ENVIRONMENTAL IMPACT ASSESSMENT

by

CHARLES WINGARD JONES

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Major Professor

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INTRODUCTION

In 1969 the National Environmental Policy Act (NEPA) was passed by the Congress. A major portion of the Act was to require all federal agencies and organizations receiving federal aid to assess the environmental effects of all ongoing and future projects. It further required that an Environmental Impact Statement (EIS) be prepared to list the results of this assessment. Since federal aid touches almost every level of the public and private sector of society and business, NEPA has had a universal applicability.

This paper presents the requirements for Impact Statements and discusses the much broader and more important area of impact assessment. It presents the principal methods of assessment and discusses their benefit and applicability. It also evaluates the overall effect of NEPA. It should provide the engineer and the governmental reviewer insight into environmental analysis and source material for determining various methodologies applicable to each type project.

The 1950's and 1960's were a period of technological progress unmatched in history. Science expanded rapidly and improved the life style of man quickly. This era was marked by the feeling that technology could accomplish anything and that science was progress. It was also marked by a lack of concern for the social consequences of this scientific progress. In the mid 60's a wave of resentment grew as more and more individuals and groups became aware of the social costs of technology. Among the first effects of this movement was the action taken by citizen groups against the Cross-Florida Barge Canal proposed by the Corps of Engineers. Citizen action has sought successfully to block this project to date.

On 1 January 1970 Congress reacted to this national concern with the passage of the National Environmental Policy Act of 1969, Public Law 91-190. The stated purposes of this far reaching document were:

> To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological system and natural resources important to the nation; and to establish a Council on Environmental Quality (CEQ). (2, p. 267).

This provided a central agency to coordinate the harmonious interaction of man and his environment. It also forced the nation to face squarely the environmental consequences of its construction activities. NEPA provided the legal framework and the administrative process to require that all construction using federal funds would consider environmental concerns as well as the typical cost-benefit ratios used in economic analysis.

FEDERAL REQUIREMENTS

Section 102(2) (c) of NEPA established the fundamental requirement for all agencies of the Federal Government to:

> include in every recommendation or proposals for legislation and other major Federal actions significantly altering the quality of the human environment, a detailed statement by the responsible official on
> (i) the environmental impact of the proposed action
> (ii) any adverse environmental effects which cannot be avoided should the action be implemented
> (iii) alternatives to the proposed action
> (iv) the relationship between short-term uses of man's environment and the maintenance and enhancement of long term productivity and
> (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented (2, p. 267).

It further requires these agencies to study, develop, and describe alternatives to those courses of action which would have a detrimental effect on the environment. Section 102(2) (d) requires that any Federal agency which is proposing either a major action or an action significantly affecting the environment must submit an Environmental Impact Statement to the CEQ. This has been extended to include those projects financed in part or in whole by federal aid (7, p. 1696). In 1973 this was further expanded to require impact statements to be prepared on actions "involving a Federal lease, permit, license certificate or other entitlements" (8, p. 20553). This then is not a small coverage. In reality it has had a sweeping effect. In compliance with NEPA, federal agencies had filed 6,466 draft EIS's with the CEQ by June 30, 1975 (4, p. 641).

The general format recommended by CEQ in its 1971 guidelines is shown in Appendix A (10, p. 7727). By 1975 the Environmental Protection Agency (EPA) had reviewed the process and recognized the repetitive nature of this format. In October 1975 it proposed a new format for Environmental Appraisal. A copy of the new format appears in Appendix B (1, pp. I-1 to IV-2). This format compares the effects on the environment if the project is not accomplished with the effects if the project is accomplished. Consideration of the future degradation of the environment in the absence of any action versus future conditions with the proposed actions is a much more realistic format for comparison. This new format also reflects several other new directions for EIS. Consideration of secondary and tertiary environmental impacts has been added. A highway in a rural area may cause air pollution as a primary effect but the induced residential and industrial growth may in turn create substantial pressures on available water supplies, sewage treatment facilities, and ecological balance. Often many of the secondary and tertiary impacts are more significant than all of the primary effects. Evaluation procedures for secondary and tertiary impacts are not yet well defined. Clearly though it is an area for greater concern in the future.

STATE REQUIREMENTS

State governments have also reflected the trends toward environmental concerns. They have enacted state legislation similar to NEPA. Fifteen states have enacted legislation similar to NEPA to set up environmental agencies and to require environmental impact statements. These are California, Connecticut, Hawaii, Indiana, Maryland, Massachusetts, Minnesota, Montana, New York, North Carolina, South Dakota, Virginia, Washington, Wisconsin, and Puerto Rico. Three other states, Michigan, New Jersey and Texas have comprehensive executive or administrative orders. Arizona, Delaware, Georgia, Nebraska, Nevada, and New Jersey also have special or limited EIS requirements (4, pp. 659-664).

The most progressive of the state requirements is found in California which has enacted the California Environmental Quality Act (CEQA). CEQA is only one of the more recent actions taken to preserve the state's critical environmental resources. Its framework respects the desire for home rule but provides minimum guidelines and requirements that must be met by local governments. State agencies have full or substantial authority on water quality matters, development of water resources, rural sub-divisions, vehicular sources of air pollution, forest practices, fish and wildlife, the use of pesticides, and numerous specialized activities such as location of utilities and oil and gas well drilling (11, p. 7). Local governments have authority over most other forms on environmental concerns. CEQA establishes minimum standards that must be met by local governments but allows the ultimate decisions to be made at the local level. Environmental Impact Statements are required on all state and local projects. As a result of the State Supreme Court ruling in Friends of Mammoth V. Board of Supervisors of Mono County, CEQA was expanded to include private developments which had a minimal link between the government and the proposed project. Such a link could be "either by direct interest or by permitting, recommending, or funding private activities" (11, p. 26). Thus, major private actions can also be required to file an EIS.

For a deeper analysis of the requirements of each state, the reader should refer to Trzyna's Environmental Impact Requirements in the States: NEPA's Offspring, Environmental Protection Agency Series #EPA-600/5-74-006, April 1974.

ASSESSMENT METHODS

Having established the federal and state requirements for impact analysis let us turn our attention to the techniques and methods available to conduct the environmental assessment process and prepare an EIS. Engineers and architects have been proficient and experienced in developing alternatives and comparing them using cost-benefit analysis. They have developed a great deal of expertise in evaluating alternatives and determining a "best cost-benefit" alternative. One major disadvantage of this method is that it does not usually consider factors that are not quantifiable as costs and benefits. Such factors, if included at all, are usually given a subjective evaluation and cursory treatment. Environmental or historical factors are the most difficult to analyze because of their subjective nature.

If done properly, environmental planning can be meshed effectively into the normal pattern of design. The generalized procedure for using any assessment is a systems approach.

A. Statement of the Objective - this lists the objectives to be accomplished by the project.

B. Technological Possibilities - the total realm of possible alternatives or options are considered and listed. This is an opportunity to examine all major alternatives.

C. Proposed Alternatives - feasible alternatives are considered from the host of possibilities. One alternative which should always be considered is the "do nothing" alternative.

D. Status of the Environment - this report characterizes the environment as it exists prior to the proposed action. It is frequently called the base line report. It details the existing air quality, water quality, wildlife habitat, and natural resources in the affected project area.

E. Engineering Plans - Engineering plans are developed to follow the alternatives selected in C above. These plans are completed and include projected costs and benefits.

F. Identification of Impact and Magnitude of Impact upon the Environment. Engineering plans are now analyzed to determine the effect they will have upon the environment. It is necessary to first identify which factors in the environment will be affected by the proposed engineering plans. Once key factors to be affected are identified, the magnitude of the impact is determined. Furthermore it is necessary to determine the importance of this impact on the overall environment.

