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APPROPRIATE METHODOLOGIES FOR THE IDENTIFICATION OF ENVIRONMENTAL IMPACTS AND THE EVALUATION OF ALTERNATIVES

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APPROPRIATE METHODOLOGIES FOR IDENTIFICATION OF IMPACTS

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1. INTRODUCTION

A comprehensive identification of impacts associated with a proposed action is a fundamental component of any environmental impact assessment (EIA). A variety of impacts, of varying degrees of severity, may be exerted by a project on both natural resources and social systems. Before any effort is made to quantify and evaluate impacts, it is necessary that a complete listing of potential impacts be established. An orderly system for identifying all of a project's impacts is needed by both the experienced and the novice alike. Numerous methodologies have been developed to meet this need. Many are appropriate for direct adaptation, or use with modifications, in the Caribbean region.

1.1 Purposes of Impact Identification

Figure 1 shows a schematic overview of the EIA process. Impact identification methodologies are applied during the preparation of the EIA report, after the environmental baseline conditions have been established and at least a preliminary project description has been developed. (In practice, the design features of many projects are seldom fixed until the time of construction. Thus it is common in the preparation of an EIA report to frequently adjust the impact analyses in response to changing project characteristics.) Once a comprehensive listing of potential impacts has been established, prediction and evaluation may proceed. The primary purpose of applying impact identification methodologies is to assure that no potential impacts escape consideration in the EIA report. As a cost saving measure, the parties concerned with the preparation of the EIA might agree to exclude from subsequent analysis those impacts which are reasonably certain to be insignificant. However, the establishment of a comprehensive list of potential impacts is necessary even before this decision can be made.

Simple impact identification methodologies may be used for other purposes earlier in the EIA process, when only minimal project and baseline data are available. During planning and scoping, a preliminary identification of impacts is necessary to define the terms of reference for the study. Simple checklists and ad-hoc procedures are appropriate for this purpose. More complex methodologies would be too costly and time consuming to use here. In addition, the roughness of the in-

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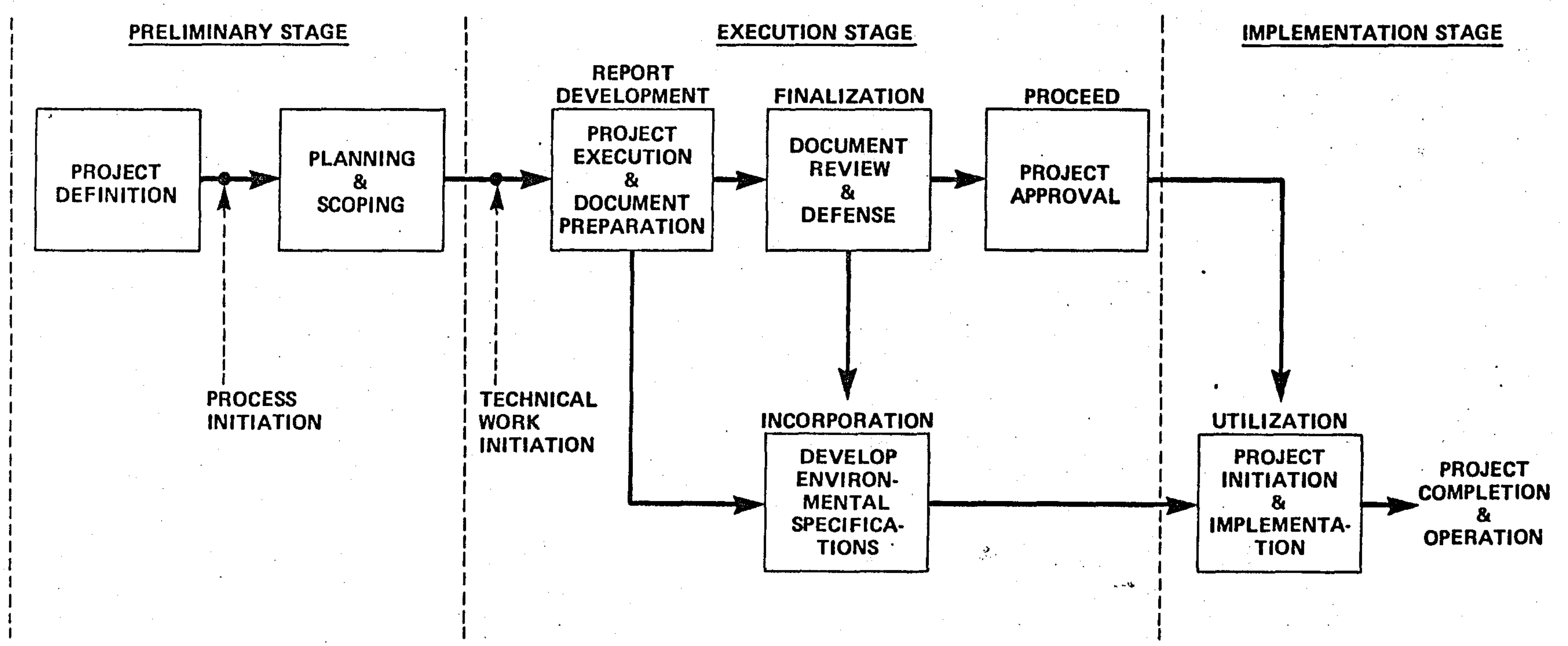
FIGURE 1

OVERALL SCHEME FOR IMPLEMENTING EIA PROCESS



put data at this early stage could not justify the use of a complex methodology.

Simple methodologies could also be used by the project sponsor to obtain a preliminary estimate of feasibility and to make a preliminary comparison of alternatives. An early listing of potential impacts may help the sponsor decide whether or not to continue with development of the project concept. By identifying potential impacts early-on, the sponsor would also be better prepared to develop an environmentally acceptable project design.

Finally, impact identification methodologies are useful to those responsible for review of completed EIA documents. They provide a systematic means of checking that all potential impacts were considered by the preparers of the EIA report.

1.2 Types of Impacts

Impact identification methodologies assist the analyst in assuring that no potential impacts are overlooked. Towards this end, the analyst must be aware of the various types of impacts that should be considered.

Not only must a project's adverse impacts be identified (e.g., loss of natural habitat, degradation of air quality, etc.), but so must any beneficial impacts (e.g., creation of jobs, balance of payment implications, etc). The ultimate objective of the EIA process is to provide to decision-makers an overall analysis of total cost/benefit including both economic and environmental considerations (Thompson et al, 1983). This requires fair consideration of both beneficial and adverse impacts.

The analyst must also be aware of the need to consider indirect as well as direct impacts. There is a tendency in preparing an EIA to concentrate on the latter since direct impacts are more obviously recognizable. Other important impacts may be excluded from susequent analysis if indirect impacts are not conscientiously considered during the impact identification stage. These types of impacts have been categorized as follows (Sorensen and Dickert, 1973):

"Direct:

- preemption or denial of use existing on project site.
- relocation of uses preempted from project site, or denied future use of project site.
- impacts on environmental conditions-systems.
- adverse impacts which the project would be subject-

ed to by existing environmental and/or social conditions.
- public service facility requirements.
- socio-economic impacts.
- access circulation, transportation modes impacts.

"Indirect:

- surrounding land use change.
- projects impacts on population in region.
- cumulative impact: potential impacts of development or anti-development trend project is establishing or reinforcing for political jurisdictions or environmental systems (watersheds, air basins, lakes, embayments)."

Similarly, the analyst must consider both long term and short term impacts. Examples of long term impacts would include preemption of land use on the project site, and jobs created for the life of the project. Short term impacts typically occur during the construction phase. Examples include dust generated by excavating equipment, and construction related jobs.

The final categories of impacts requiring an awareness on the part of the analyst are termed unavoidable and irreversible. The significance of these categories is evident by their names. The use of these terms has relevance in the latter stages of impact prediction and evaluation however. Thus, the categories of impacts of which the analyst must be aware in the impact identification stage may be summarized as:

- o adverse and beneficial;
- o direct and indirect;
- o short term and long term.

1.3 <u>Application to Alternatives</u>

EIA procedures typically require that alternatives to the proposed action be analyzed so that decision makers may consider their comparative merits. Impact identification, prediction, and evaluation methodologies must therefore be applied to reasonable alternatives. Reasonable alternatives would include:

- o alternate project designs and configurations;
- o alternate designs and configurations for portions of

the project (e.g. cooling tower versus cooling ponds; groundwater supply versus surface water supply; etc);

- alternate project sites;
- "no action" alternative.

1.4 With and Without Concept

Ecosystems as well as human social systems are by their very natures dynamic, so that their characteristics in many cases may change substantially with time, Shallow "sea gardens" for example may give way to fringing reefs, which in time may grow to a barrier reef. On the human side, an example would be the gradual abandonment of an agriculturally based economy in favor of manufacturing and service industries. In addition, many systems, both natural and human, will have already been subjected to environmental stresses prior to consideration of the project at hand, The point is that system characteristics may be expected to change over time irrespective of the impacts of a particular project. In projecting the impacts of a particular project, the analyst must therefore also project what impacts would be experienced even if the project were not implemented. The "no action" alternative can be considered as a base case for this purpose. The analyst would thus be able to project the net effects with the project, over and above those that would occur without the project.

2. IMPORTANCE OF SOCIAL IMPACTS

The widespread realization that natural resources are important components of a nation's wealth was the genesis of environmental planning and management. However, contemporary social concerns, particularly in developing countries, are frequently even more pressing than the concerns for long term protection of natural resources. Contrary to the opinion of rank industrialists, the EIA concept is not an enemy of social progress serving only to defeat or delay development projects. Rather, the EIA concept views the environment as consisting of both natural systems (physical and biological) and social systems, and it seeks to identify, predict, and evaluate the impacts of projects on both aspects of the environment. To assume *a priori* in the name of "progress" that any development project is justified on social grounds because of an influx of capital, perceived opportunities for employment, etc., is risky at best. Every project of significance warrants an appropriate degree of analysis of its impacts on both social and natural systems.

The need for social impact analysis is perhaps best illustrated by an example of a project developed without prior assessment of its impacts. The Rodney Bay development project at Gros Islet Bay, St.Lucia, was proposed by developers in the 1960's (See Figure 2). The project was to include over 1,300 acres of vacation homes, condominiums, hotels, shops, marina facilities, and open space, all in the vicinity of Gros Islet fishing village (Towle, 1984). Among the site preparation activities carried out by developers were the following:

- o construction of an artificial mile-long causeway connecting the mailand with Pegeon Island, using some 2.5 million cubic yards of dredged sand from the Bay as construction material;

- o dredging an additional million cubic yards of sand to surcharge an existing swamp and convert the core of the swamp to a lagoon marina with filled shoreline areas and access roads; and

- o conversion of the fresh water swamp to a saline system by cutting a deep channel entrance from the Bay.

For over two centuries, the West Indian fishing community had relied on the fishing resources of Gros Islet Bay as the basis of its economy. Before the Rodney Bay development project, three seine nets were operated in the Bay, pulled by 100 to 150 people who shared daily in the catch. Some 30 fishermen were occupied in pot fishing. Related economic activities included, sail of bait, fabrication and repair of nets and pots, boat building and maintenance, sale of lobster and conch to the existing St.Lucia Beach Hotel, and informal chartering of boats by tourists. Heavy sediments introduced by dredging, and changes in the movement of fishes caused by the placement of the causeway, had the following socioeconomic impacts:

- o reduction of net catches by about two-thirds, and a two-thirds reduction in manpower employment in net fishing;

- o virtual elimination of pot fishing in the Bay;

- o proportionate reduction in related economic activities.

Construction jobs associated with the Rodney Bay project were short-term, and no permanent jobs were created. In addition, the deep channel cut as an entrance to the swamp-turned-lagoon isolated the villagers from their traditional burial

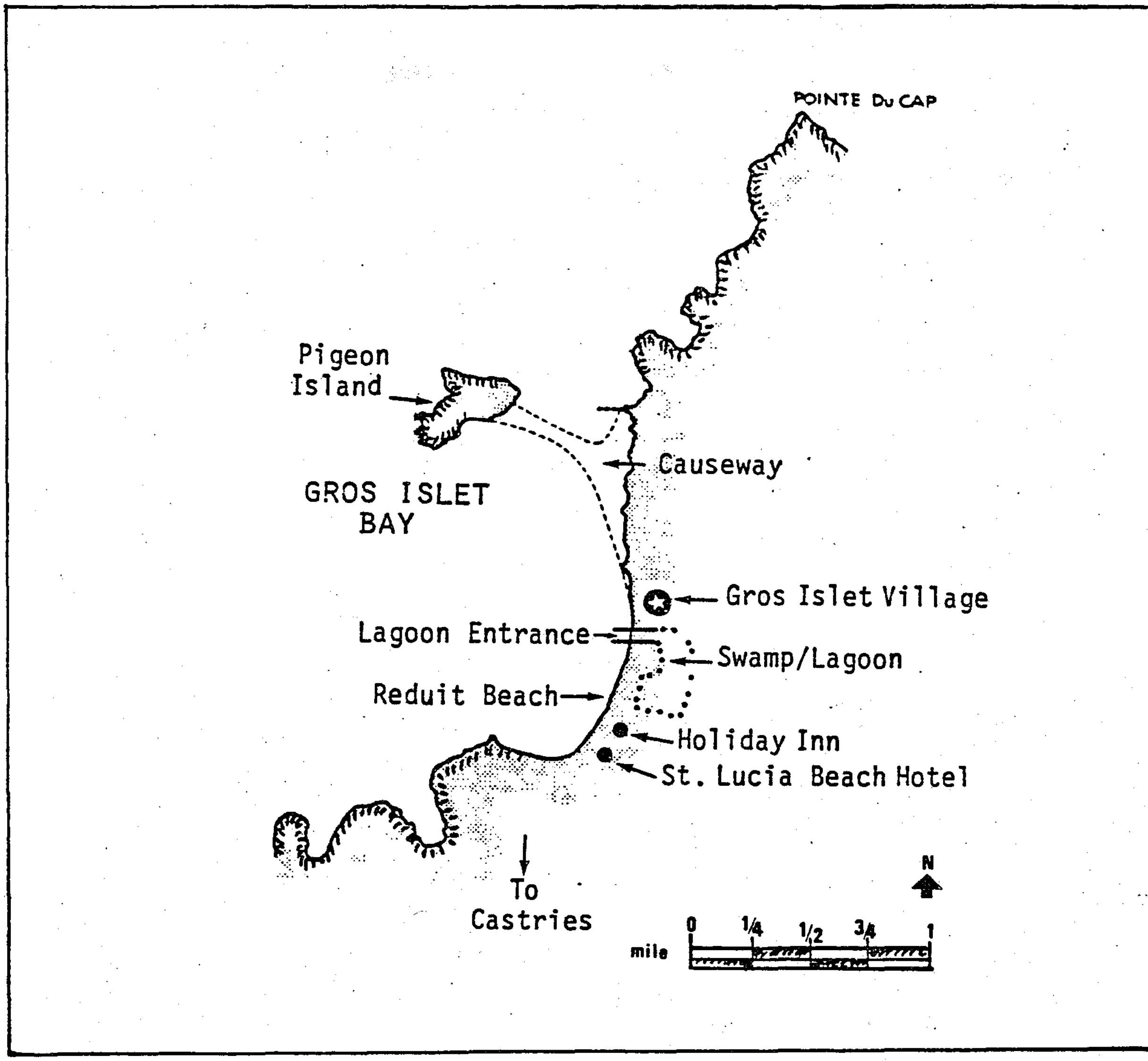


Figure 2. Location map: Rodney Bay development project at Gros Islet Bay/Pigeon Island area, St. Lucia.

ground and from the tourist development area and created a sense of indignation and discrimination among the villagers.

