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ENVIRONMENTAL ASSESSMENT

OF

WATER QUALITY MANAGEMENT PLANS

JANUARY 1977

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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NOTE

This document is not a replacement to the Act, the Regulations, or official EPA policy statements. It is a supplement to these documents, to assist State and areawide agencies in responding to water quality management program requirements. The guidance in this Handbook does not constitute a uniform National EPA standard of acceptability. Any clarification and specific conditions applicable to a State or designated area should be discussed with the EPA Regional Offices.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE: FEB 8 1977

SUBJECT: Handbook on Environmental Assessment of Water Quality Management Plans

FROM: Walter S. Groszyk for Edmund Notzon, Acting Director
Water Planning Division (WH-554)

TO: All Regional Water Division Directors

ATTN: Regional 208 Coordinators

TECHNICAL GUIDANCE MEMORANDUM: TECH-28

Purpose

This memorandum transmits the recently completed report, "Environmental Assessment of Water Quality Management Plans." It replaces the Draft Handbook on Environmental Assessment of Water Quality Management Plans which was issued in October 1976. This final report incorporates comments received on the draft handbook and is intended for use by State and Areawide agencies in the development of their water quality management programs.

Background

The preparation of an environmental assessment for a water quality management plan is a requirement under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. This handbook is designed to assist managers and staff of planning agencies in assessing the natural and man-made environmental impacts of alternative water quality management (WQM) plan elements. The intent of this guidance is to emphasize the inter-related nature of assessment and planning processes and to promote the use of the assessment in judging alternatives as they are developed.

Most of the chapters in this handbook present information on assessment methodologies, some of which provide very detailed outputs and require fairly extensive inputs of time and money. It is not expected that each WQM agency will need to use these sophisticated methodologies. The choice of appropriate methodologies will depend in large part on the expected impacts of the WQM plans. For example, if the implementation of the plan may result in significant adverse air quality impacts, then it may be necessary to use sophisticated air quality models to identify and assess those impacts. Most of the chapters discuss various methodologies which may be used so that an agency in conjunction with the regional office can choose the methodologies most applicable to its program.

If you would like further information on the handbook, please contact Bill Lienesch of the Program Development Branch (426-2522). Additional copies are available from the Water Planning Division Library (755-6993).

Enclosure

PREFACE

The preparation of an environmental assessment for a water quality management plan is a requirement under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. This Handbook prepared by Centaur Management Consultants, Inc. under EPA Contract Number 68-01-3195, provides guidance on integrating the major environmental assessment questions with the planning process itself. The environmental assessment process can cover an almost limitless number of areas within the physical, social and economic environment. However, to construct a general reference document for the most important aspects of a water quality management plan, this Handbook focuses on key assessment questions in the areas of: water quality, water quantity, air quality, land use, regional economy, visual quality, ecology, and other social impacts.

This Handbook was prepared by the Centaur staff including Cheryl Dinneen, Jane Nowak, Paul Kolp, Marilyn Schule and Isabel Reiff. Outside writing assistance was provided by Professors Leonard Ortolano of Stanford University and Carl Carlozzi of the University of Massachusetts. Many persons within EPA and 208 planning agencies helped review drafts of this Handbook. David Aggerholm and William Lienesch of the EPA Water Planning Division in Washington, D.C. were very instrumental in guiding the document's overall design.

Michael L. Frankel
CENTAUR MANAGEMENT CONSULTANTS, INC.

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INTRODUCTION

The regulations guiding water quality management planning under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 require the preparation of an environmental assessment as part of the planning process. This Handbook is designed to assist managers and staff of planning agencies in assessing the natural and man-made environmental impacts of their recommendations for alternative water quality management (WQM) plan elements. The intent of this guidance is to emphasize the interrelated nature of assessment and planning processes and to promote the use of the assessment in judging alternatives as they are developed.

> *The environmental assessment is not a separate report prepared after the WQM plan is completed. It is a process integrated with the WQM planning process itself.*

The final form of the environmental assessment should be determined by the WQM planning agency in consultation with the EPA Regional Office.

The managers of WQM planning programs are the primary intended audience for this document. That is, the technical depth of the material presented is designed to acquaint the manager with the issues surrounding an environmental assessment*, the key questions to be answered in terms of the WQM plan, and some of the techniques available to conduct the assessment. It is assumed that the actual work of conducting an environmental assessment will be undertaken by in-house staff or outside support in the form of private contracts, agreements with other public agencies, or contracts with academic institutions. In any case, this Handbook should help the manager select the resources, types of personnel, and levels of analysis appropriate for his area. In addition, the Handbook will also be useful to those who are actually conducting the assessment.