For example installing a parking lot will totally remove surface vegetation in the area of the parking lot. The magnitude of the impact is thus extremely high. On the other hand the importance of this surface vegetation may be minimal. This example also points out another important consideration. It is comparatively easy to determine the magnitude of environmental impacts. This can usually be done on some form of objective rating system. On the other hand, evaluating the importance of an environmental impact is usually much more difficult and requires a subjective analysis.

G. Assessment of Impact - Once the environmental impacts of the engineering plans on the existing conditions are identified and determined according to magnitude and importance, it is necessary to assess what the total impact will be on the environment. Each alternative is evaluated separately. At this point an EIS is prepared on each alternative still under serious consideration.

H. Alternatives Refined - Once significant environmental impacts are determined, the alternatives are refined to reduce or eliminate these impacts. If necessary new alternatives are generated which will lessen the environmental impact.

I. Recommendations - An alternative is chosen based on the engineering plans and estimates, the cost-benefit analysis, and the environmental impact of the project. The written recommendation should discuss the rationale behind each selection, the factors considered, and particularly those irretrievable resources which the project will affect.

This provides a general description of the process involved in preparing an EIS. Step G, the assessment of impact is actually one of the most difficult aspects of environmental planning. There are checklists available to list the usual primary impacts of project types. Professionals with a knowledge of the site and the nature of the project can determine the importance of a specific environmental impact. It is in the comparison of alternatives that assessment techniques have their widest use.

Methods of assessment can be broken into several types.

A. Matrix

B. Inter-action Matrix

C. Overlays

D. Checklist

E. Ad hoc method

One example of each of these types will be discussed in this paper. Appendix C is a more complete list covering 17 specific methodologies available and gives a review of each (13, pp. 195-210). It provides readers with a ready comparison of these methods and enables them to select a method for further research. Another excellent bibliography is from the Council on Planning Librarians, entitled, Environmental Impact Assessment Methodologies. An Annotated Bibliography (12).

MATRIX METHOD

One of the first methodologies published was published by Luna C. Leopold in the US Geological Survey # 645 (5). His technique was to utilize a standard matrix format to analyze all projects. The matrix could be expanded to reflect additional factors to be considered. On one axis of the matrix Leopold listed the existing environmental conditions which might be affected by the project. On the other axis he listed the specific actions of the project that might cause environmental impact. Leopold used a sample matrix that was 88 x 100 creating 8800 possible interactions to be considered. The user would normally create his own matrix using Leopold's conditions as a comprehensive source but adding additional conditions more specifically applicable to the project. The user would then list the actions involved in the project on the other axis. Leopold's sample can again be utilized as comprehensive format.

Once the matrix is determined, the user would examine each interaction and place a slash in those interactions which should be considered. Once all interactions to be considered are identified, a smaller matrix can be redrawn. Leopold states that "Preliminary trials suggest that the number of applicable interactions for a typical project analysis usually will be between 25 and 50" (5, p. 5). Later trials have confirmed that a substantially greater number would be required.

Each interaction is then examined and the magnitude of its impact plotted in the upper left-hand corner of the box. The importance of its impact is likewise plotted in the lower right-hand corner. Leopold suggests a scale of -10 to +10 for magnitude with -10 being the greatest negative environmental impact, +10 be the greatest positive impact and no impact being 0. Importance is ranked 0 to 10 with 10 being the most important. A numerical rating for each interaction is obtained by multiplying magnitude and importance. A separate matrix is prepared for each alternative. A written text accompanies the matrix and provides a record of the evaluation of each interaction.

The matrix method can be applied to all types of projects. It is a comprehensive form of assessment and serves to show the relationships between cause and effect. It is effective at communicating the results of the assessments. It has an inherent flexibility that allows it to be adapted to any level of analysis. It also serves to identify those interactions with major and minor impacts.

The matrix method is limited in its usage, however. It requires extensive subjectiveness in identifying impacts and determining the importance of interactions. Because interactions can be compared directly, the only format for comparing alternatives is interaction by interaction and developing a broad subjective analysis.

INTERACTION MATRIX

Recognizing that Leopold's matrix method can only recognize primary impacts, others have adopted systems analysis techniques to the matirx method and have developed the interaction matrix. Ross, in his Quantitative Aids in Environmental Impact Assessments describes one typical method of interaction analysis (9). Ross utilizes a matrix with the same components on both axes. In the preliminary step it is necessary to determine the components to be considered. These are defined as "each identifiable element of the environmental system being studied" (9, p. 4). Examples of these components might be salmon, herring, eelgrass, soil, water temperature, or aquatic plants. He admits that this is a difficult choice but states:

> In this respect one is probably best advised to adopt a very catholic attitude towards component creation, and designate only those which are absolutely necessary. It is anticipated that the process of component designation will involve a multi-disciplinary study team, thus several components which apply to the environmental aspects of the impact study may be defined (9, p. 4).

Once the matrix is determined Ross utilizes a nominal denotation of 0 for no interaction and 1 for our interaction. The matrix then will identify first order interaction directly. Inspection of the matrix can then be utilized to determine other orders of relationships. Ross then uses network analysis to identify those components which have a second order dependency. For example, a bird or prey may rely on a form of fish as its principal source of food. This is a first order dependency. The fish is dependent on water temperature for survival - another first order dependency. This introduced a second order dependency of the bird of prey to water temperature. An example of a completed interaction matrix comparing four alternatives is shown in Figure 1 (9, p. 30).

The interaction matrix is a definite refinement of the matrix method and provides a sound mathematical treatment of the interaction data to determine dependency relationships not easily identifiable. It provides a good visual format for communicating results of the assessment methods. When utilized by an interdisciplinary team of analysts it can be a useful technique to give a general assessment.

This procedure has significant limitations. Although it assists in quantifying the matrix method, it does not provide for any method of comparing alternatives other than interaction by interaction. Furthermore it relies on a totally subjective definition of components and analysis of the magnitude of each disruption. It fails to consider time as a factor as it does not distinguish between immediate, short term and long term disruptions. Because all interactions are considered equally, it fails to identify critical disruptions and has no provisions for treatment of irretrievable resources.

COMPONENT	1	2	3	4
1	0	0	1	0
2	1	0	0	1
3	0	1	0	0
4	0	1	0	0

Figure 1. Example of a Component Interaction Matrix

OVERLAY TECHNIQUE

Ian McHarg in Design with Nature suggests another of the original techniques for assessing environmental impacts (6). He addresses the specific problem of highway location and proposes a system of evaluating alternative routes. McHarg proposes that the present cost-benefit system does not consider social cost or benefit in its analysis. He offers a new system in which he examines the components of the environment and of man's social system and determines areas of high social cost and high social benefit. "It consists, in essence, of identifying both social and natural processes as social values (6, p. 33).

McHarg proposes that although we may not be able to put a price on institutions and natural processes we may without difficulty develop some comparative standard for each natural and social process. He establishes that where a proposed project would improve the natural or social process this would be labelled a social benefit and a destructive effort labelled a social cost. He then develops the theory of maximum social benefit at minimum social cost and uses this revised cost-benefit framework to assess the impact of various alternatives.

McHarg takes each factor and develops a graphical overlay of the area under consideration. He establishes three categories for each factor, from high social costs to low social costs. For example, slope is divided into Zone 1 - areas with slopes less than 10%, Zone 2 - areas with slopes less than 10% but in excess of 2½%, and Zone 3 - areas with slopes less than 2½%. High cost areas are then shaded in so that the darker the tone the higher the social cost. McHarg chose to examine these factors in a route location study conducted for the Borough of Richmond in New York (6, pp. 36-38).

Slope Surface Drainage Soil Drainage Bedrock Foundation Soil Foundation Susceptibility to Erosion	Normal Engineering Criteria
Land Values Tidal Inundation Historic Values Scenic Values Recreation Areas Water Values Forest Values Wildlife Values Residential Values Institutional Values	Natural and Social Processes

He prepared an overlay of each factor showing high social costs in the darkest tone. He could then utilize any series of transparencies together. The areas that had the darkest cumulative tones would have the highest social costs. By placing all of the transparencies on at one time he was able to determine those route locations that produce the lowest social cost.