In addition, the artificial causeway proved to be unstable. Its construction and the creation of deep dredge pits in the Bay resulted in erosion of the once beautiful beaches at the southern end of the Bay and on Pigeon Island. As a result, after tens of millions of dollars of investment, the developers have realized no appreciable return.

> "Not one sale, lease or option has been finalized for the causeway area. Not one new hotel has been built. There has been no deluge of buyers or leaseholders for the residential sites in the new "lagoon"... Additional capital investment (for further site improvement and remedial environmental interventions), development, and marketing costs have mounted, and the total is close to three times the original estimate." (E. Towle, 1984).

The Rodney Bay development project illustrates that dire social consequences can accrue to the community, and economic consequences to the developers themselves, when an assessment of impacts to both social and natural systems is not included in project planning.

3. REVIEW OF METHODOLOGIES

Numerous methodologies have been developed to provide systematic approaches to impact identification, prediction, and evaluation. The various methodologies may be categorized however into four general methods:

- o checklists;
- o matrix methods;
- o network analyses;
- o ad-hoc procedures.

Numerous specific methodologies within each category have been reviewed in the literature (Canter, 1977; Jain et al, 1981; Rau and Wooten, 1980). The following discussion focuses on several methodologies which are particularly applicable to the Caribbean region.

3.1 Checklists

Checklists are one of the most commonly used approaches to impact identification. A checklist is a master list of environmental factors or potential environmental impacts from which the EIA analyst selects the particular factors or impacts that might reasonably be expected to occur for the alternative under consideration. Checklists are usually not incorporated into the EIA document itself. They are used as worksheets by the analyst, and should be kept for later reference.

Because the environment consists of complex systems, each with numerous components, and each alternative may have numerous dimensions, a generalized checklist could have literally thousands of entries. The U.S. Army Construction Engineering Research Laboratory (Lee et al, 1974) for example uses a checklist that addresses the impact of some 2,000 basic army activities on over 1,000 environmental factors. This approach is so complex as to require the use of a computer for manipulation. Simpler checklists are to be preferred.

Analysts should bear in mind that no one checklist is ideally suited to all projects. Revisions and modifications will usually be necessary to adequately address a specific project. Reviewing several checklists will yield additional insight into the potential impacts associated with a project.

USAID

Project type checklists have been prepared by many agencies for implementation of projects within their area of responsibility or expertise. USAID has published a number of checklists applicable to the types of development projects it typically finances: agriculture and rural development, various specific industries, urban developments, transportation, utilities, etc. (USAID, 1974). The agency's checklist for power plants and transmission, for example, is reproduced in Figure 3. The format of this checklist categorizes potential impacts under several headings: resource linkage, physical aspects, socio-cultural aspects, and public health aspects. Under each heading, various impacts that may potentially apply to the type of project are briefly described. For a specific alternative under consideration, the analyst would review the list and select those impacts for which further assessment and evaluation are warranted.

UNEP Screening Test Table

The United Nations Environment Programme, in its "Guidelines for Assessing Indusrial Environmental Impact and Environmental Criteria for the siting of Insustry" (UNEP, 1980), published a Screening Test Table which is in fact a kind of checklist. UNEP's Table is reproduced in Appendix A. Its

6.b.4. Power Plants and Transmission
(Fossil fueled, Nuclear fueled, Hydroelectric, Geothermal)

Resource Linkage

-- Site selection, including vulnerability to earthquake, hurricane or other natural catastrophy
-- Relationship of proposed facility to other power generating projects and to energy consuming development projects in the region
-- Energy resource base utilized for project and alternative uses of resource base
-- Compatibility with other resources of area such as water resources, fish, wildlife, urban settlements, agricultural production, etc.
-- Effect of generating, transmission and distribution facilities on aesthetic resource
-- Suitability of site and process with respect to future expansion

Physical aspects

-- Estimate of pollutants expected to be generated, effect on humans, wildlife, vegetation, agricultural production, aquatic environment, air and water quality recreation, etc., and provisions for abatement, treatment, disposal and monitoring; include:
-- air pollutants from fossil fuel, geothermal steam, cooling towers
-- thermal pollution of water, air or land
-- water pollution by primary or treated waste
-- land pollution from solid wastes, ash or other residue disposal
-- nuclear wastes

6.b.4. (continued)

- Environmental consequences of failure of plant or any component thereof
- Effect of noise on surrounding environment
- Fuel storage and transfer facilities, including safety aspect
- Downstream riverine changes due to power plant discharges

Socio-cultural aspects

- Effect of electric power supply into previously unserved area on social and cultural habits and values
- Effect on unemployment in area due to growth of business and industry by virtue of new or increased power supply
- Aesthetic considerations of route and tower design for transmission and distribution facilities
- Preservation of historic, cultural or archaeological sites

Public health aspects

- Effect on health of area inhabitants due to residual pollutants
- Occupational safety provisions for generating plants
- Public safety measures adopted for transmission and distribution, including sub-station and switchyards

Note: Where power generating project includes water impoundment for hydropower, cooling and/or heat dissipation or other water requirements, see also subsection 6.b.3. Dams.

Figure 3. Example of a project type checklist (USAID, 1974).

format is different than that of the USAID checklists and it is more extensive in its treatment of impacts. Impacts are categorized under headings of various environmental elements: climate and air quality, water, geology, soils, ecology, etc. Under each element, various sub-elements are listed. Under climate and air quality for example, the sub-elements listed are: wind speed and direction, precipitation/humidity, temperature, and air quality. Potential impacts are listed for each sub-element. From this list of potential impacts, the analyst would select those impacts pertinent to the specific alternative under consideration.

The Screening Test Table has two additional features. One is that for each potential impact listed, a general description of the information required for impact assessment is also given. The other is that the sources of the required information are given as well. One drawback to the Table is that very little emphasis is given to human social systems such as economics, effects on public services, and public health. It does however provide an excellent framework for identifying potential impacts on natural resources.

Virgin Islands Coastal Zone Management

The Virgin Islands have impact assessment guidelines which make an excellent model for adaptation and use by small islands of this region. The Coastal Zone Management Act of 1978 (V.I. Code, Title 12, Chap. 21) requires that new developments in designated coastal zones apply for construction permits from the Division of Coastal Zone Management (DCZM). Permit applicants must supply an Environmental Assessment Report (EAR). The V.I. guidelines for the preparation of an EAR appear in Appendix B. The guidelines are in the form of a checklist. The practice in the V.I. is for the applicant (i.e., the project sponsor) and DCZM to jointly review the checklist guidelines in a pre-application meeting. By this process, potential impacts are identified, and the required content and level of detail in the EAR are defined. Refering to Appendix B, the listing of potential impacts to the natural environment can be found in Section 6.00. Section 7.00 lists potential impacts to the human environment. As with all checklists, only those impacts which are relevant to the specific project under consideration would be selected from the list for further assessment and evaluation.

ECNAMP Development Guidelines

The Eastern Caribbean Natural Area Management Programme (ECNAMP) has published guidelines for development in small islands, which EIA analysts can use as a checklist for impact

SEAGRASS BEDS Seagrass beds, often extensive around Caribbean islands, are an important and productive marine nutrient source as well as habitat for a number of **commercially important species**, especially **conch** and **sea turtles**.

Critical Activities	Problems Derived from Activity	Guidelines for Management
DIRECT		
1. **Dredging**	a) Destruction of habitat when seagrass beds are in dredged area.	--Prohibit dredging in extensive seagrass meadows and inshore seagrass areas.
	b) **Indirect**: Lowered productivity from sedimentation and turbidity when seagrass beds are down-stream of dredged areas.	--Study data on currents and determine potential impact of dredging operations on seagrass ecosystems. Prohibit those operations that could result in serious degradation of seagrass beds. See Appendix A, **DREDGING GUIDELINES**, for more information.
2. **Anchoring** of boats	--Frequent and heavy tearing of seagrasses by boat anchors will severely degrade seagrass beds.	--Provide permanent moorings in seagrass areas that sustain heavy boat use.
INDIRECT		
3. **Excavation, Earth-moving**, and **Agriculture** (poor techniques can cause erosion)	--Sedimentation and turbidity, resulting in lowered productivity.	--See Appendix B, **EROSION GUIDELINES**
4. **Thermal Discharge** from industrial and desalinization plants	--Mortality of seagrasses and associated species.	--Prohibit thermal discharge into or near critical seagrass areas.
5. **Toxic Waste Discharge** from industrial plants	--Mortality of seagrasses and associated animal species.	--Make provisions for safe and proper disposal of toxic wastes and prohibit their disposal in nearshore waters.

Figure 4. Excerpt from ECNAMP Guidelines (1984).

identification. Published in handbook form, "Environmental Guidelines for Development in the Lesser Antilles" describes critical resources and habitats (i.e., environmental components) common in the Eastern Caribbean, such as mangroves, coral reefs, fisheries, and socio-cultural resources. Tables are used to show development activities (i.e., project components) that might affect a critical resource or habitat, their potential environmental impacts, and guidelines for management. An excerpt from the guidelines is shown in Figure 4.

A Health-Impact Checklist

The Pan American Health Organization is particularly concerned with potential health impacts of development projects. PAHO contributed a health-impact checklist to a conference proceedings on environmental impacts of international projects (Donaldson, 1977). This checklist is reproduced in Appendix C. It is a useful supplement to other more general checklists.

3.2 Matrix Methods

Matrix methods list project components along one axis versus environmental components on another axis. Impacts occur where there is an interaction between a project component and an environmental component. Unlike the checklist approach, the matrix approach clearly identifies cause-effect relationships. It also lends itself extremely well to the evaluation of alternatives (discussed in a later paper).

USAID Matrix

An example of a matrix approach is given in Figure 5 (USAID, 1980). Across the horizontal axis are listed major environmental components of the physical, biological , and social environment. The analyst would list the major project components along the vertical axis and would identify potential impacts at the appropriate intersections by means of graphic symbols. The symbols are given qualitative significance by means of a legend, described in a later paper.

Leopold Matrix

One of the earliest matrices and perhaps the best known is the Leopold Matrix (leopold et al, 1971). A portion of the Leopold Matrix is shown in Figure 6. The complete matrix contains 100 specified actions versus 88 environmental components (the complete listing is given in Appendix D). To use the Leopold matrix the analyst would first identify which of the 100 listed actions were components of the specific project.

PROJECT IMPACT MATRIX

	PROJECT COMPONENTS	PHYSICAL ENVIRONMENT										BIOLOGICAL ENVIRONMENT										SOCIAL ENVIRONMENT									
	ENVIRONMENTAL COMPONENTS →	AGRICULTURAL LANDS	SOIL EROSION	SLOPE STABILITY	ENERGY / MINERAL RESOURCES	SURFACE WATER QUANTITY	SURFACE WATER QUALITY	GROUND WATER QUANTITY	GROUND WATER QUALITY	AIR QUALITY	NOISE	AQUATIC ECOSYSTEMS	WETLAND ECOSYSTEMS	TERRESTRIAL ECOSYSTEMS	ENDANGERED SPECIES	MIGRATORY SPECIES	BENEFICIAL PLANTS	BENEFICIAL ANIMALS	PEST PLANTS	PEST ANIMALS	DISEASE VECTORS	PUBLIC HEALTH	RESOURCES / LAND USE	DISTRIBUTION SYSTEMS	EMPLOYMENT	AT-RISK POPULATIONS	MIGRANT POPULATIONS	COMMUNITY STABILITY	CULTURAL/RELIGIOUS VALUES	TOURISM / RECREATION	NUTRITION
PLANNING & DESIGN																															
CONSTRUCTION																															
OPERATION																															

Figure 5. Project Impact Matrix (USAID, 1980)

The potential for each action or component to cause an impact on each of the 88 environmental components would then be considered. Where a potential impact is identified, the interaction box would be marked with a diagonal line. Impact identification is completed when all of the project's components have been considered against the 88 environmental components.

Having completed the process of impact identification, the magnitude and importance of potential impacts can be numerically scored on either sides of the diagonal lines. At this point the Leopold Matrix methodology ventures into the stages of impact assessment and evaluation. More shall be said of this in a later paper.

It should be noted in the Leopold Matrix that the 88 environmental components listed there give little emphasis to human social systems. Such items could easily be added by the analyst however in order to obtain a more comprehensive identification of impacts.

3.3 Network Analyses

Matrix methods go beyond checklists by identifying cause-effect relationships. Network analyses go one step farther by introducing a cause-condition-effect network which aids in the identification of cumulative or indirect effects. Figure 7 gives an example of a small portion of a network for a freeway construction project in an established downtown business district (Rau and Wooten, 1980). To develop such a network the analyst must independently or with guidance from other methodologies (checklist, matrices, etc.) identify the primary impacts of each of the project components, and must identify what are the secondary impacts, tertiary impacts, etc., arising from each project component.