It is important to emphasize from the outset that the primary function of a WQM plan is to improve the physical environment in accordance with minimum levels of waste treatment technology mentioned by PL 92-500. The major thrust of the assessment effort therefore must begin with water related concerns as the focus. Trade-offs between environmental protection and economic development, for example, can occur only after rather high levels of waste control technology have been applied.

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* In the context of this Handbook, the "environment" refers to the physical environment (e.g., air, water, wildlife habitat), the social environment (e.g., housing, culture), and the economic environment (e.g., per capita income, employment).

Although the required content of an environmental assessment is outlined in the regulations (40 CFR Parts 6, 130 and 131), the relative emphasis placed on different elements of the assessment will vary from place to place depending on the major issues in the area. Because the needs of communities vary, this document has been divided into chapters, each dealing with separate elements of the environment (e.g., air, water, economy, etc.). The combination of these elements into an overall assessment is left to the judgment of individual planning agencies. In conducting this assessment, it is particularly important that the public be involved both in identifying impacts and their relative value to society. The public can help the planners focus the investigations by identifying effects which are of particular concern and warrant examination in detail. The public can also assist in determining what tradeoffs should be made when evaluating the alternatives; that is, by prioritizing their objectives the public can help the planner select the preferred plan. The role of public involvement is discussed in greater detail in a separate EPA document entitled Public Participation Handbook for Water Quality Management (dated June, 1976).

Neither the level of detail nor the specific topics covered in this Handbook are meant to suggest uniform requirements for an environmental assessment. Each WQM planning agency will have to determine what issues are important in its area and develop an assessment process (in consultation with the EPA Regional Office) applicable to those issues.

It is unreasonable to expect that any single handbook or guideline can counsel a WQM planning agency on the level of detail for its environmental assessment. Each area and each community presents unique situations. The level of detail to meet the environmental assessment requirements of the 208 planning grant will have to be negotiated between the planning agency and the EPA Regional Office.

Many areas of the environment have not been presented in this Handbook (e.g., noise pollution). The exclusion of these areas does not mean that they are not important in special cases. However, the implementation of the WQM plan is not expected to produce major impacts in these areas. If it does produce major impacts, the environmental assessment must take these areas into consideration.

REGULATIONS AND GUIDELINES

Section 208(b)(2)(E) of the Federal Water Pollution Control Act Amendments of 1972 (FWPCAA) states that any plan prepared under this section must include "the identification of ... the economic, social and environmental impact of carrying out the plan ...." This requirement is repeated in Section 40CFR Part 131.11 Regulations for Preparation of Water Quality Management Plans.

EPA has published regulations establishing agency "policy and procedure for the identification and analysis of environmental impacts of EPA non-regulatory actions ...", 40CFR Part 6 Preparation of Environmental Impact Statements. These regulations apply to water quality management plans. Under these regulations, an "environmental assessment" must be submitted to EPA by its grantee -- the designated planning agency or State -- describing the environmental impact of a proposed action, (in this case the action would be the implementation of a water quality management plan). The EPA Regional Administrator then reviews the environmental assessment to determine whether an EIS is required. If a significant adverse environmental impact is likely to occur, a draft EIS is prepared by EPA and distributed to interested or affected groups. After the recipients of the draft have had time to comment, a final EIS is prepared incorporating their comments. If an EIS is not necessary, a negative declaration is made accompanied by an environmental appraisal which describes the reasons for concluding there will be no significant impact. The environmental appraisal is essentially a brief form of the EIS. When an EIS is prepared, no administrative action can be taken for at least 90 days after the distribution of the draft EIS. For a negative declaration, the time is 15 working days.

The information on which an EIS is based is supplied by the WQM planning agency in its environmental assessment. Subpart E of EPA's EIS regulations deals specifically with the construction grants program and the Section 208 water quality management program. This subpart contains a detailed description of what should be included in an environmental assessment:

- Description of the existing environment without the implementation of the WQM plan alternatives

- Description of the future environment without the implementation of the WQM plan alternatives

- Sources of information used in the assessment

- Evaluation of alternative elements of the plan
- Environmental impacts of the proposed implementation of the WQM plan
- Steps to minimize any adverse effects

Although an EIS will not be prepared for all WQM plans, an environmental assessment addressing the above points will be required.