McHarg's overlay technique is of particular use in communicating results to the public or where detailed methodology is not desirable. It is of great use as a screening process to make broad policy decisions and to sift out alternatives that are immediately unacceptable. Its applications in resource inventorying are widespread and contribute to a thorough understanding of the total resources available in a community. The overlay technique can help city and county officials quickly determine areas unsuited for development because of a single major disqualifying factor or a combination of factors of moderate impact.

McHarg's technique falls short of a perfect system in many areas. He implicitly assumes that every factor considered has an equal effect on the environment. Thus a unit of wildlife value is graphically portrayed the same as a unit of susceptibility to flood inundation or hurricane damage. He is unable to quantify the impacts of the alternatives and identify possible impacts. The overlay technique also requires the user to be skilled in graphical techniques of mapping and overlay preparation. Also definition of the parameters to be considered and their relative weighting requires subjective analysis.

In summary, the technique is most useful in location decision making and provides a very useful tool for an initial examination of all feasible alternatives.

CHECKLISTS

Battelle-Columbus designed another form of environmental assessment for the Bureau of Reclamation Design of an Environmental Evaluation System (14). The system was designed for determining the environmental impacts of the Bureau's many water resource projects. It can be modified to fit almost any project. The Battelle-Columbus method uses a checklist of weighted environmental categories, components and parameters to evaluate alternatives. Each alternative is then given a numerical rating so that it can be compared to other alternatives. A major objective of the method is to produce an assessment that is comprehensive, systematic, and interdisciplinary with emphasis on the systematic approach.

Battelle-Columbus divided its examination into 4 major categories, 17 components and 66 parameters. These range from general terms to specific parameters and further specify what measurements are needed to evaluate the parameters. The study describes each parameter and provides a thorough and systematic listing of the parameters that would normally be considered in a water resource project. The Battelle-Columbus method is useful in that it provides a broad and comprehensive framework for analysis.

The study goes one step further than most other systematic checklists in that it weights the impact of each parameter on the environment. This then provides a numerical "score" demanded by engineers and lay people alike. The study assigns each parameter a value of Environmental Quality Units (EQU). There are a total of 100 possible EQU's for each project. Within a given parameter, a range of quality is determined and measured through the use of a value function relating the impact to some measurement of that parameter. A listing of the parameters and their ratings is in Table 1 (14, pp. 38-39). Battelle-Columbus suggests a tentative weighting system but states that it should be further refined through practical application and provides a procedure and formula for re-evaluation of the weighting system.

The study provides for "red flag" impacts. It provides that each impact should be considered to be a potential "red flag" impact. "Red flag" impacts are those involving irreversible impacts or irretrievable resources and those involving major and catastrophic changes in the ecosystem.

The Battelle-Columbus method is a major effort to quantify the previously undefinable qualities of our environment. It seeks to achieve comprehensiveness through a "laundry-list" of parameters of the environment. It also seeks to compare "apples and oranges" by weighting each of these parameters and coming up with a "total score" for each alternative. This form of analysis obscures and distorts the trade-offs involved between the parameters. It does provide a systematic approach that can effectively evaluate different alternatives.

Table 1. Battelle-Columbus Checklist

Weights assigned to each parameter represent the combined judgment of the entire project team following several successive repetitions of weighting procedures. The weights presented below represent a suggested starting point--not the last word in defining, for all time, the relative merits of various aspects of environmental quality. One of the continuing requirements of the Bureau of Reclamation will be to assess and revise the weights assigned to each parameter as better knowledge of the public's preferences and scientific evidence become better known. The weights assigned to the parameters of the EES are as follows.

Total Environmental Quality - 1000 units

I. ECOLOGY (315 units)

A. Species & Populations (144 units)
1. Rare and endangered plant and animal species (16)
2. Productive plant species (16)
3. Game animals (16)
4. Other animals (16)
5. Resident & migratory birds (16)
6. Sport fisheries (16)
7. Commercial fisheries (16)
8. Pestilent plant and animal species (16)
9. Parasites (16)

B. Habitats and Communities (96 units)
10. Species diversity (48 units)
11. Food chains (24)
12. Land use for habitats and communities (24)

C. Ecosystems (75 units)
13. Productivity rate (25)
14. Hydrologic budget (25)
15. Nutrient budget (25)

Table 1. (Continued).

II. <u>ENVIRONMENTAL POLLUTION</u> (321 units)

D. <u>Water Pollution</u> (160 units)
16. Algal blooms (5)
17. Dissolved oxygen (20)
18. Evaporation (6)
19. Fecal coliforms (5)
20. Nutrients (12)
21. Pesticides, herbicides, defoliants (8)
22. pH (8)
23. Physical river characteristics (6)
24. Sediment load (15)
25. Stream flow (20)
26. Temperature (20)
27. Total dissolved solids (20)
28. Toxic substances (5)
29. Turbidity (10)

E. <u>Air Pollution</u> (40 units)
30. Carbon monoxide (8)
31. Hydrocarbons (8)
32. Particulate matter (8)
33. Photochemical oxidants (8)
34. Sulfur oxides (8)

F. <u>Land Pollution</u> (93 units)
35. Land use and misuse (31)
36. Soil erosion (31)
37. Soil pollution (31)

G. <u>Noise Pollution</u> (28 units)
38. Noise (28)

III. <u>ESTHETICS</u> (159 units)

H. <u>Land</u> (25 units)
39. Land forms (15)
40. Geologic surface material (10)

I. <u>Air</u> (11 units)
41. Pleasantness of sounds

J. <u>Water</u> (39 units)
42. Surface characteristics (25)
43. Water-land interface characteristics (14)

Table 1. (Continued).

K. Biota (28 units)
- 44. Vegetation (18)
- 45. Fauna (10)

L. Man-made Objects (21 units)
- 46. Visual (8)
- 47. Condition (5)
- 48. Consonance with environment (8)

M. Composition (35 units)
- 49. Interaction of land, air, water, and manmade objects (25)
- 50. Color (10)

IV. HUMAN INTEREST (205 units)

N. Educational-Scientific Significance (64 units)
- 51. Geological significance (18)
- 52. Ecological significance (18)
- 53. Archeological significance (18)
- 54. Unusual water phenomenon (10)

O. Historical Significance (55 units)
- 55. Related to persons (11)
- 56. Related to events (11)
- 57. Related to religions and cultures (11)
- 58. Related to architectures and styles (11)
- 59. Related to the "western frontier" (11)

P. Cultural Significance (54 units)
- 60. Related to Indians (18)
- 61. Related to religious groups (18)
- 62. Related to other ethnic groups (18)

Q. Mood-Atmosphere Significance (32 units)
- 63. Isolation-solitude (8)
- 64. Awe-inspiration (8)
- 65. "Oneness" with nature (8)
- 66. Mystery (8)

AD HOC METHOD

By far the most common method of impact assessment in use today is the ad hoc method. The procedure for the ad hoc process is somewhat similar to the original procedure of environmental planning suggested. It differs in that environmental consideration is added after the engineering alternative is chosen. Once an alternative is determined to be the best from the engineering and economic viewpoints, the alternative is then examined to determine what impact it will have on the environment. A multidisciplinary team is called on to list the typical impacts of projects of this nature and to examine the site selected to determine what specific impacts the project will have. A narrative is written about the project using the format at Appendix B (1, pp. I-1 to IV-2) and giving general statements about the effect of the project on the environment. If these statements go into detail about the site, they typically will delve into a detailed inventory of the existing flora and fauna but will not detail the primary or secondary effect the project will have.

These statements do not consider other alternative locations. In most cases, property has been purchased based on economic and developmental considerations only. The size and type of the project have also been determined by this same process. Therefore any new alternatives are not considered "feasible." These statements, however, determine methods of reducing the environmental impact of the project and generally will list these as a positive benefits of the project.