The advantage of a netwoek is that, if properly constructed, it can accurately describe the complex system of relationships inherent in any environmental setting. It also has significant disadvantages however. The first is that one must resort to other methodologies or to a multidisciplinary team of experts in order to assure that all impacts are identified. The second is that its complexity may verge on confusion. Frequently the network may be unintelligible to all but the most expert analysts. If this occurs, the methodology has failed at one of its prime objectives: to provide a systematic framework for informed decision making among <u>all</u> parties of concern. For these reasons, the use of network analyses is not recommended in any region in the early stages of incorporating environmental impact assessment into the planning and

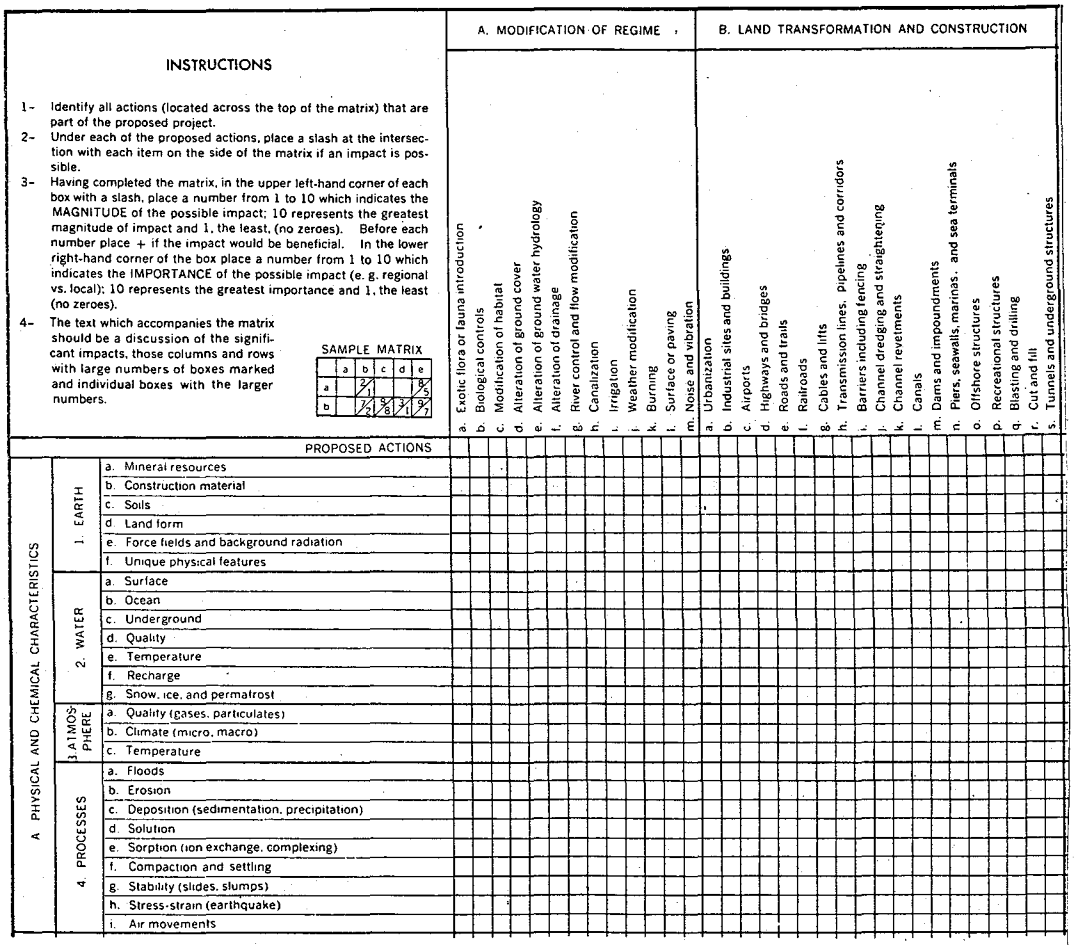


Figure 6 Portion of information matrix. (From Leopold et al., 1971.)

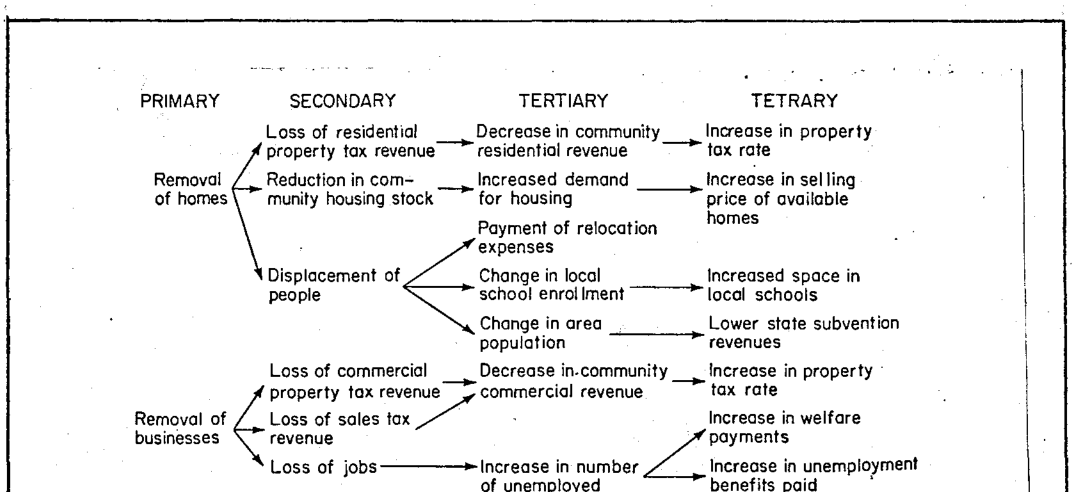


Figure 7 Example of impact tree for new freeway construction in established downtown business district.

decision making process.

3.4 "Ad Hoc" Team Approach

The "Ad Hoc" approach usually means assembling a multidisciplinary team of specialists to identify impacts in each specialist's area of expertise, without reliance on the formal methodologies described above. This approach was used widely by government agencies in the United States in the period immediately following enactment of the National Environmental Policy Act (Canter, 1977). It is still used today by many large environmental consulting firms that are capable of maintaining multidisciplinary staffs of experts. It has the advantage of being quick and easy to administer and, when the staff members involved are truly expert, it is usually accurate.

Few government agencies in the Caribbean maintain such a staff however. The composition of most agencies reflects a few specializations related to the organization's primary mission. A highway planning agency for example would have many civil engineers, transportation planners, economists, and the like, but few if any air quality and water quality specialists, terrestrial and aquatic ecologists, toxicologists, etc. This problem can be overcome however by the formation of temporary interagency or inter-ministry study teams. All that is required is a willingness on the part of the respective units to cooperate on the analysis of a particular project under the coordination of a lead agency.

This "Ad Hoc" Team concept can be extended. Often specialists' expertise can be obtained either informally or through the literature. Consider for example the proposed Panama Coal Gasification/Methanol Production project, a 20,000 ton per day synthetic fuel facility proposed on the Caribbean coast near Chiriqui Grandi. A U.S. architect/engineer consulting firm, was commissioned to perform a preliminary site selection study and to draw up terms of reference for a full scale environmental impact statement in accord with NEPA regulations. Both tasks required an identification of impacts. The budget allowed only for a cursory field reconnaissance by one executive level environmental specialist, but no field studies by a multidisciplinary team. The A/E's environmental specialists were thoroughly familiar with the project characteristics of synthetic fuel facilities, but had only the reconnaissance report to describe existing environmental conditions at the alternative project sites. The A/E supplemented this information with views and information from outside specialists. The Smithsonian Tropical Research Institute, located in Panama City, was able to provide information on ecology and cultural resources. Bathymetry and oceanographic data were obtained from the National Oceanographic and Atmospheric Administration. A nearby industrial concern provided meterological, and water quality data. Geological and topographical information was obtained from a parallel engineering feasibility study. Using all this information, the A/E's environmental specialists were able to identify potential impacts suitably enough so that a preliminary site selection could be made and the required terms of reference could be prepared.

Such an extension of the "Ad Hoc" Team approach is certainly applicable in the Caribbean region. Puerto Rico and the Virgin Islands are rich sources of environmental expertise, information and documentation, since each have had over 15 years experience in applying U.S. environmental regulations to development projects. An annotated bibliography of resulting source materials derived from the Virgin Islands experience has been compiled under the sponsorship of the UNESCO Man and the Biosphere program (Island Resources Foundation, 1982). Many of the reports listed therein are available from the V.I. library and from government offices such as the V.I. Department of Conservation and Cultural Affairs, and the V.I. Planning Office.

Other important sources of expertise and information are listed in Table 1.

4. SELECTING A METHODOLOGY

Warner and Preston (1973) developed criteria questions in order to compare environmental impact assessment methodologies. Their criteria questions for impact identification methodologies, and for methodology resource requirements, replicability, and flexibility, are presented in Tables 2 and 3. These questions can help the analyst select a particular methodology for use in analyzing a particular project. The analyst may wish to consider other methodologies besides those described in this paper. As mentioned earlier, numerous methodologies have been reviewed in the literature(Canter, 1977; Jain et al, 1981; Rau and Wooten, 1980).

Comprehensiveness is an important criteria which is frequently not met by individual checklists and matrices. Socioeconomic and public health impacts are frequently omitted from consideration. To compensate for this, it would be appropriate in many cases to use two or more checklists, or two or more matrices, or to modify a particular checklist or matrix to include the omitted impacts.

TABLE 1 - SOME SOURCES OF EXPERTISE AND INFORMATION ON CARIBBEAN ENVIRONMENTS

U.S. Virgin Islands

- Island Resources Foundation, St.Thomas - a non-profit technical assistance organization.
- West Indies Laboratory, St.Croix - the marine research station of Fairleigh Dickinsen University.
- Caribbean Research Institute, St.Thomas - a division of the College of the Virgin Islands.
- Eastern Caribbean Natural Area Management Programme, St.Croix - a cooperative undertaking of the Caribbean Conservation Association and the University of Michigan Wildland Management Center.

Commonwealth of Puerto Rico

- Center for Environment and Energy Research - a division of the University of Puerto Rico.
- Graduate School of Planning, University of Puerto Rico.
- Environmental Quality Board, Government of Puerto Rico.

Barbados

- Caribbean Conservation Association - a "grass roots" environmental advocacy organization.
- Centre for Environmental Management - a division of the University of the West Indies.

Table 2. Criteria Questions for Impact Identification

Criteria	Questions
Comprehensiveness	Does the methodology address a full range of impacts?
Specificity	Are specific environmental parameters identified?
Isolate project impacts	Does the method suggest ways of identifying project impacts?
Timing and duration	Does the method suggest construction-phase impacts vs. operational-phase impacts?
Data sources	Does the method require identification of data sources?

(Warner and Preston, 1973)

Table 3. Criteria Questions for Methodology Resource Requirements, Replicability, and Flexibility

Criteria	Questions
	Resource requirements
Data requirements	Does the method use current data or are special studies required?
Manpower requirements	Are special skills required?
Time requirements	How much time is necessary to learn the method?
Costs	What are the costs of using the method?
Technologies	Are special technologies required?
	Replicability
Ambiguity	Is the method ambiguous?
Analyst bias	To what degree will different results occur depending on the analyst?
	Flexibility
Scale flexibility	Does the method apply to projects of different size or scale?
Range	Does the method apply to projects of different types?
Adaptability	Can the method be applied to different basic environmental settings?

(Warner and Preston, 1973)

In any region where environmental planning and management is in its early stages, resource requirements are a particularly important criteria. For many natural areas in the Caribbean, there is a paucity of environmental data. Skilled environmental analysts are often in short supply. Most Caribbean nations are unaccustomed to the expenditure of funds for environmental studies. Special technologies, such as computers, may not be available. Consideration of all these factors should be given when selecting a methodology.

A consideration even more basic than the criteria questions posed by Warner and Preston is that of objective. What is the analysts' objective in applying the methodology? As discussed earlier in this paper, impact identification methodologies can be used for several different purposes at various points in the EIA process. Complex methodologies would be too costly and too time consuming for study scoping or pre-feasibility determinations. Input data would probably not be well enough refined at these points either. The use of complex methodologies might be justified after the project and project setting are well defined. At this point impact identification methodologies are applied to assure that all potential impacts will be analyzed and evaluated in subsequent stages of the EIA process.

5. CONCLUSIONS

Impact identification methodologies can be used for several purposes, the primary purpose being to establish a comprehensive list of potential impacts as a basis for subsequent impact prediction and evaluation. When executing a methodology, the analyst must bear in mind several basic points. One is that all types of impacts must be considered: adverse and beneficial, direct and indirect, short term and long term. Secondly, the proposed action and all reasonable alternatives should be subjected to analysis through impact identification, prediction, and evaluation methods. This allows decision makers to consider the comparative merits of alternatives to the proposed action. Finally, the assessment should take into consideration changes that would be likely to occur to the natural environment and social systems even if the proposed action were not implemented. This eliminates the possibility of the proposed action being credited or discredited for changes that would occur without its influence.

Numerous methodologies are available to assist in the impact identification process. Of the methods described in this paper, small island communities may find particularly useful, the Virgin Islands Coastal Zone Management guidelines, and ENCAMP's environmental guidelines for development. For large projects where greater expenditures on environmental assessment are justifiable, more sophisticated methods such as the UNEP Screening Table or the Leopold Matrix are recommended. Network analysis is not recommended because their high degree of sophistication makes them tenable only to highly expert analysts. They are often unintelligible to decision makers and other interested parties.

Ad hoc or expert review procedures are frequently used in the United States, and could be used in the Caribbean by assembling interagency project teams comprised of multidisciplinary experts. Expert information is also available through the literature. Puerto Rico and the U.S. Virgin Islands are rich sources of relevant information. Both have over fifteen years experience under U.S. laws and regulations adapting the EIA concept to a Caribbean context.

Criteria questions (Warner and Preston, 1973) useful in selecting a methodology have been presented. Two particularly important criteria are comprehensiveness and resource requirements. Few impact identification methodologies are completely comprehensive, particularly with regard to socioeconomic and public health impacts. To compensate, two or more methods of impact identification might be used, or a particular method may be modified by the analyst to include the omitted impacts. With regard to resource requirements, it isimportant that the analyst select a methodology that is consistent with the resources that will be made available to the study (i.e., time, money, technical expertise, data, special technologies, etc.)

Following the points set forth in this paper, appropriate impact identification methodologies can be selected or modified, and successfully applied to development projects in the Caribbean. However, the analyst's own resourcefulness, intuition, and common sense, and a cooperative attitude among interested parties, will be the most important elements contributing to the success of any environmental analysis.

