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HANDBOOK OF VARIABLES FOR ENVIRONMENTAL IMPACT ASSESSMENT

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PREFACE

The objective of this Handbook is to provide (1) a comprehensive listing of variables relevant to the environmental quality objective of water resource planning; and (2) descriptions of measurement, prediction and assessment techniques for the selected variables when used for environmental impact assessments of water and related land-management studies.

Variables, or assessment variables, refer to those characteristics of the environment used to describe the baseline environmental setting and upon which impacts may occur. This Handbook is organized by section into those variables associated with the terrestrial, aquatic, air and human interface environments. For each of the 62 selected variables, information is presented on their definition, measurement needs for establishing baseline conditions, and impact prediction and assessment. Functional curves are also included for most of the variables. A functional curve represents an empirical relationship between objective measurements of a variable and a subjective evaluation of the quality (good to bad) of that variable in the environmental setting.

This Handbook is intended for use by professionals working on environmental impact studies. Even though the orientation is to water resources, the Handbook is of general value due to the broad applicability and importance of the 62 variables selected. The Handbook could also be used in upper division or graduate level University courses dealing with environmental impact assessments/statements.

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CONTENTS

INTRODUCTION

The environmental impact assessment process involves five activities. The first is an understanding of the legal bases and procedural requirements for the process. Second is a description of the environmental setting where the proposed action is to take place. Assessment variables, or more simply, variables, refer to those characteristics of the environment used to describe the baseline environmental setting and upon which impacts may occur. The third activity in the process, and the one which requires the greatest scientific application of technology, is impact prediction and assessment. The impacts of each of the alternatives being evaluated on each of the variables should be predicted and interpreted. The fourth activity involves the aggregation of impact information on each alternative. Based on this aggregated information as well as technical and economic considerations, the alternative to become the proposed action is selected. The final activity involves the preparation of an environmental impact assessment report (EIA) describing the procedure and findings. The report could also be an environmental impact statement (EIS) is no EIA is required; if an EIA is prepared, information from it could be used in the EIS (Canter, 1977).

Appropriate selection and use of variables is an important component of the environmental impact assessment process. Variables represent key features of the activities involving description of the environmental setting, impact prediction and assessment, and selection of the proposed action. To provide a structure to the variables considered, the environment can be compartmentalized into physical-chemical, biological, esthetic, and socio-economic features. For example, for water resources projects the variables can be grouped into the Environmental Quality (EQ), Social Well-Being (SWB), and Regional Development (RD) accounts. The EQ account primarily addresses the natural environment and includes physical-chemical, biological and esthetic variables; the SWB and RD accounts are oriented to the man-made environment and include socio-economic variables.

The objective of this Handbook is to present a comprehensive list of variables for addressing the physical-chemical, biological and esthetic features of the environment. The variables are organized according to the EQ account for water resources projects, however, their use can be for any type of project. Use of the variables in this Handbook will enable a systematic

consideration and evaluation of the environmental consequences of project development and operation.

To provide a structuce for considering and selecting the variables presented in this Handbook, four categories were chosen, namely, terrestrial, aquatic, air, and human interface. The terrestrial and aquatic categories include physical-chemical and biological variables; the air category includes physical-chemical variables; and the human interface category includes esthetic variables along with noise and historical and archeological resources. These categories of the environment were used in a water resources environmental impact assessment methodology (Solomon, et al., 1977). Each variable included is grouped into either the terrestrial, aquatic, air or human interface categories; and described in terms of measurement, prediction and evaluation considerations.

To select variables for inclusion in this Handbook, a master list of 189 potential ones shown in Table 1 was assembled The list was compiled following review of several environmental impact assessment methodologies. One methodology which included each listed variable is shown in Table 1; in many cases individual variables were listed in each of several methodologies. Final selection of the variables for inclusion in this Handbook was made following consideration of the general importance of the variables, the impacts of water projects, and the information needed to accomplish impact prediction and assessment. The selected variables are shown in Table 1 by an asterisk. Table 2 summarizes the totals for the considered and presented variables. Figure 1 displays the hierarchical structure of the selected variables.