Writers of these statments generally are more concerned with the administrative accuracy of the statement than with its content. They are quick to follow a format that was used successfully on a previous project. Agencies contribute to this by using administrative checklists for review rather than in-depth analysis. Some agencies utilize public opinion as a check of accuracy. "If no public opinion is stirred up against a project, it must be okay..." seems to be their guideline. Concessions are made to the environment and modifications are made to lessen the impact. By and large these concessions are viewed as unnecessary and frivolous at best.

EVALUATION OF THE EFFECTS OF NEPA

Having presented several methods of assessment, I feel it is fitting to close with an evaluation of the major effects of NEPA. Although many engineers and businessmen have fought and oppose NEPA bitterly, they have to admit that it has improved the environmental quality of the entire nation. In its annual report Environmental Quality 1972, the Council on Environmental Quality listed five significant impacts that NEPA has had on the Federal Government (3).

> For the first time, maintaining environmental quality is acknowledged to be 'the continuing responsibility of the Federal Government.' Each agency has had its horizon broadened to include not only its own parochial concerns but also the need to 'assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.' (3, p. 256).

This has been a major federal effort to broaden the horizons of the entire nation. All too often, agencies have become tremendously parochial and developed tunnel vision about their area of concern. The nation desperately needs some external push to compel us to examine the future and the total effect of our actions. NEPA has fostered a growing concern to examine the effects of our actions and relate them to the world we live in. It has forced upon us the realization that man is only a part of the environment - not the controlling force of the environment. This concern and self-examination must be significant enough to prevent us from destroying the very ecology that supports us.

> Second, the 102 process provides a systematic way for the Government to deal with complex problems that cut across the responsibilities of several agencies. Many of the modern problems faced by the government are inherently complex and are larger than the responsibility of a single agency (3, p. 256).

NEPA requires that an EIS be furnished to other governmental agencies for their review and comment. This has been effective in drawing together and coordinating the bureaucracies of the federal government. It has forced agencies to insure that their actions have been coordinated and that their efforts are not counter-productive with another federal agency. The review process has served as a central focal point for all federal action in a specific area. Admittedly this has created an additional layer of bureaucracy with the attendant time and money delays. The review process of NEPA has created a new level in each federal agency whose responsibility it is to review and comment on EIS. It has also served to unify the major goals and directions of federal actions.

> Third, the 102 process has opened a broad range of Federal Government activities to public scrutiny and participation for the first time. Although many agency procedures were formerly closed, the agencies are now required to explain their decisions when significant environmental values are concerned (3, p. 256).

This is one of the broadest and most far reaching of the effects of NEPA. With the requirements for review have come the requirements for public hearings and public involvement in the decision-making process of our government. Prior to NEPA, citizen involvement was viewed as obstructionist and superfluous. Projects had already been proposed, designed, and were under construction before those affected were even aware of the project. This could be tied directly to the long lead times required for authorization and funding through Congress. Under NEPA, citizen comment is not only accepted, it is required. Draft EIS's must be made available to the public at least 15 days prior to any public hearings. Notices of these public hearings must be sent to interested parties and to local and state governmental agencies. Figure 2 shows the normal process of review and comment of an EIS (10, p. 7729). Also, by forcing public scrutiny of the policies and actions of federal agencies, NEPA has allowed public questioning and legal action concerning the intricate decision-making processes of federal agencies. This exposure has also provided the basis for the legal action which will be discussed later. It has served also to educate the nation and to produce a better-informed public. Mrs. Ruth Clusen, former Vice-President of the League of Women Voters offers some key advice to public administrators in dealing with the public.

> The first suggestion is not to patronize or talk down to a citizen; it is preferable to assume that the citizen knows more than he actually does than to treat him as what Mr. Springer humorously described as the "proverbial dumb layman." Second, involve people from the beginning, rather than inviting them in to rubber stamp a "fait accompli." All of the speakers emphasized this obvious but often ignored necessity. Third, be frank and honest to citizens and do not hesitate to describe the trade-offs involved. Offer technical assistance including scientific, technical and professional advice; citizens usually lack the resources to acquire the needed information. Workshops and educational programs are methods to meet this need. Fourth, do not expect support on every subject. Fifth, spell out the processes and complexities of government, including referral to individuals within the system who can offer

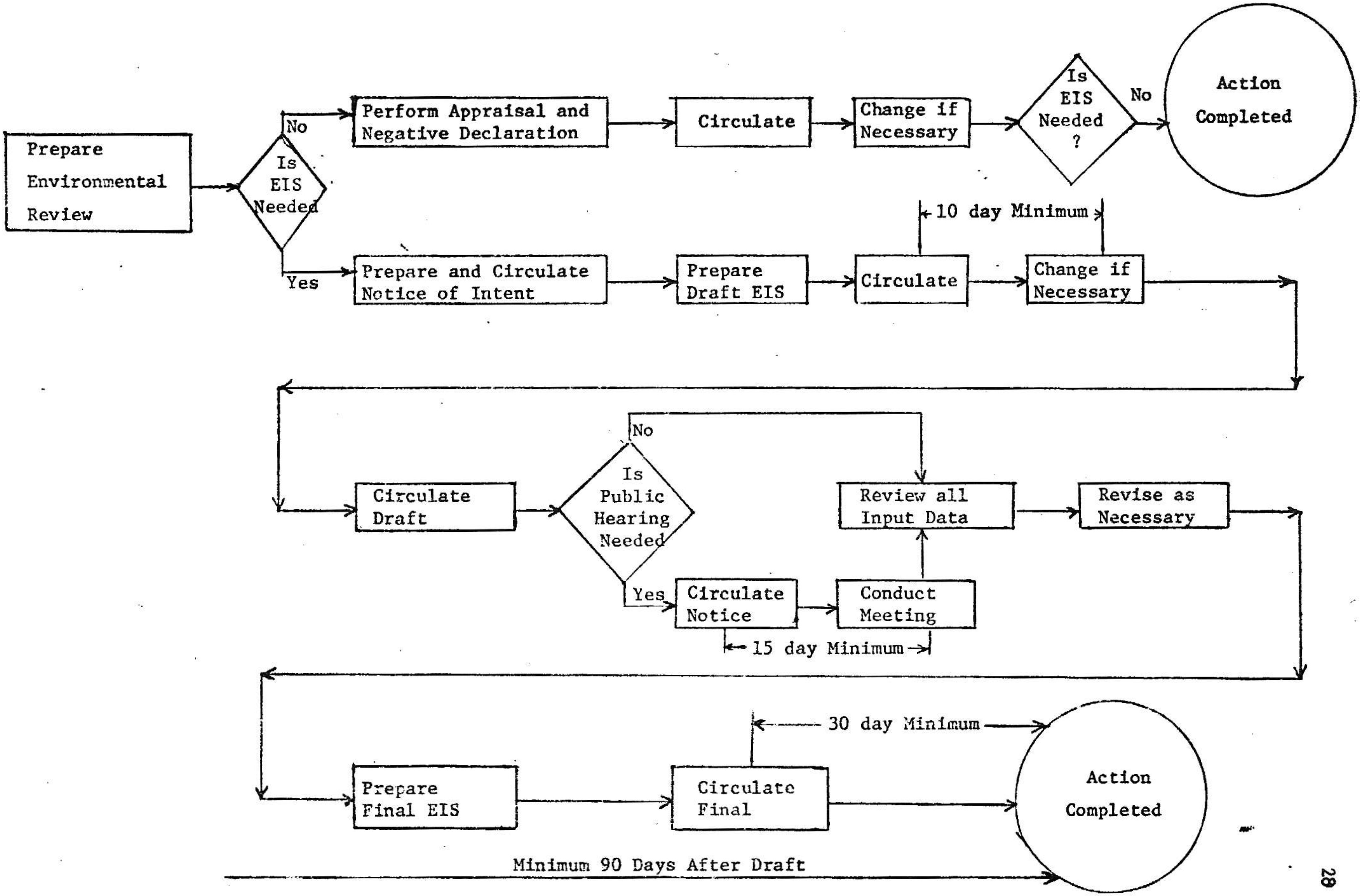
Prepare Environmental Review
Is EIS Needed
No
Yes
Perform Appraisal and Negative Declaration
Circulate
Change if Necessary
Is EIS Needed ?
No
Action Completed
Prepare and Circulate Notice of Intent
Prepare Draft EIS
Circulate
10 day Minimum
Change if Necessary
Circulate Draft
Is Public Hearing Needed
No
Yes
Circulate Notice
Conduct Meeting
15 day Minimum
Review all Input Data
Revise as Necessary
Prepare Final EIS
Circulate Final
30 day Minimum
Action Completed
Minimum 90 Days After Draft

Figure 2.