* * *

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A P P E N D I X   A

SCREENING TEST TABLES

A4.1.1	Climate and Air Quality
A4.1.2	Water
A4.1.3	Geology
A4.1.4	Soils
A4.1.5	Ecology
A4.1.6	Environmentally Sensitive Areas
A4.1.7	Land Use and Land Capability
A4.1.8	Noise and Vibration
A4.1.9	Visual Quality
A4.1.10	Archaeology, Historic and Cultural Elements

Each of the 10 screening test tables gives examples of:

- the SUBELEMENTS of each environmental element
- the POTENTIAL IMPACT(S) for each subelement - questions designed to indicate the most important potential environmental problem associated with the subelement
- REQUIRED INFORMATION - types of data and knowledge required to undertake an assessment of the probable severity or importance of the impact(s) for that subelement
- the SOURCE OF INFORMATION - organisation and/or materials (maps, reports, etc.) from which relevant data or information may be sought.

SCREENING TEST TABLE

A4.1.1 CLIMATE AND AIR QUALITY

Subelement	Potential Impact(s)	Required Information	Sources of Information
Wind: directions and speed	Will the project (structure and area) modify the local wind behaviour, e.g. channelling of wind, obstruction, etc? Will the project be placed in a "high risk" area?	Wind speeds and directions, including unusual conditions - tornadoes, etc. Height of structures.	Meteorological records; existing residents in area. Developer.
Precipitation/ humidity	Will the project have an impact upon the local precipitation/ humidity pattern? Will the project be sited in a "high risk" area?	Precipitation/humidity data including unusual conditions - flash floods, etc.	Meteorological records; existing residents in area.
Temperature	Will the project have an impact upon the local temperature pattern?	Temperature data, including extremes.	Meteorological records.
Air quality	Will the project generate and disperse atmospheric pollutants? Will the project generate any intense odours?	Estimate of atmospheric pollutant emissions from point sources (stacks, etc. area sources (parking zones) and line sources (transportation); estimate of total emissions burden; fugitive emissions from bulk loading and handling facilities; estimate of undesirable or persistent odours.	Air pollution expert

SCREENING TEST TABLE

A4.1.2 WATER

Subelement	Potential Impact(s)	Required Information	Sources of Information
Hydrological balance	Will the project alter the hydrological balance?	Extent of project; source of water - ground or other. Importance of groundwater in maintaining area rivers, streams, lakes, ponds, wells, flora and fauna.	Developer Hydrologist/ hydrogeologist
Groundwater regime	Will the project affect the groundwater regime, e.g. in terms of quality, quantity, depth/gradient of water table and direction of flow? Will alterations to water table depth alter structural qualities of soil? Will dewatering methods be necessary to undertake excavations?	Extent of project; source of water supply; waste disposal practices; proposed surface cover. Ground conditions - permeability, percolation, water table, location of recharge area, slope proximity to streams or other waterbodies.	Developer Geological maps/ survey; local well-drillers; soils engineer.
Drainage/channel pattern	Will the project impede the natural drainage pattern and/or induce alteration of channel form?	Existence, nature and pattern of drainage; soil characteristics.	Site visit; geological maps.
Sedimentation	Will the project induce a major sediment influx into area water bodies?	Location of construction and cleaning activities. Erosion potential of site soils. Direction of runoff flow, % slope on site. Erosion and sediment control plan for site.	Developer Soils surveyor Site visit; topographical map Developer
Flooding	Will there be risk to life and materials due to flooding?	Extent of project; 100-year flood plain.	Developer Geological survey
Water quality	Does potable water supply meet established standards - WHO, etc? Will receiving waters meet established standards? Will waters be adequately accommodated and treated? Will groundwater suffer contamination by surface seepage, intrusion of saline or polluted water?	Whether existing water quality meets standards for intended usage; capacity of waste treatment plant/sewerage system to accommodate project wastes. Water disposal plan; source of water. Location of groundwater recharge.	Health/waste disposal authorities Developer Hydrologist/ hydrogeologist
Surface waters	Will the project impair existing surface waters through filling, dredging, water extraction or discharge; waste discharge or other detrimental practices? Will recreation or aesthetic values be endangered? Will the project affect dry weather flow characteristics?	Location of project; location of construction and clearing activities. Source of water supply and site of waste disposal; dams/obstructions; flow characteristics over an extended period. Ecological characteristics; recreation uses.	Developer Civil engineer/ hydrologist Aquatic biologist - area survey

1108

SCREENING TEST TABLE

A4.1.3 GEOLOGY

Subelement	Potential Impact(s)	Required Information	Source of Information
Unique/special features	Will features be affected by project activities?	Geological features of educational, scientific, aesthetic and human interest at or adjacent to site; landmarks.	Government geological survey; aerial survey/ remote sensing; educational/ scientific institution.
Tectonic/seismic activity and volcanic activity	Is there risk of damage or loss resulting from tectonic/seismic activity and/or volcanic activity?	Location of project in relation to tectonic/ seismic features (e.g. faults), rock masses (e.g. valleys) and volcanic eruption.	Seismicity studies; geological maps.
Mineral resources	Are there mineral resources of potential value close to the project?	Location of mineral sources and current economic significance; presence of mine, quarry or other extractive activity.	Geological maps/ survey. Mining records; mineral resource map.
Physical/ chemical weathering	Will there be an increase in rock decomposition/degradation as a result of the project?	Existing or exposed rock susceptible to phenomenon at or adjacent to site; water pollution risk.	Geological maps/ survey; environmental scientist; mining records; developer.
Landslide	Are there potential dangers related to slope failures or falling rock?	Site location; existing geological/seismic data; existing and proposed slopes on site; existing instability; faulted, jointed or fractured rock.	Developer (site plan); Geological and topographical maps; site visit; seismicity study.
Subsidence	Is there risk of major ground subsidence associated with the project?	History of subsidence in vicinity of project; subsurface mining activities - past and present; natural subsidence features.	Geological survey; mining records/ companies; insurance companies.

SCREENING TEST TABLE

A4.1.4 SOIL

Subelement	Potential Impact(s)	Required Information	Source of Information
Erosion (wind and water)	Will there be a substantial loss of soil due to construction or operational practices?	Extent of site preparation - roadways or other linear features; slope angles; receiving waters. Ground conditions; wind patterns.	Developer - site plan Site investigation
Slope stability	Will there be a risk of losses due to instability?	Site location; existing geological data; estimate of ground conditions; existing instability.	Site investigation; developer (site plan); geological maps
Liquefaction	Will project cause or be exposed to liquefaction of soils in slopes or foundations?	Project location; general seismic data; evidence of liquefaction; machinery producing vibrations.	Developer; site investigation
Bearing capacity	Will there be risk to life or structures because of sudden failure?	Loading; dead or live load ratio; ground conditions; strength properties of soil/rock; groundwater	Developer Preliminary site investigation
Settlement/ heave	Is there risk of damage to structure or services?	As bearing capacity plus settlement/heave parameters.	Developer - Preliminary site investigation Architect/engineer
Earthworks	Will there be an alteration to existing conditions, e.g. water regime or topography, or the need for landscaping?	Extent of earthworks; location and transport of fill/excavated material; disposal of unsuitable materials.	Developer; preliminary site investigation; land survey; haul routes.
Soil structure	Will the project modify the properties of impacted soils?	Site location, soils characteristics data.	Developer; soil survey.

SCREENING TEST TABLE

A4.1.5 ECOLOGY

Subelement	Potential Impact(s)	Required Information	Source of Information
Species checklists	Are there rare/endangered species which require protection? Are there species which are particularly susceptible to human activities? Would the loss of certain plant species deny food or habitat to wildlife species?	Species checklists - unusual, rare or endangered species; species providing food and cover for wildlife.	Government departments: conservation, wildlife, forestry; university departments: conservation, wildlife, forestry, botany, zoology; natural history groups.
Plant communities	Are there any unusual populations/communities that may be of scientific value? Are there natural populations/communities that are particularly susceptible to human activities?	Identification of populations/communities; distribution and character; inter-relationships and interactions.	As above
Diversity (species & spatial)	Does the diversity (species & spatial) of any community render it susceptible to human activities?	Extent of project Number and relative frequency of species in area spatial inventory.	Developer Ecologist
Productivity	Will project activities impair natural productivity?	Extent of project Productivity of land on site and surrounding area	Developer Ecologist/ agronomist
Biogeochemical/ nutrient cycling	Will project activities disrupt nutrient materials flow, e.g. selective concentration/dilution of substances?	Extent of project; Disturbance of natural communities; soils type and erodability; slope and topography; drainage patterns; annual precipitation.	Developer Soils surveyor/ ecologist/ hydrologist

SCREENING TEST TABLE

A4.1.6 ENVIRONMENTALLY SENSITIVE AREAS

Subelement	Potential Impact(s)	Required Information	Source of Information
Prime agricultural land	Will the project be located on or near prime agricultrual land?	Location of project Land use & land capability classification on and near site Future agricultural needs	Developer Soils survey; site visit.
Forestry land	Will the project be located on or near forestry land?	Location of project Location of forests on and near site Future forestry needs	Developer Topographical map; site visit
Wetlands/ estuarine and coastal zones	Will the project impair existing wetlands/ coastal zones/shorelines through filling, dredging, waste discharges or other detrimental practices? Impact on recreation?	Location of project Location of wetlands/ coastal zones/shorelines on or near site. Water quality from construction/plant runoff Waste disposal plans; dams or obstructions downstream from project. Beach erosion from dock, pier or breakwater construction	Developer Topographical map; site visit Civil engineer Developer Sedimentologist/ hydrologist
Landfills, solid/toxic waste disposal sites	Will the project perturb abandoned, existing or planned landfills, solid/ toxic waste disposal sites?	Location of abandoned, active or planned landfill, solid/toxic waste disposal sites	Topographical maps; site visit; developer.

A4.1.7 LAND USE AND LAND CAPABILITY

Subelement	Potential Impact(s)	Required Information	Source of Information
Land use	Will the project conflict with existing or proposed land use?	Location of project Land use classification on and near site	Developer Topographical maps; site survey.
Land capability	Will the project degrade land capability types?	Location of project Land capability classification on and near site.	Developer Site visit; agronomist/ soil surveyor

SCREENING TEST TABLE

A4.1.8 NOISE & VIBRATION

Subelement	Potential Impact(s)	Required Information	Source of Information
Internal noise	Will the internal noise levels present a potential risk to the hearing of workers? Will the safe operation of the project be affected?		Plant suppliers, developer, noise expert.
External noise	Will the project create noise levels which will cause annoyance, discomfort to nearby properties?	Estimates of the external noise levels due to transportation, construction, and operation at properties in the vicinity. Existence of noise sensitive land-users within one mile of the development (educational buildings, hospitals, recreational areas etc.)	Existing land maps, planning authority, site inspection. Plant suppliers. Developer, noise expert.
Vibration	Will the project cause damage to structures (natural and man-made) due to vibration?	Details of all permanent and temporary plant likely to cause vibration - pile drivers, large generators, reciprocating machines, blasting etc.	Developer, plant supplier, vibration expert.
	Will the vibration levels within the plant be such that there is a risk to employee safety.	Estimates of internal vibration levels and employee exposure.	Plant suppliers, developer, noise expert.

A4.1.9 VISUAL QUALITY

Subelement	Potential Impact(s)	Required Information	Source of Information
Visual content and coherence	Will the content of the scene perceived by the residents of the surrounding area be adversely affected by the project? Will the coherence of the surrounding area be impaired by the project?	Proposed development plans Description of views before and after project Extent to which the site has coherence	Developer Site visit Site visit Landscape architect

SCREENING TEST TABLE

A4.1.10 ARCHAEOLOGICAL, HISTORIC AND CULTURAL ELEMENTS

Subelement	Potential Impact(s)	Required Information	Source of Information
Archaeological structures and sites	Will the project conflict with structures and sites of archaeological interest and value? Will existing and desirable future patterns of access be disrupted?	Location of project; knowledge of regional and local archaeological sites and structures. Amenity use patterns of surrounding population.	Developer Regional/local archaeologist; historical societies; university departments; social and economic statistics on use of amenity
Historic/ cultural structures, sites and areas	Will the project conflict with structures, sites and areas of historic/cultural interest and value? Will existing and desirable future patterns of access be disrupted?	Location of project knowledge of regional and local historic/cultural sites and areas; patterns of visiting and use by elements within the surrounding population.	Developer Regional/local historical societies. Social and economic statistics on mobility, associational and recreational patterns

VIRGIN ISLANDS DEPARTMENT OF CONSERVATION AND CULTURAL AFFAIRS
DIVISION OF COASTAL ZONE MANAGEMENT

GUIDELINES FOR ENVIRONMENTAL ASSESSMENT REPORT

INSTRUCTIONS FOR PREPARING THE EAR

Title: Give appropriate title including name of project, its major components and location.

☐ 1.00 NAME AND ADDRESS OF APPLICANT

☐ 2.00 LOCATION OF PROJECT: Provide a copy of the location and agency review map as required in form CZM-8, Section 1 for land projects; or a copy of the vicinity map as required on pp. 13-15 of the U.S. Army Corps of Engineers booklet (EP-1145-2-1, 1 November 1977) for water projects. Give estate, plot number, zoning and geographical coordinates as applicable.

☐ 3.00 ABSTRACT: This should highlight the results of the following document in an abbreviated manner. Significant impacts, project description, and ameliorative actions should be included.

☐ 4.00 STATEMENTS OF OBJECTIVES SOUGHT BY THE PROPOSED PROJECT: Briefly describe what the project is intended to achieve.

☐ 5.00 DESCRIPTION OF THE PROJECT: This section should include a description of what is to be done if a permit is granted. How many cubic yards of dredging, number of condominiums, modifications of existing facilities, etc.

☐ 5.01 Proposed Dates of Construction (Start and Finish Dates): The time required for the processing of all necessary permits must be taken into account here. For water projects additional time must be allocated since such permit applications must be forwarded to the offices of the Governor and V.I. Senate after approval by the CZM Committee; this requires additional time. Water projects also require a permit from the U.S. Army Corps of Engineers, which are applied for simultaneously with the coastal zone application through the joint V.I./Corps of Engineers application procedure.

