fewer fish and small organisms would be affected. However, the constant recirculation of water through the pumps and condensers would kill all of the entrained food chain organisms. The impact of 5 tons of concentrated chemicals per day would have a definitely larger effect on the food chain system in the water also. To date, clear-cut data does not exist to specify the effects of these chemicals on aquatic life. Under adverse conditions, the steam vapor trail from the towers could kill some domestic and migratory birds flying through the plume.
CULTURAL- RECREATIONAL	This design would have the effect of slightly decreasing the total number of fish available for sport fishing. The two cooling towers would be dominantly visible from both of the two historical landmarks, and would be expected to impinge on these landmarks.
HEALTH- SAFETY	Radioactive risks are identical to those described for the once-through cooling design. The steam vapor plume would create ground fogging and icing under unusual weather conditions. This fogging and icing would create a serious driving hazard over several square miles on an average of one day per year.

DESIGN 5

COOLING TOWER DESIGN, LAKE LOCATION

On the preceding page, information is furnished which describes some of the environmental effects created by a cooling tower design, lake location. After reading the descriptions of the 8 types of impacts, judge the degree of acceptability of each impact using the rating scales below. Circle the number which best describes your feeling.

1. How acceptable is Design 5 to you with respect to the AESTHETIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
2. How acceptable is Design 5 to you with respect to the ECONOMIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
3. How acceptable is Design 5 to you with respect to the effects on WATER quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
4. How acceptable is Design 5 to you with respect to the effects on AIR quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
5. How acceptable is Design 5 to you with respect to the effects on LAND USE considerations?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
6. How acceptable is Design 5 to you with respect to the effects on ANIMAL AND PLANT life?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
7. How acceptable is Design 5 to you with respect to the effects on CULTURAL-RECREATIONAL features of the region?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
8. How acceptable is Design 5 to you with respect to the effects on HEALTH-SAFETY?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

Taking all factors into consideration, how acceptable is Design 5 to you?

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

DESIGN 6 COOLING POND OPTION, LAKE LOCATION

AESTHETICS	As shown in the slide, the surrounding area is flat, open land, with few wooded areas. The reactor building is 200 feet high (about the height of a 16 story building) and would have a major visual impact within two miles. The cooling pond and earthen dikes would be visible at close distances.
ECONOMIC	The costs involved in building and operating this plant would cause an increase of \$5.30 per year in the amount paid for electrical energy by an average family (four people). The plant would employ 80 people and would add \$3 million per year to the local tax base.
WATER	The increase in temperature of the lake water would be minor compared to that created by the once-through design. However, this design would discharge 5 tons of chemicals per day in a more concentrated form into the water. Again, by the time the chemicals were one-half mile beyond the discharge point, their effects would be difficult to detect.
AIR	The chemicals added to the air from this type of plant design would be almost negligible. This can be compared with the previously described air impacts created by a comparable fossil fuel burning plant.
LAND USE	The power plant and cooling pond would commit 2100 acres of land valued at \$400 per acre and zoned for rural-agricultural use. A cooling pond design would not be in agreement with the regional land use plan.
ANIMAL- PLANT	The fish life in the lake would be largely unaffected by this design. Less water would be drawn into the plant and thus fewer fish and small organisms would be affected. However, the constant recirculation of water through the pumps and condensers would kill all of the entrained food chain organisms. The impact of 5 tons of concentrated chemicals per day would have a definitely larger effect on the food chain system in the water also. To date, clear-cut data does not exist to specify the effects of these chemicals on aquatic life. This design would also displace the habitat for 2100 acres of plant and animal life.
CULTURAL- RECREATIONAL	The cooling pond could have a potential for use as a fishery for warm water species. Similarly, the pond would have some potential for water sports. The reactor structure would not be visible from the two historical landmarks in the area.
HEALTH- SAFETY	Radioactive risks are identical to those described for the once-through and cooling tower designs. A ground fogging and icing condition would be created by the cooling pond and would create a driving hazard as follows: Fogging and icing would extend one mile downwind for two days/year; fogging and icing would extend five miles for one day/year; fogging and icing would extend 10 miles approximately five hours/year.

DESIGN 6

COOLING POND DESIGN, LAKE LOCATION

On the preceding page, information is furnished which describes some of the environmental effects created by a cooling pond design, lake location. After reading the descriptions of the 8 types of impacts, judge the degree of acceptability of each impact using the rating scales below. Circle the number which best describes your feeling.