> further assistance. Do not consider citizen participation as adversary procedure; it can and should be a productive interchange. Finally, receptiveness to the ideas and opinions of citizens is essential.

Her advice is sound and is particularly important in light of the requirements by NEPA for public involvement in the EIS. All too often federal agencies have forgotten how to communicate with those outside their field.

> Fourth, agencies whose personnel have reflected a narrow focus of concerns are being required now to supplement their staffs with persons of different backgrounds relevant to environmental issues. NEPA's required 'interdisciplinary' approach means that personnel must be hired who bring not only new skills but a fresh viewpoint into the agencies (3, p. 256).

The interdisciplinary approach required by NEPA has forced all federal agencies to add new members to their staff. This forced conversation and cooperation between different disciplines has led to significant improvements in the environmental effect of projects. The interdisciplinary approach has created a need for engineers and administrators who have been trained in the social science and environmental fields. This training has provided the opportunity for engineers to adapt their work so as to reduce its adverse impact on the environment. Additionally the different outlooks and different value systems of the environmentalists have provided a needed sounding board to point out the disadvantages of a project and prevent seemingly minor impacts from being overlooked.

> Fifth NEPA's initiatives are enforceable in Federal court by citizen suit .... The willingness of citizens to sue to vindicate NEPA and the vigilance of the courts in enforcing the Act help to ensure that the agencies take their new tasks seriously (3, p. 256).

This has been another of the monumental effects of NEPA. It has provided the legal framework for local interest groups and concerned citizens to challenge the actions of the nation's largest agencies. The American people have been quick to use this power. They have brought suit to stop actions ranging from the Cross Florida Barge Canal to the location of county roads. This provision has also been used to shape our federal policies and to force compliance of the Federal Government with the provisions of NEPA. When coupled with the over-zealousness and near fanaticism of the "no-growth" representatives, NEPA has forced the nation to thoroughly analyze and to decide what price we will pay for progress.

CONCLUSIONS

The Environmental Protection Act has had a far reaching effect on the nation. It has come at a time when we are concerned with getting back to nature and has heightened our national awareness of the world around us. It has had its effect at every level of government with many state and local governments implementing their own policies and procedures to protect the environment. It has required engineers and planners to consider the total effect of their actions on the world. NEPA has added a vital review and comment process to federal actions. This has provided an opportunity for minority opinions to be expressed.

NEPA has required that concern for the environment be introduced to the planning process. It has directed that this be done in the earliest stages of the project. This has generally not been accomplished. EIS are written once the project is proposed. A significant benefit is that negative impacts have to be identified and actions taken to correct or lessen their impact. Communication between natural scientists and engineers, even if only to meet a legal requirement, has had a valuable effect on the ecology of the nation. The natural scientists have been able to point out minor adjustments in engineering plans that have had major beneficial impacts on the ecology.

The methodology to assess the total impact of projects and to adequately compare alternatives exists. The matrix method and the overlay technique are excellent for doing initial work and for communicating the results of more complex methods to local administrators and elected officials. More complex methods such as the checklist and computer programs can be used for detailed analysis of specific alternatives. Although this methodology is available and valid, the ad hoc method is the most widely used. It does not meet the intent of NEPA but has done a great deal to improve the effect of construction on the environment.

NEPA is here to stay. By understanding the requirements it imposes and the techniques available to meet those requirements, local governments and engineers will be able to profit from NEPA while at the same time contribute to man's continued existence on our planet.

APPENDIX A

ENVIRONMENTAL IMPACT APPRAISAL
SUGGESTED FORMAT

A. Identify Project

Name of Applicant:

Address:

Project Number (if assigned):

B. Summarize Assessment

1. Brief description of project:

2. Probable impact of the project on the environment.

3. Any probable adverse environmental effects which cannot be avoided.

4. Alternatives considered with evaluation of each.

5. Relationship between local short-term uses of environment and maintenance and enhancement of long-term productivity.

6. Any irreversible and irretrievable commitment of resources:

7. Public objections to project, if any, and their resolution:

8. Agencies consulted about the project:

State Representative's name:

Local Representative's name:

Other:

C. Reasons for concluding there will be no significant impacts.

____
Signature of Appropriate Official

APPENDIX B

I. DESCRIPTION OF THE PROPOSED NEW SOURCE

  A. Overview

  B. Summary of Major New Source Features

  C. Detailed Descriptions of New Source

    1. Description of Resource Requirements

    2. Description of the Process or Production Facility

    3. Description of Economic Benefits and Product Markets

II. ENVIRONMENT WITHOUT THE PROPOSED ACTION

  A. Purpose

  B. Special Considerations

  C. Description of the Baseline

    1. Meteorology and Climatology

    2. Air Quality

    3. Topography

    4. Geology

    5. Soils

    6. Hydrology

    7. Biology

    8. Land Uses

    9. Identification of Environmentally-Sensitive Areas

    10. Population Projections and Economic Forecasts

    11. Other Programs in the Area

III. ENVIRONMENTAL EFFECTS OF THE PROPOSED NEW SOURCE

A. General

B. Impact Identification

1. General

2. Process Impacts Identification

3. Raw Material Impact Identification

4. Transportation Impact Identification

5. Site Impact Identification

6. Other Impacts

C. Impact Evaluation

1. General

2. Universal Assessment Methodology

3. Methodology Success

4. Significance vs. Magnitude

5. Inevitable vs. Possible Impacts

6. Cumulative Impacts

7. Primary and Secondary Impacts

8. Long-Term vs. Short-Term Impacts

9. Reversibility

D. Impact Aggregation

IV. ALTERNATIVES TO THE PROPOSED NEW SOURCE

A. General

B. Special Considerations

C. Criteria

D. Detail of Alternative Description

APPENDIX C

METHODOLOGY DESCRIPTIONS

A brief description of each methodology follows, discussing the following points.

- The methodology type
- The general approach used
- The range of actions or project types for which the methodology may be applicable
- The comprehensiveness of the methodology in terms of the range of impacts addressed
- The resources required (data, manpower, time, etc).
- The limitations of the methodology (replicability, ambiguity, flexibility)
- Key ideas or particularly useful concepts offered
- Other major strengths and weaknesses as identified by the review criteria

Because of the brevity and subjectivity of these characterizations, they should not be considered as adequate critiques of the tools examined. They may instead serve as a useful introduction to the range of techniques now evolving.

1. Adkins, William G. and Dock Burke Jr., Interim Report: Social, Economic, and Environmental Factors in Highway Decision Making, research conducted for the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration: College Station, Texas; Texas Transportation Institute, Texas A&M University (October 1971).

The Adkins methodology is a checklist using a +5 to -5 rating system for evaluating impacts but providing no guidelines for measuring impacts. The approach was developed to deal specifically with the evaluation of highway route alternatives. Because the bulk of parameters used relate directly to highway transportation, the approach is not readily adaptable to other types of projects.

The parameters used are broken down into categories of transportation, environmental, sociological, and economic impact. Environmental parameters are generally deficient in ecological considerations. Social parameters emphasize community facilities and services.