Other environmental laws, although not specifically directed at the WQM plan's environmental assessment process, should be considered in the WQM planning process. These include, but are not limited to:

- Safe Drinking Water Act (P.L. 93-523)
- National Flood Insurance Act of 1968
- Flood Disaster Protection Act 1973
- Water Resource Planning Act of 1965
- Wild and Scenic Rivers Act of 1968
- Clean Air Act Amendments of 1970
- Solid Waste Disposal Act of 1972
- The Endangered Species Act of 1973
- Coastal Zone Management Act of 1972
- National Environmental Policy Act of 1969
- National Historic Preservation Act of 1966
- Resource Conservation and Recovery Act of 1976

EPA has published four documents which provide a general review of the environmental assessment process. They are:

- Guidelines for State and Areawide Water Quality Management Program Development*, Washington, D.C. November, 1976.
- Manual for Preparation of Environmental Impact Statements for Wastewater Treatment Works, Facilities Plans, and 208 Areawide Waste Treatment Management Plans, Washington, D.C., July, 1974.
- A Review of Environmental Impact Assessment Methodologies, Washington, D.C., April, 1974, (EPA 600/5-74-002).
- Areawide Assessment Procedures Manual, Municipal Research Laboratory,Office of Research and Development; Cincinnati, Ohio, July, 1976, (EPA-600/9-76-014).

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* Hereafter referred to as "the Guidelines".

The Guidelines identify the types of alternatives that should be considered in the WQM plan for point and nonpoint controls. These alternatives include the possibility of no substantial action which should also be addressed. The planner must project over a 20 year period the possible effects of each alternative on the environment. Where possible these effects should be quantified -- but only when the quantification represents an objective measurement and can be related back to the goals of the community or nationally accepted standards. Assigning numbers to essentially subjective judgments is misleading and should be avoided. Also, unnecessarily detailed numbers representing such things as wildlife counts should be avoided unless they can be related directly to community goals. The margins for error should be clearly indicated on all projections. In each of the following chapters, a differentiation is made between clearly identifiable and recognized standards, like National Ambient Air Quality Standards, and more subjective measures such as the priorities placed by a community on air quality. The community does not have the option of selecting an alternative which causes a violation of the NAAQS. However, once it is clear that the standards are not violated, the community can decide how much deterioration will be allowed (except in non-significant deterioration areas).

The assessment process is iterative; that is, it entails continual review and refinement. Adverse environmental effects identified by the assessment may be eliminated or reduced by changes in components of the plan. It is therefore important, where possible, to present findings in clear cause and effect terms, so as to assist in the design of alternatives. The assessment should produce some comparison of the various alternatives so that decision makers can clearly see the advantages and drawbacks of each. These comparisons must also include the cumulative effects of plans across all elements of the WQM plan. Chapter 14 of the Guidelines provides one technique for an overall comparison of the alternatives. Additional charts or other displays such as maps or matrices can be used to illustrate the environmental effects of the plans.

Guidance in the National Environmental Policy Act calls for identification of impacts under several evaluative titles: <u>adverse</u>; <u>short term resource vs. long term productivity</u>; <u>unavoidable adverse impacts</u>; and <u>irretrievable commitments of resources</u>. Both the direct and indirect impacts of alternative actions must be identified and interpreted.

Direct impact assessment is by far the simplest because direct impacts usually occur at specific sites or to a specific segment of the population. These impacts typically have such measurable characteristics as the amount of landscape changed, particular physical or chemical alterations to air or water, job losses or per capita income changes.

Indirect or secondary effects are considerably harder to estimate with accuracy.* Indirect impacts are those which usually occur offsite, or are expressed at a later time. In many instances indirect effects are induced as part of desirable project or program outcomes. For instance, the WQM plan may forecast a large improvement in the quality of surface waters allowing for greater domestic, industrial, or recreational use of water. Accomplishing this aim may result in further expansion of industrial sites, residential and commercial areas, or the creation of new recreational units in the area which may in turn cause increases in nonpoint source runoff pollution, partially offsetting water quality gains from the project's point source management. Likewise, increased attractiveness of water bodies may induce more waterfront recreational use or create new uses, placing greater stress on the shoreline and aquatic plants and animals.

Much of the detail in both direct and indirect impacts of WQM plan alternatives will be investigated as a result of specific project recommendations such as wastewater treatment plants. The environmental assessment of these plants is covered in separate guidance on Section 201 of the Act including an EPA report entitled Guidance for Preparing a Facility Plan: Municipal Wastewater Treatment Works Construction Grants Program, May, 1975.

The environmental assessment process for a WQM plan, however, goes beyond the examination of isolated plan elements. It provides a unique opportunity to assess the cumulative effects of the combination of measures proposed both throughout the designated area and outside the designated area. The latter is particularly important in the case of neighboring WQM areas where major activities proposed in one district may significantly effect the other district. In such situations, coordination between WQM agencies would be most advantageous.