1. How acceptable is Design 6 to you with respect to the AESTHETIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
2. How acceptable is Design 6 to you with respect to the ECONOMIC effect it creates?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
3. How acceptable is Design 6 to you with respect to the effects on WATER quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
4. How acceptable is Design 6 to you with respect to the effects on AIR quality?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
5. How acceptable is Design 6 to you with respect to the effects on LAND USE considerations?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
6. How acceptable is Design 6 to you with respect to the effects on ANIMAL AND PLANT life?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
7. How acceptable is Design 6 to you with respect to the effects on CULTURAL-RECREATIONAL features of the region?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE
8. How acceptable is Design 6 to you with respect to the effects on HEALTH-SAFETY?
VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

Taking all factors into consideration, how acceptable is Design 6 to you?

VERY UNACCEPTABLE: 1 2 3 4 5 6 7 : VERY ACCEPTABLE

Below, you will find the 8 issues or impacts discussed earlier. They are listed in various combinations. Three issues are listed on each line. In addition, a ninth issue has been added: the United State's reputation in the world as a nation concerned about environmental preservation. Below, the issue is abbreviated: "U.S. Reputation."

We'd like for you to put yourself in the position of determining the overall guidelines concerning the location of power plants. How much concern should we pay to each issue? What should be our order of priorities with respect to each issue?

Please rank the 3 issues in each line in the order of how much attention should be paid to each.

On each line place a 1 by the issue which you think should have top priority or importance with respect to power plant siting. Place a 3 by the issue which should receive the least attention. Then place a 2 by the remaining issue.

Again, rank these issues with respect to the location of power plants.

___ Culture-Recreational	___ U.S. Reputation	___ Water
___ Aesthetic	___ Economic	___ Culture-Recreational
___ Water	___ Land use	___ Animal-Plant
___ Culture-Recreational	___ Health-Safety	___ Land use
___ Air	___ Animal-Plant	___ Culture-Recreational
___ Economic	___ Land use	___ U.S. Reputation
___ Economic	___ Water	___ Air
___ Aesthetic	___ Water	___ Health-Safety
___ Health-Safety	___ U.S. Reputation	___ Air
___ Land use	___ Air	___ Aesthetics
___ Animal-Plant	___ Health-Safety	___ Economic
___ U.S. Reputation	___ Aesthetics	___ Animal-Plant

This section contains some general questions about atomic energy and other issues which relate to energy production in the United States.

DIRECTIONS. Read each statement and indicate whether you agree with it or disagree with it. Circle one of the five choices after each question.

	Strongly Agree	Agree	Partly Agree/ Partly Disagree	Disagree	Strongly Disagree
1. I would be willing to make some real changes in my life style to conserve electric power.	SA	A	AD	D	SD
2. The public should be willing to conserve power even if it means changing our way of life.	SA	A	AD	D	SD
3. Restricting the amount of electricity for industry will do more harm than good.	SA	A	AD	D	SD
4. Unless a nuclear power plant makes the local area more attractive, I would oppose its construction.	SA	A	AD	D	SD
5. It's not important that power plants look nice.	SA	A	AD	D	SD
6. Science and technology create more problems for society than they solve.	SA	A	AD	D	SD
7. If we don't change our way of life, the environment will be totally destroyed.	SA	A	AD	D	SD

8.	I wouldn't be concerned about swimming in lake water used to cool a nuclear power plant as long as the A.E.C. says it's safe.	SA	A	AD	D	SD
9.	There should be more concern with long-term radiation effects than with ending the energy crisis.	SA	A	AD	D	SD
10.	There must be a better alternative than nuclear energy.	SA	A	AD	D	SD
11.	I would be happy to pay 20% more for power if I could be sure it was clean and safe.	SA	A	AD	D	SD
12.	Ten years from now the average person will use twice as much electricity as he does today.	SA	A	AD	D	SD
13.	Private citizens will have to change their habits of power consumption if the energy crisis is to end.	SA	A	AD	D	SD
14.	As long as it works, who cares what a nuclear plant looks like.	SA	A	AD	D	SD
15.	A.E.C. is pushing nuclear energy only to justify its own existence.	SA	A	AD	D	SD
16.	We would all have a better life if there were more poets and writers and fewer scientists and engineers.	SA	A	AD	D	SD
17.	"Saving the environment" sounds fine but continued economic development is still the best way to a better life.	SA	A	AD	D	SD
18.	All modern conveniences have some risks; the risks of nuclear power aren't any worse.	SA	A	AD	D	SD
19.	The loss of one human life because of a radiation leak is absolutely unacceptable.	SA	A	AD	D	SD
20.	Other sources of power, such as solar energy, should be developed instead of building more nuclear plants.	SA	A	AD	D	SD