Route alternatives are scored +5 to -5 in comparison to the present state of the project area, not the expected future state without the project. Since the approach uses only subjective relative estimations of impacts, the data, manpower, and cost requirements are very flexible. Reliance on subjective ratings without guidelines for such ratings greatly reduces the replicability of analysis and generally limits the valid use of the approach to a case-by-case comparison of alternatives only.

The detailed listing of social and, to a lesser extent, economic parameters may be helpful for identifying and cataloging impacts in other types of projects. An interesting feature of possible value to other analyses using relative rating systems is the practice of summarizing the number as well as the magnitude of plus and minus ratings for each impact category. The number of pluses and minuses may be a more reliable indicator for alternative comparison since it is less subject to the arbitrariness of subjective weighting. These summarizations are additive and thus implicitly weigh all impacts equally.

2. Dee, Norbert, et al, Environmental Evaluation System For Water Resources Planning, report to the U.S. Bureau of Reclamation, Columbus, Ohio: Battelle Memorial Institute (January 1972).

This methodology is a checklist procedure emphasizing quantitative impact assessment. It was designed for major water resource projects but most parameters used are also appropriate for other types of projects. Seventy-eight specific environmental parameters are defined within the four categories of ecology, environmental pollution, aesthetics, and human interest. The approach does not deal with economic or secondary impacts and social impacts are only partially covered within the human interest category.

Impacts are measured via specific indicators and formulas defined for each parameter. Parameter measurements are converted to a common base of "environmental quality units" through specified graphs or value functions. Impacts can be aggregated using a set of preassigned weights.

The resource requirements are rather high, particularly data requirements. These requirements probably restrict the use of the approach to major project assessments.

The approach emphasizes explicit procedures for impact measurement and evaluation and should therefore produce highly replicable results. Both spatial and temporal aspects of impacts are noted and explicitly weighted in the assessment. Public participation, uncertainty, and risk concepts are not dealt with. An important idea of the approach is the highlighting of key impacts via a "red flag" system.

3. Dee, Norbert, et al., Planning Methodology for Water Quality Management: Environmental Evaluation System, Columbus, Ohio: Battelle Memorial Institute (July 1973).

This unique methodology of impact assessment defies ready classification since it contains elements of checklist, matrix, and network approaches. Areas of possible impacts are defined by a hierarchial system of four categories (ecology, physical/chemical, aesthetic, social), 19 components and 64 parameters. An interaction matrix is presented to indicate which activities associated with water quality treatment projects generally impact which parameters. The range of parameters used is comprehensive, excluding only economic variables.

Impact measurement incorporates two important elements. A set of "ranges" is specified for each parameter to express impact magnitude on a scale from zero to one. The ranges assigned to each parameter within a component are then combined by means of an "environmental assessment tree" into a summary environmental impact score for that component. The significance of impacts of each component is quantified by a set of assigned weights. A net impact can be obtained for any alternative by multiplying each component score by its weight factor and summing across components.

The key features of the methodology are its comprehensiveness, its explicitness in defining procedures for impact identification and scoring, and its flexibility in allowing use of best available data.

Sections of the report explain the several uses of the methodology in an overall planning effort and discuss means of public participation.

The data, time, and cost requirements of the methodology when used for impact assessment are moderate, though a small amount of training would be required to familiarize users with the techniques used.

Because of its explicitness, the methodology possesses only minor ambiguities and should be highly replicable. Because the environmental assessment trees are developed specifically for water treatment facilities, the methodology cannot be adapted to other types of projects without reconstructing the trees though the parameters could be useful as a simple checklist.

One potentially significant obstacle to use of the approach is the difficulty of explaining the procedures to the public. Regardless of the validity of the "trees", they are unfamiliar devices developed by highly specialized multivariant analysis techniques and public acceptance of conclusions reached by their use may be low.

4. Institute of Ecology, University of Georgia, "Optimum Pathway Matrix Analysis Approach to the Environmental Decision Making Process: Test case: Relative Impact of Proposed Highway Alternatives", Athens, Georgia: University of Georgia, Institute of Ecology (1971) (mimeographed).

The "Georgia" methodology incorporates a checklist of 56 environmental components. Measurable indicators are specified for each component. The actual values of alternative plan impacts on a component are normalized and expressed as a decimal of the largest impact (on that one component). These normalized values are multiplied by a subjectively determined weighting factor. This factor is the sum of one times a weight for "initial" effects plus ten times a weight for "long-term" effects.

The methodology is used to evaluate highway project alternatives and the components listed are not suitable for other types of projects. A wide range of impact types are analyzed including land use, social, aesthetics, and economic impacts.

The lower replicability of the analysis produced by using subjectively determined weighting factors is compensated for by conducting several passes at the analysis, and incorporating randomly generated error variation in both actual measurements and weights. This procedure provides a basis for testing the significance of differences in total impact scores between alternatives.

The procedures for normalizing or scaling measured impacts to obtain commensurability, and testing of significant differences between alternatives are notable features of potential value to other impact analyses and methodologies. These ideas may be useful whenever several project alternatives can be identified and compared.

The Georgia methodology places rather high resource demands on the user since computerization is necessary to generate random errors and make the large number of repetitive calculations.

5. Krauskopf, Thomas M., and Dennis C. Bunde, "Evaluation of Environmental Impact Through a Computer Modelling Process", Environmental Impact Analysis: Philosophy and Methods, (eds.) Robert Ditton and Thomas Goodale, Madison, Wisconsin: University of Wisconsin Sea Grant Program (1972), pp. 107-125.

This methodology employs an overlay technique via computer mapping. Data on a large number of environmental characteristics are collected and stored in the computer on a grid system of 1 km square cells.

Highway route alternatives can either be evaluated by the computer (by noting the impacts on intersected cells) or new alternatives may be generated via a program identifying the route of least impact.

The environmental characteristics used are rather comprehensive, particularly as regards land use and physiographic characteristics. Though the methodology was developed and applied to a highway setting, it is adaptable, with relatively small changes in characteristics examined, to other project types with geographically well defined and concentrated impacts. Because the approach requires considerable amounts of data on the project region, it is not practical for the analysis of programs of broad geographical scope. The high manpower-skill, money, and computer technology requirements of the approach may also make it impractical at the present time for any but major projects, or in situations where a statewide, computerized data base exists (New York, Minnesota, Iowa, etc).

The estimation of impact importance is done through the specification of subjective weights. Because the approach is computerized, the effects of several alternative weighting schemes can be readily analyzed.

The methodology is attractive on several viewpoints. It allows a demonstration of which weighted characteristics are central to a particular alternative route; it presents a readily understandable graphic representation of impacts and alternatives; it easily handles several subjective weighting systems; the incremental costs of considering or generating additional alternatives is low; and it fits well with developing regional and statewide data bank systems.

The mechanics of the approach--how impacts are measured and combined--are not readily apparent from the reference cited. Considerable training beyond the information available in this reference would be required to use the approach.

6. Leopold, Luna B., et al., A Procedure for Evaluating Environmental Impact, Geological Survey Circular 645, Washington: Government Printing Office (1971).

This is an open-cell matrix approach identifying 100 project activities and 88 environmental characteristics or conditions. For each action involved in a project, the analyst evaluates the impact on every impacted environmental characteristic in terms of impact magnitude and significance. These evaluations are subjectively determined by the analyst. Ecological and physical-chemical impacts are treated comprehensively, social and indirect impacts are less well handled, and economic and secondary impacts are not addressed.

Because the assessments made are subjective, resource requirements of the approach are very flexible. The approach was not developed in reference to any specific type of project and may be broadly applied with some alterations.

Guidelines for use of the approach are minimal and several important ambiguities are likely in the definition and separation of impacts. The reliance on subjective judgment, again without guidelines, reduces the replicability of the approach.

The approach is chiefly valuable as a means of identifying project impacts and as a display format for communicating results of an analysis.