☐ 5.02 Drawings and Maps Required: For land projects, the drawings comprising the Erosion and Sedimentation Control Plan (ESCP - See Section d. of form CZM/8) shall be referenced as necessary in the EAR, or additional figures may be used to illustrate a discussion in the EAR. For water projects, drawings showing the plan and elevation views of the proposed activity, as required on pp. 13-15 of the U.S. Army Corps of Engineers booklet (EP-1145-2-1, 1 November 1977), shall be included in this section.

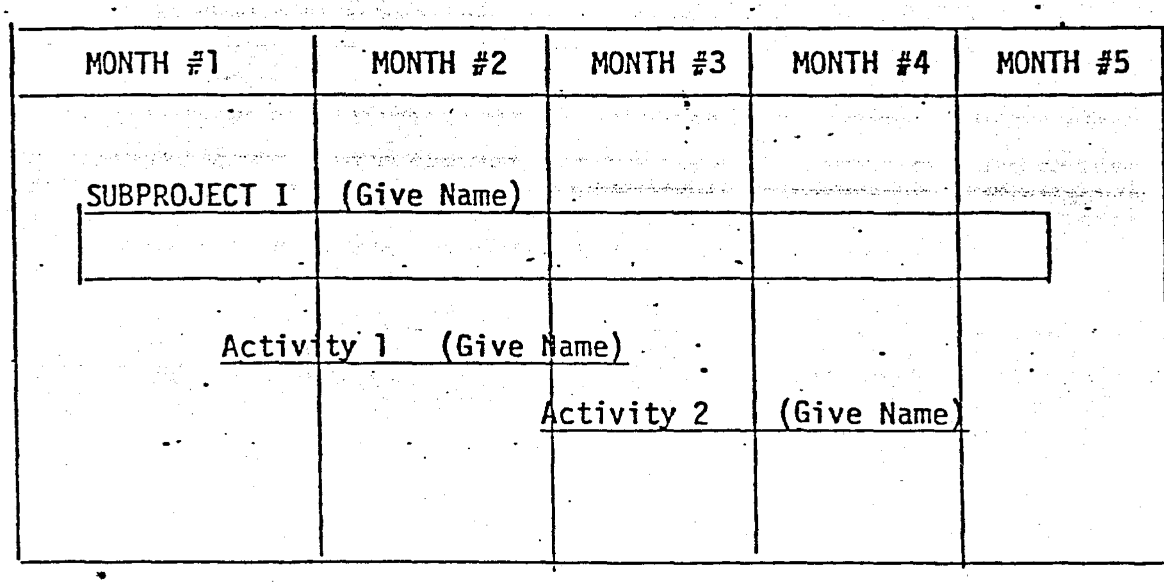
For projects involving dredging, the location and dimensions (length, width, depth) of the dredged area as well as any areas used for fill or spoil disposal must be given. Give methods of excavation, type of material to be used for backfill, quantity and type of materials to be excavated, intended use of excavated and/or filled areas, methods to be used to retain materials and prevent erosion of filled areas.

5.03 Project Workplan:

a. Identification of subprojects and activities: For all major applications the project must be divided into a set of subprojects, defined as the smallest physical components of a project that would be recognized by an engineer as separate units. For each subproject listed a corresponding set of activites must be identified, and each activity must be described in sufficient detail so that the nature of the work can be determined. An activity is a major human work action or process involved in the construction of a subproject, as distinct from the physical components. For example:

Subproject I: Site Preparation
Activity 1. Brush clearing by bulldozer (describe)
Activity 2. Settling pond construction (describe)

b. Phasing of subprojects and activities: A time schedule of the work elements must be provided in the form of a phasing diagram (see example below).



COMMENTS:

6.00 ENVIRONMENTAL SETTING AND PROBABLE PROJECT IMPACTS ON THE ENVIRONMENT

While the methods selected by the preparer of the Environmental Assessment Report (EAR) will ultimately depend on the type of ecosystem being investigated, the nature of the proposed environmental alteration and the magnitude of the development, the following checklist will help in designing studies compatible with the goals and policies of the V.I. Coastal Zone Management Act.

a. Scope of information required: 1) A description of the existing environme including plant and animal species, existing community structure, marine life, soil conditions, geology, etc., is required. In some cases, a broader or more regional perspective (regional meaning encompassing all or a substantial portion of a major island, insular shelf area, or the coastal waters surrounding such areas) may be necessary if those resources may be affected by the proposed project. 2) The applic should evaluate and assess potential impacts likely to occur on the environment due to development. 3) Also include all of the actions which are to be taken by the permittee to reduce impacts within the surrounding natural and human environment. Examples would be the use of sediment curtains in dredging, limitation of noise producing activities to daylight hours and other such actions which will be used by the developer to reduce the environmental impacts.

b. Currency of information: Applicants are encouraged to make full use of information already existing in EARs, government studies, reports, etc.. Such information must meet the quality standards contained herein, and must represent a synthesis of available data updated as necessary to provide an accurate picture of present conditions. A bibliography of some of the available literature is presented in the appendix.

c. Seasonal data: Some types of projects will require that the EAR include data on seasonal variations in such factors as winds, currents, rainfall, community structure, etc.. If such data are not available, they would have to be collected by the applicant. Both the necessity for information on seasonal variations and the time period for such studies will be decided on a case-by-case basis in consultation with the DCZM staff. Applicants for such projects should plan to begin data collection well in advance of the projected application date.

☐ 6.01 Climate and Weather: A summary of climatic information for the area should be presented along with any potential modification of the microclimate which might be affected by the project. Seasonality should be considered in this section. This discussion should include both the rainfall averages for the general area and those for the nearest individual reference station. Rainfall data will help to anticipate flooding probabilities so that runoff from project activiti can be minimized.

Comments:

6.02 Landforms, Geology and Soils: Available information regarding soils, topography, and underlying geological formations, and any historical information regarding land use patterns, salt pond filling, or dredging should be included. The range of slopes (%) on the site should be given as well as the average slope.

Any change likely to occur in the topography or bathymetry of the area as a result of the implementation of the project should be discussed. Elevation drawings should also be referenced.

6.03 Drainage, Flooding and Erosion Control:

a. Drainage information from such sources as topographic maps, site inspections, persons living in the area, etc., should be included to show the relationship of the project to existing drainage patterns. A water resources map showing all major drainage channels and watersheds is available at DCZM or Public Works.

b. In addition, project activities that will result in alterations in drainage patterns, flood plains, and watershed should be discussed.

c. Both terrestrial erosion and shoreline erosion questions should be dealt with and how these drainage and erosion questions relate in regards to potential impacts on the environment.

d. The relationship of the project to the coastal flood plan (100-year frequency tidal flood) should be discussed - this information can be found in Flood Plain Information (Army Corps of Engineers, 1975), available at DCZM. The elevation of a 100 year frequency inland flood mush be identified and discussed as it relates to the project - this information is computed and illustrated on maps for selected drainages basins as part of the National Flood Insurance Program. For other areas, computations will have to be presented in the EAR.

e. Peak flow calculations for runoff should be made for the downstream point of discharge of the existing site as a result of a 25-year, 24-hour storm (50-year, 24-hour storm if drainage area is in excess of 50 acres, or if the site or areas downstream from it are subject to flooding).

f. Existing storm water disposal structures (if any) must be discussed.

6.04 Fresh Water Resources: Discuss the relationship of the project site to any existing surface water or ground water resources in the area.

6.05 Oceanography: When a project bears any relationship to the marine environment, a thorough discussion of the biological and physical oceanography is warranted. Some of this information is available in a variety of EARs and government publications (see appendix) but frequently the permittee will have to gather this information for his project area.

a. Sea Bed Alteration: When a proposed project involves alteration of the sea bed (pier construction, dredging, etc.) or when runoff will alter the topography, it is expected that the EAR will include an anlaysis of the existing bathymetry and geology of the area in question.

Comments:

☐ b. Tides and Currents: When a project is marine-related, this information should be supplied. The National Oceanic and Atmospheric Administration (NOAA) publishes tide tables annually. Information on current patterns is available from EARs prepared for island development and from several government publications (see appendix).

☐ c. Wave Impacts: The impact of both normal wave action and potential storm wave action on the project site should be described. Hurricane frequency and the resultant increase in sea level and wave height should also be discussed.

☐ d. Marine Water Quality: Most of the available information regarding marine water quality is available through the DCCA Water Resources Program (774-3411 or 773-0565). The potential effects of sediment runoff on water quality should be discussed.

☐ 6.06 Marine Resources: This section should include a discussion of the marine organisms present in the waters likely to be affected by the project. Habitat distribution maps and a list of the important or characteristic species observed, with some indication of relative abundance should be supplied. A thorough discussion of project impacts regarding displacement, habitat reduction or decimati of aquatic organisms should be addressed. In addition, marine projects should be discussed in terms of their impacts on commercial fishing and recreational activiti that have traditionally taken place in these areas.

☐ 6.07 Terrestrial Resources: A discussion of the flora and fauna of the project site and a description of the general ecology of the area should be address Particular reference should be made to those plant and animal communities likely to be impacted by the project.

☐ 6.08 Wetlands: The term "wetlands" refers to those areas that are inundated or saturated by ground or surface water at a frequency and duration to support a community of organisms specifically adapted to this type of environment. This definition includes terrestrial wetlands as well as those shallow and intertidal marine areas supporting seagrasses or attached marine algae (including, but not limited to, salt or freshwater ponds, salt marshes, lagoons, tidal flats, etc.). Discuss the effects of the project on existing wetland habitats and give the area of wetlands likely to be affected by dredging, filling or other related activities (impoundment, water level manipulation, thermal or other effluents) and list the predominant emergent and/or submerged plant species.

☐ 6.09 Rare and Endangered Species: A discussion of the occurrence of any fede or locally endangered species in the project area should be included. A list of federal endangered species is given in the Endangered Species Act (U.S. Fish and Wildlife Service, 1974) and local endangered species are described in V.I. Fish and Wildlife Service publications. Any potential project impacts upon an endanger species must be discussed.

Comments:

☐ 6.10 Air Quality: DCCA publishes summaries of air quality for the Virgin Islands and this information can be obtained by contacting the Division of Natural Resources Management at 774-6420 or 773-0565. Additionally, the applicant should discuss any modifications in local air quality resulting from project activities including noise, dust and dirt, and other air contaminants.

☐ 6.11 Land and Water Use Plans: The zoning of both project site and adjacent areas, CZM designations (SNA's, APC's, etc.), and any other long-term use information (ex: future development plans) should be included and discussed in this section.

Comments:

7.00 IMPACTS ON THE HUMAN ENVIRONMENT

☐ 7.01 Visual Impacts: This section should include a discussion of the aesthetic implications and visual effects of the proposed project, including architectural and landscaping considerations, visual compatibility with the surroundings and preservation of open space and vistas.

7.02 Impacts on Public Services: A quantitative statement should be presented regarding project for the following public services along with methods intended to help reduce anticipated demands:

☐ a. Water: This section should include an analysis of available fresh water supplies vs project demands (in gal./person/day) and should specify how any supply deficiencies will be dealt with.

☐ b. Sewage Treatment and Disposal: Project sewage must be handled in an environmentally safe manner. A discussion of the amounts of sewage expected to be generated by the project as well as methods to be used in the handling, treatment and disposal of these wastes is expected.

☐ c. Solid Waste Disposal: The applicant should quantify the amount of solid wastes expected to be generated by the project as well as methods for disposal. The impacts of project solid wastes on public disposal facilities (ie. landfill areas) should be described if they expect to be utilized along with options to reduce the impacts (compaction, garbage separation, on-site incineration, etc.) Also address removal methods (private haulers, Public Works removal, etc.).

Comments:

☐ d. Roads, Traffic and Parking: The permittee should describe the potential impacts of the development on area roads and highways in the vicinity of the project. Topics should include anticipated increased traffic loads, access and entry ways, circulation patterns, existing road hazards, highway safety, etc.. Additional information may be asked of the applicant to help evaluate project impacts on roads and traffic (traffic counts, detailed drawings of entry ways, etc. Parking requirements should be described. Parking minimums are outlined in the V.I. Zoning Code, but additional spaces should be considered if necessary.

☐ e. Electricity: Estimates of project power demands, as well as the anticip source(s) (including emergency back-up generating power for essential project services, if necessary) should be addressed.

☐ f. Schools: A statement as to the long term or short term impacts likely to be created on the local educational system because of the project is necessary.

☐ g. Fire and Police Protection: Project security and fire preventions measures should be described (eg. parking lot and walkway lighting, easy access for firetrucks and firefighters, an accessible water supply for fighting fires, fire retardant building materials, etc.).

☐ h. Public Health: Likely impacts upon island hospital and medical facilities should be addressed.

Comments:

☐ 7.03 Social Impacts: Discuss the ways in which the proposed project could affect the social environment of the immediate area and of the island as a whole. Information on potential population increases, resulting in more temporary and long-term residents, as well as the rate of increase should be considered. Discus changes in population composition (age, income, household size, place of origin, Also address the characteristics of the project which may encourage additional gr and development (eg. a major expansion of a waste water treatment plant might all for more construction in the area). The desireability of such growth or growth incentives should be discussed.

☐ 7.04 Economic Impacts: The effects of the development on the local economy should be clarified including: the number of jobs which will be generated (both construction and permanent), the number or percent of jobs that will be seasonal, and the income likely to be generated by new employment opportunities. Secondary economic effects must be considered including, but not limited to, locally retain economic multipliers, effects on adjacent real estate values, impact on the housing market, and others.

A quantitative statement of all tax revenues which will accrue to the V Government as a result of the project should be provided (Property tax, gross receipts, income tax, etc.). This should be balanced by information on the capit costs and operating costs associated with the provision of needed public faciliti and services.

☐ 7.05 Impacts on Historical and Archaeological Resources: Such sites should be adequately described and mapped. Anticipated impacts should be discussed. DCCA has an archaeologist on staff if questions need be answered.

☐ 7.06 Recreational Use: If the project causes any adverse impacts on current or traditional recreational activities within the area, these should be thoroughly discussed and the affected groups identified.

☐ 7.07 Hazardous Waste Disposals: Describe methods for disposal of any wastes to be generated by the proposed project during construction and during the operational phase of project including, but not limited to thermal or saline effluents, chemical residues, dredge spoils, oil and hazardous materials. Discuss the effects of waste discharges on the natural and human environment and state whether such discharges have been permitted by the appropriate federal or territorial regulatory agencies.

☐ 7.08 Accidential Spills: Projects handling oil or other hazardous materials are required to prepare a Spill Contingency Plan under Act 3538 - this document should be referenced and the major points summarized under this section.