For each of the 62 selected variables in this Handbook, information is presented on their definition, measurement needs for establishing baseline conditions, and impact prediction and assessment. Functional curves are also included for most of the variables. A functional curve represents an empirical relationship between objective measurements of a variable and a subjective evaluation of the quality (good to bad) of that variable in the environmental setting. Objective measurements are plotted on the x-axis, while the subjective quality index is presented on the y-axis. The quality index is presented on a a scale from 0.0 to 1.0 with 0.0 representing low or undesirable quality and 1.0 representing high or desirable quality. Usage of functional curves in environmental impact studies provides an approach for systematically describing the quality of the existing environment as well as assessing the potential impacts of projects. The functional curves which are presented are considered to be generally applicable. Individual functional curves may need to be modified to address specific

environmental conditions in a given region or locale, and professional judgement would be required to accomplish necessary modifications.

This Handbook primarily serves as a source document for information on pertinent variables for environmental impact assessment studies. It is organized by section into those variables associated with the terrestrial, aquatic, air, and human interface environments. Selected references on background information for each of the 62 variables are also identified and contained in the last section. Usage of the information contained herein requires professional judgement in application.

TABLE 1: LIST OF VARIABLES CONSIDERED FOR ENVIRONMENTAL QUALITY ACCOUNT
(* = selected variables)

TERRESTRIAL

I. Populations

*1. Crops (Battelle EES)
2. Vegetation (Battelle Dredging Impact Assessment Method)
3. Trees (Lower Mississippi Valley Division - LMVD)
4. Shrubs (Bureau of Reclamation)
5. Grasses (LMVD)
6. Forbs (Bureau of Reclamation)
7. Ground cover (LMVD)
*8. Natural vegetation (Battelle EES)
9. Animal life (Bureau of Reclamation)
10. Browsers and grazers (Battelle EES)
11. Big game (Bureau of Reclamation)
12. Upland game (Bureau of Reclamation)
13. Fur-bearing animals (Bureau of Reclamation)
14. Game mammals (Battelle Dredging Impact Assessment Method)
*15. Herbivorous mammals (Battelle EES)
*16. Carnivorous mammals (Battelle EES)
*17. Upland game birds (Battelle EES)
*18. Predatory birds (U.S. Army - CERL)

II. Habitats/Land Use

1. Terrestrial habitat (Battelle Water Resources Project)
2. Wildlife habitat (Soil Conservation Service - SCS)
3. Bottomland forest (LMVD)---composite indicator based on following 11 factors:

Species Associations
Percent Mast-Bearing Trees
Percent Coverage of Understory
Diversity of Understory
Percent coverage by Groundcover
Diversity of Groundcover
Number of Trees ≥18 in. dbh/ac
Percent of Trees ≥18 in. dbh

Frequency of Inundation
Quantity of Edge
Mean Distance to Edge

*4. Upland forest (LMVD)---composite indicator based on following 10 factors:

Species Association
Percent Mast-Bearing Trees
Percent Coverage of Understory
Diversity of Understory
Percent Coverage of Groundcover
Diversity of Groundcover
Number of Trees ≥16 in. dbh/ac
Percent of Trees ≥16 in. dbh
Quantity of Edge
Mean Distance to Edge

*5. Open (non-forest) lands (LMVD)---composite indicator based on the following four factors:

Land Use
Diversity of Land Use
Quantity of Edge
Mean Distance to Edge

6. Land/water interface (Battelle Water Resources Project)
7. Drawdown zone (Battelle Water Resources Project)
8. Land use (Battelle EES)
9. Woodland (SCS)
10. Cropland (SCS)
11. Pastureland (SCS)
12. Rangeland (SCS)
13. Wildlife land (SCS)
14. Urban land (SCS)
15. Recreation land (SCS)
16. Other land uses; e.g., surface mined land (SCS)
17. Water (SCS)

III. Land Quality/Soil Erosion

1. Topography (Battelle EES)
2. Flood hazard/flood plains (SCS)
3. Deposition (SCS)
4. Subsidence (Battelle Dredging Impact Assessment Method)
5. Toxic materials (Battelle Dredging Impact Assessment Method)
*6. Soil erosion (Battelle EES)