7. Arthur D. Little, Inc., Transportation and Environment: Synthesis for Action: Impact of National Environmental Policy Act of 1969 on the Department of Transportation, Vol. 3, Options for Environmental Management, prepared for Office of the Secretary, Department of Transportation (July 1971).

This is less a complete methodology than an overview discussion of the kinds of impacts that may be expected to occur from highway projects and the measurement techniques that may be avilable to handle some of them. A quite comprehensive list of impact types and the stages of project development at which each may occur are presented. As broad categories, the impact types identified are useful for other projects as well as for highways.

The approach suggests the separate consideration of an impact's amount, effect (public response), and value. Some suggestions are offered for measuring the amount of impact within each of seven general categories: noise, air quality, water quality, soil erosion, ecologic, economic, and sociopolitical impacts.

Five possible approaches to the handling of impact significance are presented. Three of these are "passive" (requiring no agency action) such as "reliance on the emergence of controversy". The other two involve the use of crude subjective weighting scales. No specific suggestions are made for the aggregation of impacts either within or between categories.

In general, the reference cited is a useful discussion of some of the important issues of impact analysis, particularly as they apply to transportation projects, but does not present a complete analytical technique.

8. McHarg, Ian., "A Comprehensive Highway Route-Selection Method", Highway Research Record, Number 246, 1968, pp. 1-15, or McHarg, Design with Nature, Garden City, New York: Natural History Press, 1969, pp. 31-41.

The McHarg approach is a system employing transparencies of environmental characteristics overlaid on a regional base map. Eleven to sixteen environmental and land use characteristics are mapped. The maps represent three levels of the characteristics, based upon "compatibility with the highway". These references do not indicate how this compatibility is to be determined but available documentation is cited.

This approach is basically an earlier, noncomputerized version of the ideas presented in the Krauskopf reference. Its basic value is as a method for screening alternative project sites or routes. Within this limited use, it is applicable to a variety of project types.

Limitations of the approach include its inability to quantify as well as identify possible impacts and its implicit weighting of all characteristics mapped.

Resource requirements of the McHarg approach are somewhat less demanding, in terms of data, than those of the Krauskopf approach because information is not directly quantified, only categorized into three levels. High degrees of skill and training are required, however, to prepare the map overlays.

The approach seems most useful as a "first cut method" of identifying and sifting out alternative project sites, preliminary to detailed impact analysis.

9. Moore, John L., et al., A Methodology for Evaluating Manufacturing Environmental Impact Statements for Delaware's Coastal Zone, Report to the State of Delaware, Columbus, Ohio: Battelle Memorial Institute (June 1973).

This approach was not designed as a method for impact analysis but its principles could be adapted for such use. It employs a network approach, linking a list of manufacturing-related activities to potential environmental alterations, to major environmental effects, and finally to human uses affected. The primary strength of the set of linked matrices is their utility in displaying cause-condition-effect networks and tracing out secondary impact chains.

Such networks are useful primarily for identifying impacts and the issues of impact magnitude and significance are addressed only in terms of high, moderate, low, or negligible damage. As a result of these subjective evaluations the approach would have low replicability as an assessment technique. For such a use, guidelines would likely need to be proposed to define the evaluation categories.

The approach incorporates indicators especially tailored to manufacturing facilities in a coastal zone though most indicators would also be pertinent to other types of projects.

The approach would perhaps be valuable as a visual summary of an impact analysis for communication to the public and decision makers.

10. Central New York Regional Planning and Development Board, Environmental Resources Management, prepared for Department of HUD (October 1972) (available through the National Technical Information Service PB 217-517).

This methodology employs a matrix approach to assess in simple terms the major and minor, direct and indirect impacts of certain water related construction activities. It is designed primarily to measure only the physical impacts of water resource projects in a watershed, and is based on an identification of the specific, small-scale component activities that are included in any project. Restricted to physical impacts on nine different types of watershed areas (e.g., wetlands) and fourteen types of activities (e.g., tree removal), the procedure indicates four possible levels of impact-receptor interactions (major direct through minor indirect). Low to moderate resources in terms of time, money, or personnel are required for the methodology, due principally to its simple way of quantification (major versus minor impact). However, the procedure is severely limited in its ability to compare different projects or the magnitude of different impacts. There is no spatial or temporal differentiation, hence the full range of impacts cannot be assessed. Impact uncertainty and high damage-low probability impacts are also not considered. Only two levels of the magnitude of an impact are identified while the importance of the impacts are not assessed, resulting in moderate replicability. The lack of objective evaluation criteria may produce ambiguous results. NEPA requirements for impact assessments are not directly met by this procedure.

The value of this methodology is less in the actual assessment of the quantitative impacts of a potential project than in a "capability rating system" which determines recommended development policies based on existing land characteristics. Thus, guidelines on desirable and undesirable activities with respect to the nine types of watershed areas are used to map a region in terms of the optimum land use plan. The actual mapping procedure is not described, however, and hence that aspect of the impact assessment methodology cannot be evaluated here.

*11. Smith, William L., "Quantifying the Environmental Impact of Transportation Systems", Van Doren-Hazard-Stallings-Schnacke, Topeka, Kansas (undated) (mimeographed).

The Smith approach, as developed for highway route selection, is a checklist system based on the concepts of probability and supply-demand. The approach attempts to identify the alternative with least social cost to environmental resources and maximum social benefit to system resources. Environmental resources elements are listed as: agriculture, wildlife conservation, interference, noise, physical features, and replacement. System resources elements are listed as: aesthetics, cost, mode interface, and travel desires. For each element, categories are defined and used to classify zones of the project area. Numerical probabilities of supply and of demand are then assigned to each zone for each element. These are combined to produce a "probability of least social cost"

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*For additional material published by this author see "References."

(or maximum social benefit). These social cost probabilities are then multiplied across the elements to produce a total for the route alternative under examination.

The approach is tailored and perhaps limited to project situations requiring comparison of siting alternatives. The range of environmental factors examined is very limited, but presumably could be expanded to cover more adequately ecological, pollution, and social considerations.

Since procedures for determining supply and demand probabilities are not described, it is difficult to anticipate the amounts of data, manpower and money required to use the approach. The primary limitations of this methodology are difficulties inherent in assigning probabilities, particularly demand probabilities, and the implicitly equal weightings assigned to each element analyzed when multiplying to yield an aggregate score for an alternative.

12. Sorensen, Jens, A Framework for Identification and Control of Resource Degradation and Conflict in the Multiple Use of the Coastal Zone, Berkeley: University of California, Department of Landscape Agriculture (1971), and Sorensen and James E. Pepper, Procedures for Regional Clearinghouse Review of Environmental Impact Statements -- Phase Two, report to the Association of Bay Area Governments (April 1973).

These two publications present a network approach usable for environmental impact analysis. The approach is not a full methodology but rather a guide to the identification of impacts. Several potential uses of the California coastal zone are examined through networks relating uses-to causal factors (project activities)-to first order condition changes-to second and third order condition changes, and finally-to effects. The major strength of the approach is its ability to identify the pathways by which both primary and secondary environmental impacts are produced.

The second reference also indicates types of data relevant to each effect identified, though no specific measurable indicators are suggested. In this reference some general criteria for identifying projects of regional significance are suggested, based on project size and types of impacts generated, particularly land use impacts.

Because the preparation of the required detailed networks is a major undertaking, the approach is presently limited to some commercial, residential, and transportation uses of the California coastal zone for which networks have been prepared. An agency wishing to use the approach in other circumstances might develop the appropriate networks for reference in subsequent environmental impact assessments.