☐ 7.09 Potential Adverse Effects Which Cannot Be Avoided: All such effects should be listed and discussed.

Comments:

☐ 8.00 ALTERNATIVES TO PROPOSED ACTION: All such reasonable alternatives, including a no action alternative, should be discussed. Describe alternatives which would reduce or eliminate any adverse effects, even if such alternatives substantially impede the attainment of the project objectives and are more costly.

☐ 9.00 RELATIONSHIP BETWEEN SHORT TERM AND LONG TERM USES OF MAN'S ENVIRONMENT: This section should involve a thorough discussion regarding the relationship of this project to long term uses of Virgin Islands Coastal Zone Resources, including the natural, social and economic environment.

Uses of nonrenewable resources during the initial and operation phases of the project may be irreversible since a large commitment of such resources makes removal or nonuse thereafter unlikely. Primary impacts and, particularly, secondary impacts (such as a highway improvement which provides access to a non-accessible area) generally commits future generations to similar uses. Irretrievable commitment of resources should be evaluated to assure that such current consumption is justified.

Comments:

10.00 ORGANIZATIONS AND PERSONS CONSULTED: The identity of all federal, state or local agencies, other organizations and private individuals consulted in preparing the EAR, and the identity of the persons, firm or agency preparing the EAR by contract or other authorization, must be given. It is recommended that adjacent property owners, impacted citizens groups, and affected individuals should be contacted.

☐

Comments:

This checklist of items recommended for preparing an Environmental Assessment Report (EAR) has been reviewed and approved with comments and modifications as are noted within the text.

Date:________________________

Applicant or Authorized Representative

V.I. Coastal Zone Management Representative

APPENDIX C - ENVIRONMENTAL HEALTH IMPACT CHECKLIST (DONALDSON, 1977)

1. Direct Impact Caused by Project on Those Living in the Project Area

1.1 Impact on Communicable Disease Patterns

1.1.1 Introduction of new strains of locally endemic diseases.
1.1.2 Introduction of new diseases not normally found in the area.
1.1.3 Extension of the area of locally endemic diseases.

1.2 Impact of Local Sanitation Measures

1.2.1 Failure of local sanitation measures because of large influx causing increase of diarrheas, etc.
1.2.2 Increase of respiratory pollution due to overcrowding.
1.2.3 Increase of environmental pollution due to inadequate disposal of human excreta and/or solid waste.
1.2.4 Increase of venereal diseases.

1.3 Impact of Water Resources

1.3.1 Deterioration of water quality because of contamination of groundwater, lakes, streams, etc., because of the burden of increased waste disposal.
1.3.2 Deterioration of water quality due to leaking, etc., from materials used by and/or disposed of in the project.
1.3.3 Deterioration of water quality due to increased diversions for project needs.

1.4 Impact on Ecological Balance

1.4.1 Fish kills due to reduced oxygene content of impounded water can cause a lowering of nutrition standards.
1.4.2 Long-term decline in fish spawning with persistent deoxygenation.
1.4.3 Thermal pollution of power plant operations can effect types or number of aquatic growths which can influence disease patterns.
1.4.4 Discharge of toxic effluents into the air and/or water courses.

1.5 Impact on Agriculture

1.5.1 Expose farmers to new diseases. For example, schistosomiasis in irrigation projects.
1.5.2 Reduced nutrition levels due to limited food supplies being bought up by project workers.
1.5.3 Reduced food supplies due to increased soil salinity.

1.6 Miscellaneous Impacts

1.6.1 Increased exposure of local population to traffic accidents.
1.6.2 Risks from certain industrial processes: accidental release of chemicals; excessive air pollution; discharge of chemical wastes such as mercury, etc.; excessive noises.
1.6.3 Adverse psychological effects due to displacement of from ancestral homes.
1.6.4 Dietary changes can result in serious side effects (diarrhea, cramps, etc.) from lactose intolerance.

2. Direct Impact on Project Workers

2.1 Exposure of Many Nonimmune Persons to Locally Endemic Diseases

2.1.1 Malaria is often underestimated as to distribution, ease of control (even with anti-malarial drugs) as well as severity.
2.1.2 Onchocerciasis is of particular concern on water resource projects in East and West Africa; Guatemala (Western slopes) Southern Mexico, Northern Venezuela and Amazonas in Brazil.
2.1.3 Schistosomiasis is of concern in water resource projects in Sub-Sahara Africa, Arabian peninsula, the Nile Valley, Iran, portions of the Middle East, Brazil, Venezuela, the lesser Antilles and Puerto Rico, China, Japan and the Philipines.
2.1.4 Tryponosomiasis (African sleeping sickness) which occurs in a very wide band accross the middle of Africa (between 15° N to 20° S) is generally fatal if not treated in its earliest stages. The American form, Chagas disease, is found mainly in South America (principally Argentina and Venezuela) and in much of Middle America.
2.1.5 Two forms of human filariasis are prevalent in vast areas of the world (more or less 250 millions in 1967) especially in South-east Asia extending along the coastal region as far north as Korea and into Indonesia.
2.1.6 Trachoma is widespread in the Middle East, in Asia, along the Mediterranean Littoral, and in parts of Africa, as well as parts of Haiti. High prevalence in generally associated with poor hygiene, poverty and crowded living conditions, particularly in dry, dusty regions.

2.2 Exposure to Chemical and Physical Hazards

2.2.1 Chemical hazards include: Dust, fumes, vapors, toxic liquids, etc.
2.2.2 Physical hazards include: vibration, temperature, pressure, radiation, noise, etc.

2.3 Nutritional Status

2.3.1 By providing low-cost food and/or supplementary foods the health and productivity of workers has been improved as well as reduction in accident rates.

3. <u>Indirect Impact Due to Disease Vectors</u>

3.1 <u>Introduction of New Diseases</u>

3.1.1 An example of this is the "sleeve" distribution of sleeping sickness in the settlements along roads, tracks and communicating streams of Africa.

3.1.2 The snail vector of schistosomiasis can be spread into an area carried on the mud on the underside of a car. A single snail is capable of quickly colonizing a new habitat.

3.2 <u>Reinfection of Areas Previously Cleared of Disease</u>

3.2.1 Control programs should aim at a combination of four actions: A) Erradication of the cause of the disease; B) Breaking the chain of transmission; C) Isolating the victim; and D) Strengthening the resistance of the victim.

3.2.2 Major emphasis is usually on vector control and treatment, with education in prevention an important element.

3.2.3 Once erradication has been achieved strict vigilance is required to avoid reintroduction of diseases (such as malaria) through reinfection of surviving vectors by feeding on infected humans who come from outside the area.

3.3 <u>Increased Propagation and Spread of Existing Vectors</u>

3.3.1 Increase in propagation of vectors

3.3.2 An increase in mosquito population results from the early stages of clearing, trash heaps, etc., therefore, engineering control measure and residual spraying must be used to control it.

3.3.3 The explosive growth of water plants can favor the massive reproduction of snails. Thus starting the disease chain for Schistosomiasis.

3.4 <u>Spread of Vectors</u>

3.4.1 Breeding of the fly vector of Onchocerciasis is generally arrested by the still water of a reservoir but, breeding sites are increased around spillways and below the dam where higher velocities and turbulence provide a favorable habitat. Treatment of the stream with insecticides is usual control method.

4. <u>Impact on Existing Health Services</u>

4.1 <u>Heavy Demands on a Weak Infrastructure</u>

4.1.1 Project creates a new force for a number of social and health services (i.e. medical care, etc.).

4.1.2 Project creates the need for increased surveillance; inspection, monitoring and action.

4.2 <u>Overwhelming of Locally Available Resources</u>

4.2.1 New demands often exceed budgetary possibilities of local authorities.

4.2.2 Many of the increased services are temporary (i.e. life of the project--sanitation surveillance) while others are long-range (Malaria, etc.).

4.3 <u>Provision of Additional Facilities as a Project Cost</u>

4.3.1 Project authorities should at least plan to provide sanitation and vector control measures during construction phase.

4.3.2 Designer should incorporate long-term measures into project (swamp drainage, lined ditches, piped water to relocated inhabitants, etc.).

4.3.3 National authorities should insist on assigning part of the project revenue to Public Health sector to allow it to develop needed long-term infrastructure in the area.

APPENDIX D

Actions and Environmental Items in Leopold Interaction Matrix

Actions				Environmental items			
Category		**Description**		**Category**		**Description**	
A	Modification of regime	a	Exotic fauna introduction	A	Physical and chemical characteristics		
		b	Biological controls	1	Earth	a	Mineral resources
		c	Modification of habitat			b	Construction material
		d	Alteration of ground cover			c	Soils
		e	Alteration of groundwater hydrology			d	Land form
		f	Alteration of drainage			e	Force fields and background radiation
		g	River control and flow modification			f	Unique physical features
		h	Canalization	2	Water	a	Surface
		i	Irrigation			b	Ocean
		j	Weather modification			c	Underground
		k	Burning			d	Quality
		l	Surface or paving			e	Temperature
		m	Noise and vibration			f	Recharge
B	Land transformation and construction	a	Urbanization			g	Snow, ice, and permafrost
		b	Industrial sites and buildings	3	Atmosphere	a	Quality (gases, particulates)
		c	Airports			b	Climate (micro, macro)
		d	Highways and bridges			c	Temperature
		e	Roads and trails	4	Processes	a	Floods
		f	Railroads			b	Erosion
		g	Cables and lifts			c	Deposition (sedimentation, precipitation)
		h	Transmission lines, pipelines, and corridors			d	Solution
		i	Barriers including fencing			e	Sorption (ion exchange, complexing)
		j	Channel dredging and straightening			f	Compaction and settling
		k	Channel revertments			g	Stability (slides, slumps)
		l	Canals			h	Stress-strain (earthquakes)
		m	Dams and impoundments			i	Air movements
		n	Piers, seawalls, marinas, and sea terminals	B	Biological conditions		
		o	Offshore structures	1	Flora	a	Trees
		p	Recreational structures			b	Shrubs
		q	Blasting and drilling			c	Grass
		r	Cut and fill			d	Crops
		s	Tunnels and underground structures			e	Microflora
						f	Aquatic plants
C	Resource extraction	a	Blasting and drilling			g	Endangered species
		b	Surface excavation			h	Barriers

(continued) Actions and Environmental Items in Leopold Interaction Matrix

Actions: Category	Actions: Description	Environmental items: Category	Environmental items: Description
	c Subsurface excavation and retorting		i Corridors
	d Well dredging and fluid removal	2 Fauna	a Birds
	e Dredging		b Land animals including reptiles
	f Clear cutting and other lumbering		c Fish and shellfish
	g Commercial fishing and hunting		d Benthic organisms
D Processing	a Farming		e Insects
	b Ranching and grazing		f Microfauna
	c Feed lots		g Endangered species
	d Dairying		h Barriers
	e Energy generation		i Corridors
	f Mineral processing	C Cultural factors	
	g Metallurgical industry	1 Land use	a Wilderness and open spaces
	h Chemical industry		b Wetlands
	i Textile industry		c Forestry
	j Automobile and aircraft		d Grazing
	k Oil refining		e Agriculture
	l Food		f Residential
	m Lumbering		g Commercial
	n Pulp and paper		h Industry
	o Product storage		i Mining and quarrying
E Land alteration	a Erosion control and terracing	2 Recreation	a Hunting
	b Mine sealing and waste control		b Fishing
	c Strip mining rehabilitation		c Boating
	d Landscaping		d Swimming
	e Harbor dredging		e Camping and hiking
	f Marsh fill and drainage		f Picnicking
F Resource renewal	a Reforestation		g Resorts
	b Wildlife stocking and management	3 Aesthetic and human interest	a Scenic views and vistas
	c Groundwater recharge		b Wilderness qualities
	d Fertilization application		c Open-space qualities
	e Waste recycling		d Landscape design
G Changes in traffic	a Railway		e Unique physical features
	b Automobile		f Parks and reserves
	c Trucking		g Monuments
	d Shipping		h Rare and unique species or ecosystems
			i Historical or archeological sites and objects
			j Presence of misfits
		4 Cultural status	a Cultural patterns (life-style)

(*continued*) **Actions and Environmental Items in Leopold Interaction Matrix**

Actions: Category	Actions: Description	Environmental items: Category	Environmental items: Description
	e Aircraft		b Health and safety
	f River and canal traffic		c Employment
			d Population density
	g Pleasure boating	5 Manufactured facilities and activities	a Structures
	h Trails		b Transportation network (movement, access)
	i Cables and lifts		
	j Communication		
	k Pipeline		c Utility networks
H Waste replacement and treatment	a Ocean dumping		d Waste disposal
	b Landfill		e Barriers
	c Emplacement of tailings, spoils, and overburden		f Corridors
		D Ecological relationships	a Salinization of water resources
	d Underground storage		b Eutrophication
			c Disease–insect vectors
	e Junk disposal		
	f Oil well flooding		d Food chains
	g Deep well emplacement		e Salinization of surficial material
	h Cooling water discharge		f Brush encroachment
			g Other
	i Municipal waste discharge including spray irrigation	E Others	
	j Liquid effluent discharge		
	k Stabilization and oxidation ponds		
	l Septic tanks, commercial and domestic		
	m Stack and exhaust emission		
	n Spent lubricants		
I Chemical treatment	a Fertilization		
	b Chemical deicing of highways, etc.		
	c Chemical stabilization of soil		
	d Weed control		
	e Insect control (pesticides)		
J Accidents	a Explosions		
	b Spills and leaks		
	c Operational failure		
K Others			

APPROPRIATE METHODOLOGIES FOR EVALUATION OF ALTERNATIVES

Terrence P. Thompson, P.E.[a]

1. INTRODUCTION

The process of environmental impact assessment was developed in order to incorporate environmental considerations into the project planning process. Its intent is to give environmental considerations greater weight in the planning process than has previously been given in decades past. When properly used however, an EIA attempts to strike a balance between environmental, economic, and technical considerations in project planning.

The practice in the United States and elsewhere is for an EIA to assess not only the proposed action (i.e., the project), but also reasonable alternatives. Reasonable alternatives would include:

- o alternate project designs and configurations;
- o alternate designs for portions of the project;
- o alternate project sites; and
- o "no action" alternative.

After impacts of the various alternatives have been identified and predicted, there is a need to evaluate the alternatives in light of its effects on natural resources and social systems (i.e, environmental impact), economic costs, and technical considerations. In so doing, the EIA will arrive at a "preferred alternative." Note that the preferred alternative is not necessarily the environmentally preferred alternative, although environmental concerns will have been given due consideration in its selection.