21.	We must face the fact that our society will continue to need more and more power.	SA	A	AD	D	SD
22.	If industry would stop wasting energy, the crisis would be over.	SA	A	AD	D	SD
23.	A reduction in energy production will make the United States a second rate world power.	SA	A	AD	D	SD
24.	Any nuclear power plant should be a long ways from where anyone lives.	SA	A	AD	D	SD
25.	Scientists who challenge the A.E.C. facts and information are mostly seeking publicity.	SA	A	AD	D	SD
26.	The United States has been run too long by "science and technology."	SA	A	AD	D	SD
27.	Nuclear energy is now the best solution to the energy crisis.	SA	A	AD	D	SD
28.	To solve the energy crisis we will have to be willing to take some real risks.	SA	A	AD	D	SD
29.	The energy crisis should be solved by restricting the electricity consumed by private citizens.	SA	A	AD	D	SD
30.	We don't know enough about long-term radiation effects on health to be able to think in terms of nuclear energy.	SA	A	AD	D	SD
31.	Domestic power production must continue to increase if the United States is to remain a major world power.	SA	A	AD	D	SD
32.	We should be more concerned with conserving energy rather than producing more energy.	SA	A	AD	D	SD
33.	The energy crisis is a ploy of politicians to get a vote.	SA	A	AD	D	SD
34.	I would be just as willing to live near a nuclear power plant as any other factory or plant.	SA	A	AD	D	SD
35.	People wanting more energy should be willing to accept a loss of environmental quality.	SA	A	AD	D	SD

36.	The A.E.C. is keeping as much information secret about nuclear energy as it did the underground bomb testing.	SA	A	AD	D	SD
37.	Greater emphasis on science and technology is the best way to achieve a better life for all.	SA	A	AD	D	SD
38.	The environment comes first, energy production second.	SA	A	AD	D	SD
39.	The informed public can make much better judgments than the A.E.C. can about nuclear power.	SA	A	AD	D	SD
40.	Environmentalists are people caught up in a fad.	SA	A	AD	D	SD
41.	The only safe amount of radiation is zero radiation.	SA	A	AD	D	SD
42.	Our nation does not need to increase energy production.	SA	A	AD	D	SD
43.	An increase in energy production is worth an increase in pollution.	SA	A	AD	D	SD
44.	The A.E.C. is concerned only with the welfare of the public utility companies.	SA	A	AD	D	SD
45.	The average person does not have the knowledge to make rational decisions about nuclear energy.	SA	A	AD	D	SD
46.	The energy crisis won't become severe for many years.	SA	A	AD	D	SD
47.	Energy production must be absolutely safe.	SA	A	AD	D	SD
48.	Preserving our environment is more important than creating jobs for the unemployed.	SA	A	AD	D	SD
49.	If private citizens would stop wasting energy there wouldn't be an energy crisis.	SA	A	AD	D	SD
50.	Much of the publicity about the energy crisis is created by the A.E.C. to encourage more nuclear power plant construction.	SA	A	AD	D	SD

51.	Issues as complicated as nuclear energy should be decided by the scientists, not the public.	SA	A	AD	D	SD
52.	The energy crisis will pass just like all crises.	SA	A	AD	D	SD
53.	We'll need more sources of power if we expect to continue using the modern conveniences of life.	SA	A	AD	D	SD
54.	Unless we continue to fully support scientific and technological efforts, the United States will not survive another 50 years.	SA	A	AD	D	SD

The following questions deal with atomic energy and electrical power generation.

Write the letter of the best answer on the line beside the question.