13. Stover, Lloyd V., Environmental Impact Assessment: A Procedure, Miami, Florida: Sanders and Thomas, Inc. (1972).

This methodology is a checklist procedure for a general quantitative evaluation of environmental impacts from development activities. The type and range of these activities is not specified, but is believed to be comprehensive. Fifty different impact parameters are sufficient to include most possible effects, and thereby allow much flexibility. Subparameters indicate specific impacts, but there is no indication of how the individual measures are aggregated into a single parameter value. While spatial differences in impacts are not indicated, both initial and future impacts are included and explicitly compared. Resource requirements are moderate to heavy, especially in terms of an interdisciplinary personnel team which grows as more subparameters are included, requiring additional expertise in specific areas. However, the actual measurements are not based on specific criteria and are only partially quantitative, with seven possible values ranging from an extremely beneficial impact to an extremely detrimental one. Therefore, there is potential for ambiguous and subjective results, with only moderate replicability. Impact areas are implicitly assumed to be of equal importance. A specific methodology is mentioned for choosing the optimum alternative in terms of benefits and adverse effects. The procedure for alternatives comparison may be the most interesting aspect of the procedure, with results given in terms of the proportional significance of an impact vis-a-vis other potential alternatives. There is no explicit mention of either public involvement in the process, or environmental risks.

The impact assessment procedure is presented as only one step in a total evaluation scheme which includes concepts of dynamic ecological stability and other ideas. An actual description of the entire process is not included, however.

14. Multiagency Task Force, "Guidelines for Implementing Principles and Standards for Multiobjective Planning of Water Resources", Review Draft, Washington: U.S. Bureau of Reclamation (1972).

The Task Force approach is an attempt to coordinate features of the Water Resources Council's Proposed Principles and Standards for Planning Water and Related Land Resources with requirements of NEPA. It develops a checklist of environmental components and categories organized in the same manner as the WRC Guidelines. The categories of potential impacts examined deal comprehensively with biological, physical, cultural, and historical resources, and pollution factors but do not treat social or economic impacts. Impacts are measured in quantitative terms where possible and also rated subjectively on "quality" and "human influence". In addition, uniqueness and irreversibility considerations are included where appropriate. Several suggestions for summary tables and bar graphs are offered as communications aids.

The approach is general enough to have wide applicability to various types of projects, though its impact categories are perhaps better tailored to rural than urban environments. No specific data or other resources are required to conduct an analysis, though an interdisciplinary project team is specified to assign the subjective weightings. Since quality, human influence, uniqueness, and irreversibilities are all subjectively rated using general considerations only, results produced by the approach may be highly variable. Significant ambiguities include a generally inadequate explanation of how human influence impacts are to be rated and interpreted.

Key ideas incorporated in the approach include explicit identification of the without-project environment as distinct from present conditions, and use of uniqueness rating system for evaluating quality and human influence (worst known, average, best known, etc). The methodology is unique among those examined in not labeling impacts as environmental benefits or costs but only as impacts to be valued by others. The approach also argues against the aggregation of impacts.

15. Tulsa District, U.S. Army Corps of Engineers, Matrix Analysis of Alternatives for Water Resource Development, draft technical paper (July 31, 1972).

Despite the title, this methodology can be considered a checklist under the definitions used here since, though a display matrix is used to summarize and compare the impacts of project alternatives, impacts are not linked to specific project actions. The approach was developed to deal specifically with reservoir construction projects but could be readily adapted to other project types.

Potential impacts are identified within three broad objectives: environmental quality, human life quality, and economics. For each impact type identified, a series of factors are described, indicating possible measurable indicators. Impact magnitude is not measured in physical units but by a relative impact system. This system assigns the future state of an environmental characteristic without the project a score of zero; then assigns the project alternative possessing the greatest impact on that characteristic a score of +5 (for positive impact), or -5 (for negative impact). All other alternatives are assigned scores between 0 and 5 by comparison. The raw scores thus obtained are multiplied by weights determined subjectively by the impact analysis team.

Like the Georgia approach, the Tulsa methodology tests for the significance of differences between alternatives by introducing error factors and conducting repeated runs. The statistical manipulations are different from those used in the Georgia approach, however, and considered by the Corps' writers to be more valid.

Resource requirements of the Tulsa methodology are variable. Since specific types or levels of data are not required, data needs are quite flexible. The consideration of error, however, requires specific skills and computer facilities.

The major limitations of the approach, aside from the required computerization, are the lack of clear guidelines on exactly how to measure impacts and the lack of guidance on how the future no-project state is to be defined and described in the analysis. Without careful description of the assumptions made, replicability of analyses made using the approach may be low since only relative measures are used. Since all measurements are relative, it may also be difficult in some cases to deal with impacts that are not clearly definable as gains or losses.

The key ideas of wider interest incorporated in the Tulsa approach include reliance on relative rather than absolute impact measurement, statistical tests of significance with error introduction, and specific use of the no-project condition, as a base line for impact evaluation.

16. Walton, L. Ellis, Jr., and James E. Lewis, A Manual for Conducting Environmental Impact Studies, Virginia Highway Research Council (January 1971) (available through the National Technical Information Service PB-210 222).

The Walton methodology is a checklist, unique in its almost total reliance on social impact categories and strong public participation. The approach was developed for the evaluation of highway alternatives and identifies different impact analysis procedures for the conceptual, corridor, and design states of highway planning. All impacts are measured by either their dollar value or a weighted function of the number of persons affected. (The weights used are to be determined subjectively by the study team.) The basis for most measurements is a personal interview with a representative of each facility or service impacted.

Resource requirements for such a technique are highly sensitive to project scale. The extensive interviewing required may make the approach impractical for many medium-size or large projects because agencies preparing impact statements seldom have the necessary manpower or the money to contract for such extensive interviewing.

Analyses produced by the approach may have very poor replicability due to the lack of specific data used and the criticality of the decision regarding boundaries of the analysis since many impacts are measured in numbers of people affected. There is also no means of systematically taking into account the extent to which these people are affected.

The key ideas of broader interest put forth by the approach are the use of only social impacts without direct consideration of other impacts (pollution, ecology, etc), the heavy dependence on public involvement and specific suggestions on how the public may be involved, and the recognition of the need for different analyses of different stages of project development.

17. Western Systems Coordinating Council, Environmental Committee, Environmental Guidelines (1971). (Mr. Robert Coe, Southern California Electric Company, Environmental Committee Chairman.)

The environmental Guidelines are intended primarily as a planning tool for siting power generation and transmission facilities. However, they address many of the concerns of environmental impact analysis and have been used in the preparation of impact statements. Viewed as an impact assessment methodology, the approach is an ad hoc procedure, suggesting general areas and types of impacts but not listing specific parameters to examine.

The approach considers a range of pollution, ecological, economic (business economics), and social impacts but does not address secondary impacts such as induced growth, or energy use patterns. The format of the approach is an outline of considerations important to the selection of sites for each of several types of facilities -- e.g., thermal generating plants, transmission lines, hydroelectric and pumped storage, and substations. An additional section offers suggestions for a public information program.

Since the approach does not suggest specific means of measuring or evaluating impacts no particular types of data or resources are required. The application of this approach is limited to the siting of electric power facilities with little carry over to other types of projects.

APPENDIX D

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ENVIRONMENTAL IMPACT ASSESSMENT

by

CHARLES WINGARD JONES

B.S. United States Military Academy, 1968

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ABSTRACT

This paper presents the requirements for Environmental Impact Statements and discusses the methodology currently available to perform impact assessment. It presents the Federal requirements for Impact Statements and provides a suggested format for Environmental Impact Statements. It presents a survey of the state requirements for Impact Assessment.

The paper presents the 5 major methodologies of performing Impact Assessment. It examines the Matrix Method as proposed by Leopold, et al., the Interaction Matrix Method as presented by Ross of Environment Canada; the Overlay Technique presented by McHarg in his Design with Nature; the checklist Methods proposed by Battelle Columbus; and the Ad Hoc Method used by the majority of agencies. The paper examines their applicability in the assessment process and presents strong and weak points of each method. Appendix C provides an annotated bibliography of additional major works on assessment methodologies.

The effect of the National Environmental Policy Act on the nation is evaluated. NEPA has served to broaden the Federal decision making process and to provide for the public input into this process.