The decision making process can be aided by systematic methodologies that evaluate the various alternatives and assist interested parties in conceptualizing the significance of myriad impacts.

2. SOME APPROPRIATE METHODOLOGIES

For small, uncomplicated projects, a simple narrative description of the pros and cons of the various alternatives will often suffice. As projects increase in size and complexity, so too increases the need for a systematic methodology

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to evaluate the alternatives. Several appropriate methodologies are described below. Each method attempts to compare the alternatives concisely and comprehensively. Because of their concise nature, each method needs to be supplemented or accompanied by a narrative description to provide additional detail.

2.1 Paradigms

A paradigm is constructed by putting each alternative under a separate column heading and juxtaposing these against row headings of environmental components. Under each column heading (alternatives) the impact on the environmental components is described row by row by entering a descriptive sentence or short descriptive paragraph. Eleven by fourteen or eleven by seventeen inch spread sheets are useful when constructing a paradigm. An example of a paradigm appears in Appendix A. This paradigm compares environmental impacts for three alternative sites for a proposed 25 million ton per year coal exporting terminal. It concisely summarizes the impacts at the alternative sites.

A paradigm provides an excellent basis for discussions of alternatives in official and public forums. Its use is highly recommended.

2.2 Plan Ranking

Plan ranking depends on the calculation of a single index value for each alternative considered. Under this approach, all impacts associated with a particular alternative are reduced to an aggregate measurement. The usual method of plan ranking is weighted averaging. A variation of this is the Batelle Environmental Evaluation System.

Weighted Averaging

In its simplest form, weighted averaging entails the assignment of "weights" of importance to environmental components, multiplying these by measures of the respective impacts, and summing the results to arrive at an aggregrate measuremnt of overall impact.

In the following example, impacts are assumed to accrue to terrestrial habitats, water quality, air quality, and cultural resources. Two alternatives are compared.

Environmental Component	Weight,W	Alternative A Impact,I	Alternative A WxI	Alternative B Impact,I	Alternative B WxI
Terrestrial	30	19	570	19	570
Water Quality	25	59	1475	5	125
Air Quality	30	23	690	15	450
Cultural	15	0	0	63	945
			2735		2090

Alternative B is seen to have less of an overall impact than Alternative A.

In order to make this method defensible however, a rational means of assigning weights and impact measurements is needed. Te Batelle Environmental Evaluation System is one method developed to fill this need.

Batelle Environmental Evaluation System

As shown in Figure 1, the Batelle System (Dee et al, 1972) considers environmental impacts in four categories: ecology, environmental pollution, esthetics, and human interest. These categories are divided into 18 environmental components, which are further divided into 78 environmental parameters. The environmental impact (EIU) on each parameter is calculated by multiplying its parameter importance units (PIU) by its environmental quality (EQ):

Environmental impact = parameter importance x environmental quality

EIU = PIU x EQ

The parameter importance units shown in Figure 1 were developed by the Batelle investigators using the ranked pairwise comparison technique. As an example of this technique, consider the distribution of 100 PIU's among three environmental parameters. After some discussion, a multidisciplinary team considers parameter B to be more important than parameter C, which is more important than parameter A. Next, parameter B is assigned a value of 1.0. Parameter C is considered relative to parameter B and assigned an importance on a scale from 0 to 1. Parameter C is considered to be one-half as important as parameter B for the purposes of this example. Parameter A is then considered relative to parameter C, and in this example a value of one-fifth is applied. The 100 PIU's would then be assigned based on the following proportionalities:

$$\text{Parameter B} = \frac{1.0}{(1 + 0.5 + 0.1)} \times 100 = 63$$

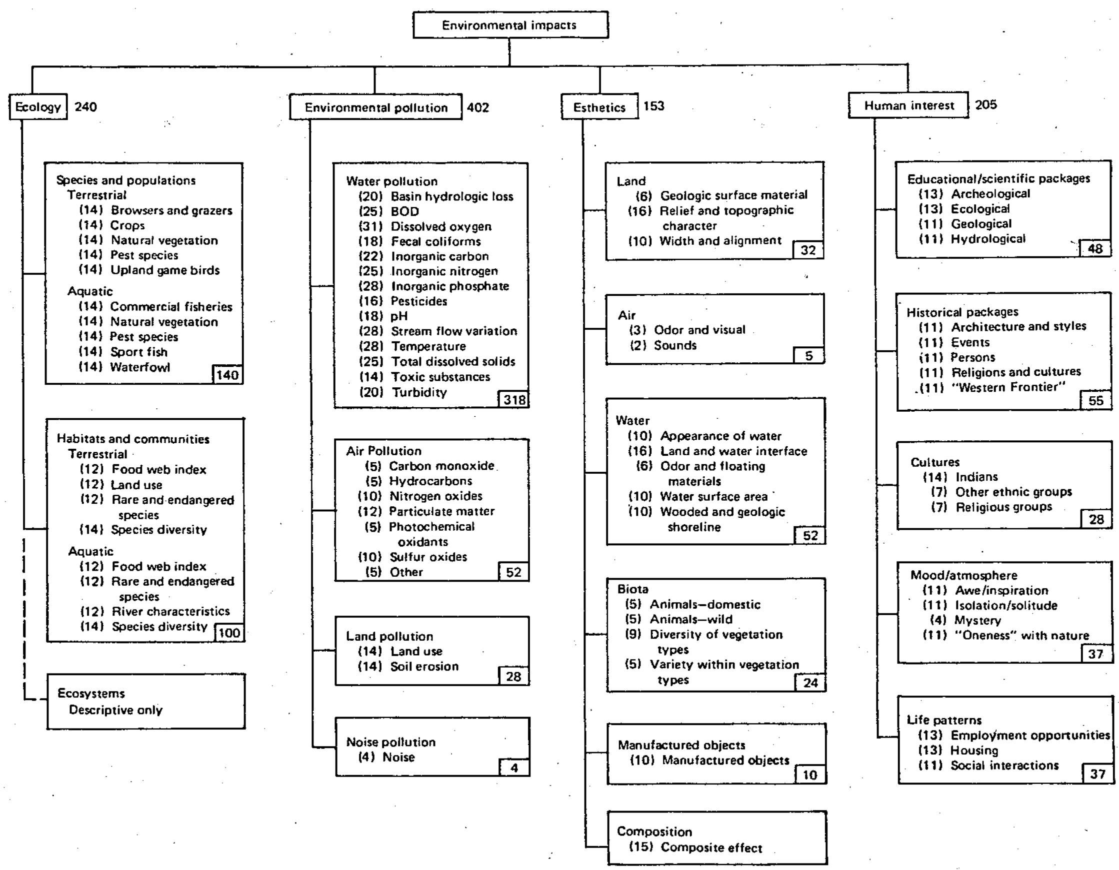


Figure 1 Battelle environmental evaluation system. Numbers in parentheses are parameter importance units. Numbers enclosed in boxes represent the total.

$$\text{Parameter C} = \frac{0.5}{1.6} \times 100 = 31$$

$$\text{Parameter A} = \frac{0.1}{1.6} \times 100 = 6$$

The Batelle investigators (Dee et al, 1972) used this procedure to distribute 1,000 PIU's as shown in Figure 1.

The parameter importance units are constant values, unchanging from one alternative to the next. Environmental quality (EQ) values vary however according to the specific impacts associated with each alternative. The EQ values are determined by means of value function graphs which have been developed for each of the 78 parameters in the Batelle system. Figure 2 shows several sample graphs. Environmental quality can range from 0, poor quality, to 1.0, very good quality. For each alternative being evaluated, EQ values would be determined from the graphs for each of the 78 parameters.

An aggregate measure of overall impact for each alternative would be calculated by multiplying each of the 78 EQ's by its corresponding PIU, and summing the products.

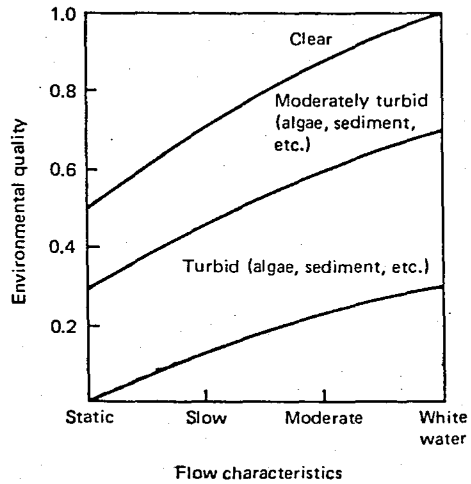
2.3 Matrix Methods

It has been argued that certain environmental components are intrinsically non-quantifiable, and when numerical values are assigned and then incorporated into a single index, or aggregate measure, the evaluation process serves as a basis for disguising and masking the discrete impacts. This inhibits, rather than encourages, public discussion of the project's specific impacts. Instead, an evaluation framework can be organized to allow environmental impacts to be judged on an individual basis, or according to common categories (e.g., water quality, air quality, etc.), (Sorensen and Moss, 1973). Several matrix methods are organized in this way.

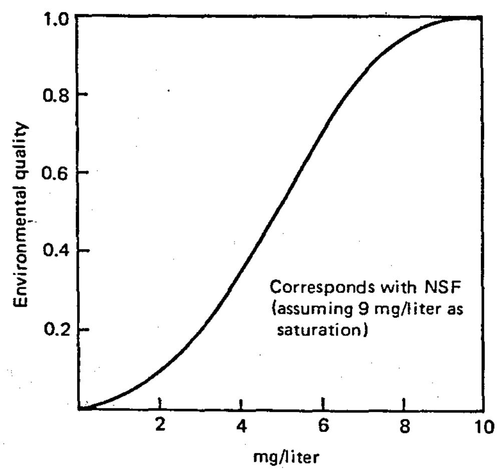
Leopold Matrix

The use of the Leopold Matrix for impact identification was discussed earlier (Thompson, 1985), It can also be used for evaluation of alternatives.

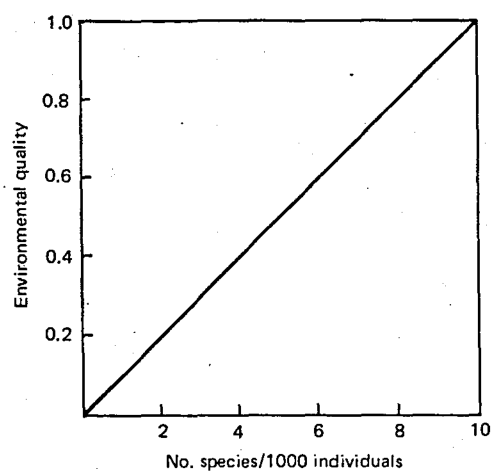
In an earlier paper (Thompson, 1985) it was seen that potential impacts are identified in the Leopold matrix by drawing diagonal lines at intersections between environmental components and project components. Evaluation of these impacts entails placing numerical scores of magnitude and importance



Appearance of water.



Dissolved oxygen.



Species diversity.

Figure 2. Environmental Quality Value Graphs

on either side of the diagonal. The term "magnitude" indicates degree, extensiveness, or scale of the impact. "Importance" refers to the significance or weight of the impact. Within each box for which a potential impact has been identified, a score from 1 to 10 would be placed in the upper left-hand corner to indicate the relative magnitude of the impact. A score from 1 to 10 would be placed in the lower right-hand corner to indicate importance. Ten represents the greatest, and 1 the least.

The actual scores assigned to each impact would be decided on the basis of information developed through predictive methodologies.

An example of a reduced Leopold matrix appears in Figure 3. (It is "reduced" in the sense that columns and rows for which no potential impacts were identified have been eliminated.) Note that the most important impacts are those which effect rare and unique species. Overall, the impacts are of low magnitude, with most scoring 1 or 2 in the upper-left hand corner and none greater than 5.

In order to compare alternatives one may consider multiplying the magnitudes and importances, and summing the products to arrive at an aggregate measure of overall impact. However, Leopold et al (1971) argue against the aggregate measure philosophy, and in favor of discrete comparisons of impacts in related categories:

> "It must be emphasized that no two boxes on any one matrix are precisely equitable. Rather, the significance of high or low numbers for any one box only indicates the degree of impact one type of action may have on one part of the environment. If alternative actions are under consideration, and a separate matrix is prepared for each action, identical boxes in the two matrices will provide a numerical comparison of the alternatives considered."

Comparisons between alternatives can be made in the accompanying text. The matrices serve as a kind of "abstract" for the preparers of the EIA document, as well as an aid for reviewers of the document to assist them in following the preparers' line of reasoning.

<u>USAID Matrix</u>

The U.S. Agency for International Development also advocates discrete comparisons of impacts as oppossed to aggregate

		Industrial sites and buildings II B. b.	Highways and bridges II B. d.	Transmission lines II B. h.	Blasting and drilling II C. a.	Surface excavation II C. b.	Mineral processing II D. f.	Trucking II G. c.	Emplacement of tailings II H. c.	Spills and leaks II J. b.
I A. 2. d.	Water quality					2/2	1/1		2/2	1/4
I A. 3. a.	Atmospheric quality						2/3			
I A. 4. b.	Erosion		2/2			1/1			2/2	
I A. 4. c.	Deposition, Sedimentation		2/2			2/2			2/2	
I B. 1. b.	Shrubs					1/1				
I B. 1. c.	Grasses					1/1				
I B. 1. f.	Aquatic Plants					2/2			2/3	1/4
I B. 2. c.	Fish					2/2			2/2	1/4
I C. 2. e.	Camping and hiking					2/4				
I C. 3. a.	Scenic views and vistas	2/3	2/1	2/3		3/3		2/1	3/3	
I C. 3. b.	Wilderness qualities	4/4	4/4	2/2	1/1	3/3	2/5	3/5	3/5	
I C. 3. h.	Rare and unique species		2/5		5/10	2/4	5/10	5/10		
I C. 4. b.	Health and safety							3/3		

FIGURE 3. The reduced matrix for a phosphate mining lease.

measurement (USAID, 1980), In its matrix methodology, USAID suggests the use of graphic symbols rating impacts. A sample matrix is shown in Figure 4. The Agency also suggests that other symbols may be used in lieu of those shown in the Figure, such as a system of plus and minus signs, various degrees of shading, colors, etc. No such symbols could possibly be used however to calculate an aggregate measure of impact.