- _____ 1. Which one of the following is a function of the Atomic Energy Commission?
 - a. licensing of nuclear power plants
 - b. construction of nuclear power plants
 - c. operation of nuclear power plants
 - d. approving rate increases in electricity costs
- _____ 2. Approximately how many nuclear power plants are in operation in the United States today?
 - a. about 5
 - b. about 10
 - c. about 30
 - d. about 60
- _____ 3. Which of the following has not been seriously considered as a possible source of power?
 - a. coal gasification
 - b. geothermal energy
 - c. glacier movement
 - d. solar energy
- _____ 4. The fuel from which nuclear power is generated is
 - a. cobalt
 - b. uranium 235
 - c. zirconium
 - d. neptunium
- _____ 5. A geothermal power plant is now in operation in which state?
 - a. Washington
 - b. Alaska
 - c. California
 - d. Oklahoma
- _____ 6. The greatest single source of electrical power in Washington state comes from
 - a. nuclear energy plants
 - b. coal burning plants
 - c. oil burning plants
 - d. hydroelectric dams
- _____ 7. Nuclear power today supplies the United States with what percentage of its total energy?
 - a. about 1%
 - b. about 10%
 - c. about 30%
 - d. more than 50%

Sex: M F

Age: ☐ under 20 years
☐ 20-24 years
☐ 25-29 years
☐ 30-34 years
☐ 35-39 years
☐ 40-44 years
☐ 45-49 years
☐ 50 years and over

Education (years of school or highest degree) _____

Occupation _____

How many elective offices (in politics, clubs, lodges, church, school, and civic groups, etc.) have you held in the last five years? (check one)

☐ none
☐ 1
☐ 2
☐ 3
☐ 4 or more

Compared to most people, how knowledgeable are you on the subject of nuclear energy? (circle one)

1	2	3	4	5	6	7
(know much less than most people)			(know about as much as most people)			(know much more than most people)

THANK YOU FOR YOUR PARTICIPATION. ON THE LAST PAGE, WE WOULD APPRECIATE HEARING ANY COMMENTS YOU MAY WISH TO MAKE ABOUT THE STUDY OR ANY SUGGESTIONS YOU HAVE FOR INCREASING THE EFFECTIVENESS OF PUBLIC INPUT TO THE PLANNING OF TECHNOLOGICAL CHANGE.

APPENDIX D
VIEWSCAPE QUESTIONNAIRE

APPENDIX D - VIEWSCAPE QUESTIONNAIRE

A. PRE-EVALUATION TECHNIQUE (1)

The overall visual quality of a viewscape may be evaluated on a scale ranging from 1 (very high visual quality) to 100 (very low visual quality) once a scale of comparison is agreed upon, depending on the observer's immediate reaction or visual response. Is the viewscape highly scenic - - distinctive and memorable - - visually stimulating? Is it of moderate or low visual quality, being visually dull, unstimulating and of low distinction? Or, is its visual quality very low, presenting a visual array which is disturbing and disjointed and of little or no scenic value? Viewscapes of the Grand Canyon, Yosemite Falls, or the Grand Tetons might be given scores close to 1, while viewscapes of unrestored strip mines, active landfill operations, or highly polluted wastelands might be given scores close to 100. The evaluator should be objective and impartial in his judgement, attempting to separate his preference or dislike of the viewscape from a true evaluation of the visual merits or drawbacks of the viewscape. Rate the visual quality of this viewscape "before" and "after" the facility. (Note: throughout this questionnaire low numerical scores (i.e. 1) are given to qualities which are of best or highest quality; high numerical scores (i.e. 100) are reserved for those attributes of low quality. Please remember: "big numbers are bad scores".)

Overall visual quality before ____ (1-100). Overall visual quality after ____ (1-100).

B. INTACTNESS EVALUATION: Intactness is the relative degree of natural condition of a viewscape or its elements. Intactness may be evaluated by considering the level of urbanization and degree of encroachment present;

IV.B. Intactness Evaluation cont. intactness scores are highest (1) when man-made development and visual disturbances are absent, as discussed and illustrated in the accompanying text (Section IV.B).

1) Rate the intactness of the overall viewscape by checking the appropriate box in each column below; place one check for "before" and one for "after".

Before After

_____	_____	1. Very highly intact/no alteration.
_____	_____	2. Highly intact/little alteration.
<u>(x)</u>	_____	3. Moderately highly intact/moderately little alteration.
_____	_____	4. Moderately intact/moderately altered.
_____	<u>(x)</u>	5. Moderately low intactness/moderately highly altered.
_____	_____	6. Low intactness/highly altered.
_____	_____	7. Very low intactness/very highly altered.