7. Soil texture/permeability (Housing and Urban Development - HUD)
8. Soil nutrients - NO_3 and PO_4 (SCS)
*9. Soil chemistry - nutrients, salinity, SO_4, alkalinity, Fe, Mn and B (SCS)
10. Quality for specific uses; e.g., cropland, pasture-land, rangeland, woodland, wildlife land, urban, recreation, other (SCS)
11. Wetlands (SCS)
12. Geological resources (Bureau of Reclamation)
*13. Mineral extraction (SCS)
14. Unique geological features (HUD)
15. Depth to impermeable layers (HUD)
16. Special land features - sanitary landfill, coastal zones/shorelines, mine dumps/spoil areas, and prime agricultural land (HUD)
17. Natural hazard (CERL)

IV. Critical Community Relationships

1. Food web index (Battelle EES)
*2. Species diversity (Battelle EES)
3. Ecosystem productivity (Tulsa District)
4. Ecosystem diversity and stability (Tulsa District)
5. Nutrient cycling (HUD)

V. Threatened and/or Endangered Species

1. Threatened and/or endangered species (Battelle EES)

VI. Pests

1. Pest species (Battelle EES)

AQUATIC

I. Populations

*1. Natural vegetation (Battelle EES)
*2. Wetland vegetation (Battelle Dredging Impact Assessment Method)
*3. Zooplankton (Battelle Dredging Impact Assessment Method)
*4. Phytoplankton (Battelle Dredging Impact Assessment Method)
5. Algae (Environmental Impact Center)
6. Fish (Battelle Dredging Impact Assessment Method)
*7. Sport fish (LMVD and Battelle EES)
*8. Commercial fisheries (Battelle EES)

*9. Intertidal organisms (Battelle Dredging Impact Assessment Method)
*10. Benthos/epibenthos (Battelle Dredging Assessment Method)
*11. Waterfowl (Battelle EES)

II. Habitats

1. Lotic - flowing (Tulsa District)
2. Lentic - standing (Tulsa District)
3. Change from lotic to lentic (Battelle Water Resources Project)
4. River characteristics (Battelle EES)
*5. Stream (LMVD)---composite indicator based on following 8 factors:

Sinuosity
Dominant Centrarchid
Mean Low Water Width
Turbidity
TDS
Chemical Type
Diversity of Fishes
Diversity of Benthos

*6. Freshwater lake (LMVD)---composite indicator based on following 10 factors:

Mean Depth
Turbidity
TDS
Chemical Type
Shore Development
Spring Flooding
Standing Crop of Fishes
Standing Crop of Sport Fishes
Diversity of Fishes
Diversity of Benthos

*7. River swamp (LMVD)---composite indicator based on following 6 factors:

Species Associations
Percent Forest Cover
Percent Flooded Annually
Groundcover Diversity
Percent coverage by Groundwater
Days Subject to River Overflow

*8. Non-river swamp (LMVD)---composite indicator based on following 5 factors:

Species Associations
Percent Forest Cover
Percent Flooded Annually
Groundcover Diversity
Percent Coverage by Groundcover

9. Beaches and shores (Bureau of Reclamation)
10. Community alterations - freshwater, estuarine, ocean (Battelle Dredging Impact Assessment Method)
11. Wetlands (HUD)
12. Stream community downstream (Battelle Water Resources Project)

III. Water Quality

*1. pH (Battelle EES)
2. Odor intensity (SCS)
*3. Turbidity (Battelle EES)
*4. Suspended solids (Battelle Dredging Impact Assessment Method)
*5. Water temperature (Battelle EES)
6. Radioactivity (SCS)
*7. Dissolved oxygen (Battelle EES)
*8. Biochemical oxygen demand (Battelle EES)
9. Chemical oxygen demand (SCS)
10. Electrical conductance (SCS)
11. Calcium (SCS)
12. Magnesium (SCS)
13. Sodium (SCS)
14. Sodium absorption rate (SCS)
15. Acidity (SCS)
16. Alkalinity (SCS)
17. Chlorides (SCS)
18. Sulfates (SCS)
19. Bicarbonates (SCS)
*20. Dissolved solids (Battelle EES)
21. Nitrogen compounds (Battelle Water Resources Projects)
*22. Inorganic nitrogen (Battelle EES)
23. Phosphorus (Battelle Water Resources Projects)
*24. Inorganic phosphate (Battelle EES)
*25. Salinity (Battelle Dredging Impact Assessment Method)
26. Inorganic carbon (Battelle EES)
*27. Iron and manganese (Battelle Water Resources Projects)
*28. Toxic substances (Battelle EES)
29. Heavy metals (CERL)
*30. Pesticides (Battelle EES)
31. Oil (CERL)