As with the Leopold methodology, when alternatives are being evaluated and separate matrices have been prepared for each alternative, comparisons can be made in the accompanying text with the matrices serving as guides for both the preparers and the reviewers of the EIA document. This process leads to discrete comparisons of impacts in related categories, and also results in a thorough discussion of all significant impacts by all interested parties.

2.4 Other Evaluation Methods

Other evaluation methods have been reviewed in the literature (Canter, 1977; Jain et al, 1981; Rau and Wooten, 1980).

Statistical decision theory is used with network analyses where uncertainty exists concerning projected impacts. The methodology involves estimations of probabilities of occurence. An excellent treatise on decision theory is available from Benjamin and Cornell (1970).

With linear vector approaches, an impact index, I, is found by summing the product of component values, X, scaling factors, S, and weighting factors, W. (Whitlatch, 1976).

$$I = \sum_{i=1}^{n} Wi \; Si \; Xi$$

In some instances, evaluation is based on judgements by panels or multidisciplinary teams.

3. PUBLIC INVOLVEMENT

In the United States, public involvement in the EIA process is required by Federal regulations (Council on Environmental Quality, 1973). In countries where the practice of public involvement has not been established, it may be more expedient to rely soley on government officials, experts, and pro-

SMALL-SCALE IRRIGATION
AND ON-FARM WATER MANAGEMENT POTENTIAL IMPACTS

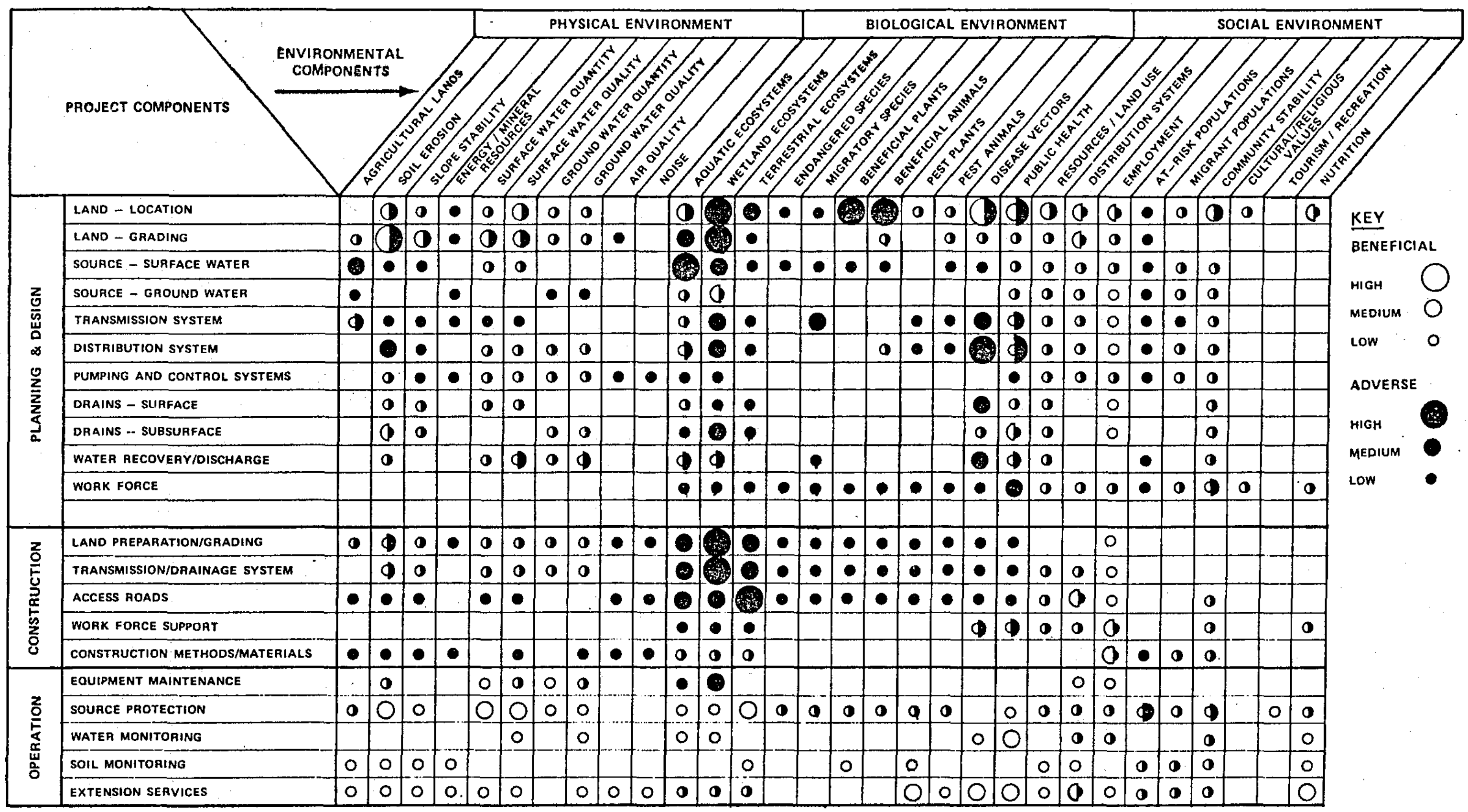


Figure 4. Project Planning Matrix (USAID, 1980)

ject sponsors to complete the evaluation process. However, there are significant advantages to public involvement which should be considered.

One advantage is that the public may provide useful information to the responsible ministry, particularly when the significance of some environmental impacts cannot be easily estimated (Canter, 1977). Having the opportunity to raise issues and have those issues addressed by the responsible ministry raises public confidence in the government and increases public acceptance of the proposed project.

Another benefit is that public involvement places additional accountability on the responsible ministry. Officials are therefore compelled to adhere to official procedures for decision making. The responsible ministry is also forced to be responsible to issues beyond those of the immediate project (Canter, 1977).

In total, public involvement results in better decision making and greater public acceptance of proposed projects. These advantages weigh heavily against the disadvantage of potential delays in schedule.

Public involvement can usually be achieved through several forms:

- official public hearings;
- informal informational meetings; and
- solicitation of written comments.

Some practical suggestions for organizing and conducting public involvement programs have been discussed by Canter (1977).

4. CONCLUSIONS

Alternatives are evaluated in the EIA process to allow decision makers to arrive at a "preferred alternative" in light of the relative merits and demerits of various courses of action. The evaluation is based on a balanced consideration of environmental, economic, and technical factors.

For the simplest projects, a narrative description of the alternatives will usually be sufficient for evaluation. With increasingly complex projects, methodical approaches significantly aid in the selection of the preferred alternative. A paradigm is an effective approach for all but the most complex projects (for example, nuclear power plants). While being effective, they are also easy to construct, easy to use, understandable by virtually all interested parties, and excellent for promoting informed discussions. The use of paradigms is highly recommended.

Plan ranking is a popular method of alternative evaluation, especially among many usually achieved through weighted averaging techniques. This entails the assignment of weights of importance to environmental components, multiplying these by the measures of the respective impacts, and summing the results to arrive at an aggregate measurement of overall impact. The Batelle Environmental Evaluation System provides a rational means of assigning weights and impact measurements. A drawback to the Batelle system is that it places relatively little emphasis on social impacts.

Evaluation methodologies used with the Leopold Matrix and USAID's Project Planning Matrix involve comparisons of alternatives according to common categories of impacts, as opposed to aggregate measurement. The matrices then serve as guides to both the preparer and the reader of the EIA document. With the help of the matrices, alternatives are evaluated in narrative form. Decision makers are thus forced to look at individual impacts rather than the aggregate impact. Instead of selecting projects on an "all or nothing" basis, consideration can be given to modifying portions of alternatives in order to ameliorate impacts in specific categories.

Many other evaluation methodologies have been reviewed in the literature, as mentioned earlier.

Public involvement in the evaluation process is encouraged. Members of the public can often provide otherwise unattainable information. From the project sponsor's viewpoint, public involvement may be seen as unnecessary, costly, and time delaying. Experience shows however that sincere efforts to address public concerns increases public acceptance of projects, and can help prevent formidable opposition. Public involvement also improve governments' integrity and raises public confidence in government.

Simple, defensible methodologies for alternatives evaluations, used in an atmosphere of openness and public involvement help decision makers formulate plans for the preferred alternative. Such an approach promotes the implementation of projects that are technically and economically sound, and environmentally and socially acceptable.

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APPENDIX A

TABLE 3.2.2-4

COMPARISON OF ENVIRONMENTAL FACTORS FOR ALTERNATIVE SITES

	St. Julian Creek	Pig Point	Portsmouth
Natural Resources			
o Aesthetics	Aesthetic value already negatively impacted by extensive military facilities existing on the Site and industrial facilities existing to the south, north, and east.	High aesthetic value due to rural nature of Site with no aesthetic intrusions.	Aesthetic value due to rural nature of Site with minimal aesthetic intrusions accruing from adjacent military and municipal facilities.
	Site is visible from west and northwest residences and northwest Cradock Historic District.	Site is visible from all sides. Potential for visual intrusions on Tidewater Community College, General Electric Plant, and Community of Huntersville. Rural nature of the Site would be dramatically changed.	Site is fully visible from the Elizabeth River to the east and proposed Western Freeway to the south. Site would be screened from view from the Coast Guard Support Base to the north by a berm and vegetation and partially screened from view from residential area to the west by a berm and vegetation.
o Surface Water Quality	Short term increase in suspended solids and some heavy metals concentrations due to dredging of 1.6 MCY of contaminated sediment.	Short term increase in suspended solids and some heavy metals concentrations due to dredging of 0.5 MCY.	Short term increase in suspended solids and some heavy metals concentrations due to dredging of 5.7 MCY.
	Periodic permitted discharge of treated wastewater to moderately assimilative capacity of waterbody (St. Julian Creek).	Periodic permitted discharge of treated wastewater to highly assimilative capacity of waterbody (Nansemond River).	Periodic permitted discharge of treated wastewater to lowly assimilative capacity of waterbody (Craney Island Creek).
o Groundwater Quality	Unknown	Potential contamination of the Yorktown aquifer (an important freshwater aquifer) in the event of a failure of the leachate containment system or wastewater pond liners.	Potential localized contamination of shallow groundwater aquifer (from which there are no withdrawals) in the event of a failure of the leachate containment system or wastewater pond liners.
o Aquatic Ecology	Approximately 18 acres of shallow bottom habitat (polluted and closed to shellfishing) would be removed.	No removal of shallow bottom habitat.	Approximately 44 acres of shallow bottom habitat (condemned and unproductive or marginally productive) would be removed.
	No impact on commercial fishing.	4 1/2 mile trestle would infringe on state licensed gill net locations.	No impact on commercial fishing.

TABLE 3.2.2-4 (Cont'd)

	St. Julian Creek	Pig Point	Portsmouth
Natural Resources (Cont'd)			
o Terrestrial Ecology	Approximately 22 acres of onsite salt marsh would be filled.	Approximately 4 acres of onsite salt marsh and 0.5 acre freshwater pond would be filled. Additionally, the action would fragment a large, diverse and relative undisturbed upland-wetland system.	Approximately 7 acres of onsite salt marsh and 0.7 acre freshwater pond would be filled.
	Mitigation of wetland removal through creation of additional salt marsh may not be feasible due to unavailability of nearby land and siting constraints.	Filling of wetlands can be mitigated by creating salt marsh on land between Nansemond River and the terminal railroad tracks.	Filling of wetlands can be mitigated by creating salt marsh and aquatic freshwater habitat in-land adjacent to Craney Island Creek.
o Air Quality	Potential for occasional exceedances of NAAQS and VAAQS standards. Cradock Historical District and Brentwood residences may be impacted by dust.	Compliance with NAAQS and VAAQS standards. Tidewater Community College and GE Plant may be impacted by dust.	Compliance with NAAQS and VAAQS standards. Coast Guard Support Center and Merrifield Apartments may be impacted by dust.
Land Uses			
o Land Availability	Navy has indicated that this Site is unavailable.	Site is available.	Site is available. (See Section 2.2.2).
o Compatibility with Adjacent Land Uses	North: Cradock Historical District and N&W rail spur.	North: General Electric Plant and Tidewater Community College.	North: Coast Guard Support Center; Naval Fuel and Ammunitions Depot; Craney Island Landfill.
	East: Docking facilities along Elizabeth River; wetlands.	East: Proposed I-664; undeveloped land.	East: Docking facilities along Elizabeth River.
	South: St. Julian Creek.	South: Huntersville; wetlands.	South: Proposed Western Freeway right-of-way; municipal sewage treatment plant.
	West: Brentwood residences.	West: Farmlands; Nansemond River; wetlands.	West: Junior High School; park; residences.
o Prime Agricultural Land Preempted	None.	159 acres.	67 acres.
o Displaced Residences	None.	Two or three.	None.
o Impact on Existing Infrastructure	Relocation of utilities, including VEPCO transmission line, and removal of onsite military facilities required.	Relocation of two private cemeteries and skeet and rifle ranges required.	Relocation of utilities and Coast Guard Boulevard required.

TABLE 3.2.2-4 (Cont'd)

	St. Julian Creek	Pig Point	Portsmouth
Cultural Resources			
o On-Shore Archaeological Resources	No known archaeological sites; some potential for previously undiscovered sites although previous development is likely to have destroyed all or most of them.	Two archaeological sites recorded by Virginia Research Center for Archaeology would be eliminated. High potential for additional archaeological impacts of the same order of magnitude as Portsmouth Site, pending an intensive survey.	Eleven sites potentially eligible for National Register of Historic Places would be eliminated; three would be partially eliminated.
o Architectural Resources	Cradock Historic District to the north may potentially be impacted by increases in noise and dust levels.	One onsite house of potential architectural significance would be moved or demolished.	One offsite house potentially eligible for National Register would be minimally impacted by increases in noise and dust levels.
o Off-Shore Archaeological Resources	No data available, however upriver location makes occurrence of underwater targets unlikely.	At least six shipwrecks are located in the vicinity of the trestle proposed for this Site. Detailed archaeological survey required for impact assessment.	Eighteen potentially significant targets would be impacted by dredging. Three of these targets may be associated with remnants of the CSS Virginia. National Register eligibility has not been established.
Noise and Vibrations			
o Affected Properties	Sensitive receptors include Cradock Historic District and Brentwood residences.	Sensitive receptor is Tidewater Community College.	Sensitive receptors are Coast Guard Support Center and Merrifield Apartments.