2) Rate the intactness of each major element of the viewscape, as identified in the viewscape sketch. In the "after" viewscape, do not rate the facility's intactness, but consider its effect on the visual intactness of viewscape elements which it physically alters or visually blocks from view, in part or as a whole. Use the numerical intactness rating system from above in scoring the intactness of each viewscape element.

<u>Element Name</u>	<u>Intactness Score</u>	
	<u>Before</u>	<u>After</u>
A.Sky	2	3
B.Etc.		
C.		
D.		

C. VIVIDNESS EVALUATION: Vividness is the memorability of visual impression of the overall viewscape or its elements. Vividness is high in viewscales when there is distinction or prominence resulting from high contrast or from mutual accentuation of visually diverse elements. In rating vividness, consider the levels of definition of viewscale boundary, diversity of spatial enclosure, degree of topographic relief, diversity of vegetative pattern, prominence of natural features, prominence of waterforms, vividness of sky, and vividness of man-made elements, as discussed in the accompanying text.

1) Rate the vividness of each major element of the viewscale, as identified in the viewscale sketch. In the "after" viewscale, rate the vividness of the facility as well as its effects on the vividness of the other viewscale elements which have been visually blocked, physically altered, or affected by visual contrast or legibility with the addition of the facility. Use the numerical vividness rating system from above in scoring the vividness of each viewscale element.

<u>Element Name</u>		
	<u>Before</u>	<u>After</u>
A. River	3	4
B. Etc.		
C.		
D.		
E.		
F.		
G. Facility		

D. UNITY EVALUATION: Unity is the degree to which individual elements in the viewscape join together to form a single coherent harmonious visual unit. Unity refers to the level of compositional harmony or visual intercompatibility of the individual elements which comprise the viewscape. Unity does not require similarity or blandness, but may depend rather on visual dominance and subordination of viewscape elements with some level of integrating organization between them. It must be remembered that unity deals only with visual coherence and compositional integrity between viewscape elements, and should be clearly distinguished from both "intactness" and "vividness" rated above. (See accompanying text).

1) Rate the unity of the overall viewscape by checking the appropriate box below for "before" and "after" conditions.

Before After

<u> </u>	<u> </u>	1 Very high overall unity.
<u> </u>	<u> </u>	2 High overall unity.
<u>(x)</u>	<u> </u>	3 Moderately high overall unity.
<u> </u>	<u> </u>	4 Moderate overall unity.
<u> </u>	<u>(x)</u>	5 Moderately low overall unity.
<u> </u>	<u> </u>	6 Low overall unity.
<u> </u>	<u> </u>	7 Very low overall unity.

2) Rate the level of unity or degree of harmonious visual integration between man-made and natural elements in the viewscape, considering the facility as an additional man-made element in the "after" viewscape. Check the appropriate box below for "before" and "after" conditions.

Before After

_____	_____	1 Man-made elements very highly unified with natural/
not present.
<u>(x)</u>	_____	2 Man-made elements highly unified with natural.
_____	_____	3 Man-made elements moderately highly unified with
natural.
_____	<u>(x)</u>	4 Man-made elements moderately unified with natural.
_____	_____	5 Man-made elements of moderately low unity with
natural.
_____	_____	6 Man-made elements of low unity with natural.
_____	_____	7 Man-made elements of very low unity with natural.

E. IMPORTANCE EVALUATION: Visual importance is the level of visual contribution an element makes to the overall viewscape after the facility has been introduced into it. An element's visual importance may be due to its size, number, singularity, contrast, or position in the viewscape. In the "after" view-
scape rate the visual importance of each major element, using the importance rating scale from 1 to 7 provided below.*

<u>Element Name</u>	<u>Importance Score</u>
	<u>After</u>
A.	2
B.	4
C.	1
D.	5
E.	3
F.	.
G. Facility	1

7 Element very high in visual importance to viewscape.

6 Element high in visual importance to viewscape.

5 Element moderately high in visual importance to viewscape.

4 Element of moderate visual importance to viewscape.

3 Element of moderately low visual importance to viewscape.

2 Element of low visual importance to viewscape.

1 Element of very low visual importance to viewscape.

*Note: Importance score is the only score which is numerically reversed. i.e. 7 = element very high in visual importance to viewscape. Please note this single exception to the rule that "big numbers are bad scores".

APPENDIX E
SPECIAL-COMPETENCE GROUP CREDENTIALS

APPENDIX E
SPECIAL-COMPETENCE GROUP CREDENTIALS

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