32. Total coliforms (Battelle Water Resources Projects)
*33. Fecal coliforms (Battelle EES)
34. Fecal streptococcus (SCS)
*35. Stream assimilative capacity (Battelle EES)
36. Sedimentation (Battelle Water Resources Projects)
37. Thermal stratification (Battelle Water Resources Project)
38. Chemical reactions (Battelle Water Resources Projects)
39. Eutrophication (CERL)

IV. Water Quantity

1. Spring flooding (LMVD)
2. Percent of area flooded annually (LMVD)
3. Days subject to river overflow (LMVD)
*4. Stream flow variation (Battelle EES)
*5. Basin hydrologic loss (Battelle EES)
6. Interflow---groundwater (Battelle Dredging Impact Assessment Method)
7. Water uses and consumptive losses (SCS)
8. Aquifer safe yield (CERL)

V. Critical Community Relationships

1. Food web index (Battelle EES)
*2. Species diversity (Battelle EES)
3. Ecosystem productivity (Tulsa District)
4. Ecosystem diversity and stability (Tulsa District)

VI. Threatened and/or Endangered Species

1. Threatened and/or endangered species (Battelle EES)

VII. Pests

1. Pest species (Battelle EES)

AIR

I. Quality

*1. Carbon monoxide (Battelle EES)
*2. Hydrocarbons (Battelle EES)
*3. Oxides of nitrogen (Battelle EES)
4. Photochemical oxidants/ozone (Battelle EES)
5. Sulfur oxides (Battelle EES)
6. Ammonia (SCS)
7. Hydrogen sulfide (SCS)
8. Odor (CERL)
*9. Particulates (Battelle EES)

10. Pollen (SCS)
11. Smoke (SCS)
12. Visibility (SCS)
13. Hazardous toxicants (CERL)

II. Climatology

*1. Diffusion factor (CERL)
2. Inversions (SCS)
3. Air drainage (SCS)

HUMAN INTERFACE

I. Noise

*1. Noise (Battelle EES)
2. Noise intensity (Battelle Dredging Impact Assessment Method)
3. Noise duration (Battelle Dredging Impact Assessment Method)
4. Noise frequency (SCS)
5. Physiological effects (CERL)
6. Psychological effects (CERL)
7. Communication effects (CERL)
8. Performance effects (CERL)
9. Social behavior effects (CERL)

II. Esthetic

1. Geological surface material (Battelle EES)
2. Relief and topographic character (Battelle EES)
3. Surface configuration (Battelle Dredging Impact Assessment Method)
*4. Width and alignment (Battelle EES)
5. Visual quality of landscape (SCS)
6. Open space and green belts (Bureau of Reclamation)
7. Natural areas (Bureau of Reclamation)
8. Other areas of natural beauty (Bureau of Reclamation)
9. Diversity of vegetation type (Battelle EES)
*10. Variety within vegetation type (Battelle EES)
11. Shore line vegetation (Battelle Dredging Impact Assessment Method)
12. Upland vegetation (Battelle Dredging Impact Assessment Method)
13. Terrestrial animals (Battelle Dredging Impact Assessment Method)
*14. Animals - domestic (Battelle EES)
*15. Native fauna (Battelle EES)
16. Birdwatching (Battelle EES)
17. Land/water interface (Battelle EES)

18. Water surface area (Battelle EES)
19. Wooded and geological shoreline (Battelle EES)
*20. Appearance of water (Battelle EES)
*21. Odor and floating materials (Battelle EES)
22. Aquatic animals (Battelle Dredging Impact Assessment Method)
23. Visibility (SCS)
*24. Odor and visual quality (Battelle EES)
*25. Sound (Battelle EES)

III. Historical

*1. Historical internal and external packages (Battelle EES)
2. Historical structures (HUD)

IV. Archeological

*1. Archeological internal and external packages (Battelle EES)
2. Archeological sites and structures (HUD)