ENVIRONMENTAL ASSESSMENT AND THE PLANNING PROCESS

As previously discussed, the purpose of this Handbook is to assist managers, staff and local planning officials in working

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* Manual for Estimating Selected Socioeconomic Impacts and Secondary Environmental Impacts of Sewage Treatment Plant Construction and Operation. Dr. Rae Zimmerman, U.S. EPA, Region II. New York, N.Y., September, 1974. Copies available from the Environmental Program Division, Region II, EPA 26 Federal Plaza, New York, N.Y. 10007.

with the public to select the preferred elements of a WQM plan. The environmental assessment should provide information on the potential effects of plan alternatives on community goals and objectives. The WQM plan is designed to achieve primarily one objective -- achievement and maintenance of water quality standards. However, the community has other objectives it wishes to and must achieve at the same time (e.g., flood control, historic preservation, air quality). When one objective can be reached only at the expense of another, decisions must be made concerning relative priorities. The environmental assessment can assist this decision-making process by clarifying the choices to be made. It is therefore essential to include the public throughout the assessment process.

Table 1-1 illustrates the basic steps of the planning process as described in Chapter 1 of the Guidelines. It also shows how the environmental assessment process is inexorably related to the planning process.

The first step in the planning process is to define the problem or objective of the plan. For WQM plans, the main objective is achievement of water quality consistent with the 1983 goals of the Act. Water quality is related to community objectives through water quality standards which are defined in terms of beneficial uses. Sufficiently high water quality must be maintained for each stream to meet water quality standards and protect instream uses. The pollution problems which prevent the achievement of this objective are then identified in terms of their relative impact on water quality.

Before possible solutions can be formulated the constraints on meeting water quality goals should be identified and the priorities for solving water quality problems should be established (Step 2). Constraints include, for example, technical limitations which can make some of the goals unattainable for certain areas, or financial constraints which make some solutions too costly. Community goals and objectives also act as constraints in the sense that goals may be conflicting. If one community goal is the development of a growing, stable economic base, water pollution controls could be perceived as adding unjustifiable burden on industry. If another goal is maintaining a balanced budget while avoiding skyrocketing taxes, a capital intensive waste treatment program may be viewed as unacceptable.

Presumably the desire to restore and preserve the natural environment and minimize pollution is the objective of the WQM plan. However, this same objective can act as a constraint, since elements of the plan itself can have other adverse environmental effects. The planner must have an understanding of the community's overall

TABLE 1-1 ENVIRONMENTAL ASSESSMENT AND THE PLANNING PROCESS

PLANNING PROCESS	ENVIRONMENTAL ASSESSMENT
Step 1 -- Identify problems in meeting water quality goals of Section 101(a)(2) of the Act	
Step 2 -- Identify constraints and priorities	Identification of community goals and objectives related to environmental considerations
Step 3 -- Identify possible solutions	Preliminary assessment of possible environmental effects Collection of data
Step 4 -- Develop alternative plans	Detailed environmental assessment
Step 5 -- Assess alternative plans	Development of possible mitigation measures Public involvement to determine significance of environmental effects in relation to community goals and objectives Decisions on environmental impact
Step 6 -- Selection of an areawide plan	Documentation of the assessment

objectives as plan alternatives are developed. Other existing plans, such as comprehensive land use plans, existing environmental standards, and existing laws, can be utilized as measures of the community's goals. Through a public involvement program, more specific information can be obtained from those concerned or affected by the proposed plan.

Given these general constraints within which the plan is developed, Step 3 is to identify all reasonable structural, regulatory, and management control methods as possible alternative actions. As these alternatives are developed, the planner should make a preliminary determination of what types of environmental problems can result from the implementation of the alternatives being considered. This should not be a detailed assessment, but a "first cut" to eliminate proposals which are completely unacceptable and to identify the kinds of environmental effects that may occur.

For this preliminary assessment, a checklist can be useful as a means of considering all possible areas of impact and noting which are most likely. Several checklists have been developed including one which appears in Chapter 13 of the Guidelines. The use of checklists and other display and comparison techniques is discussed in detail in A Review of Environmental Impact Assessment Methodologies, EPA-600/5-74-002, April 1974.

This type of early preliminary assessment, besides filtering out unacceptable alternatives, also focuses the task of data collection. Instead of initially collecting data on every possible area of impact, the planner can concentrate effort on those areas where the impact is potentially more significant. It is important that the study director coordinate exchange of information both within and among impact study areas so that the full range of impact possibilities may be understood. For clarity purposes, the Handbook deals with each impact area separately. However, it is essential that the interrelationship of impacts be understood. For example, the Land Use Chapter only treats runoff in terms of soil loss; the Water Quality chapter will have to translate this information into levels of suspended solids in the water.

With alternative solutions identified and preliminary environmental assessments performed, the planning agency should turn to the development of alternative WQM plans (Step 4) incorporating the solutions of Step 3. The detailed environmental assessment of these alternative WQM plans will provide the basis for comparing alternatives and selecting the final WQM plan. A careful examination of possible structural and nonstructural measures which might mitigate or eliminate significant adverse effects (e.g., developing and enforcing land use regulations) should be presented to help in the selection of plan alternatives.

Following the development of alternative WQM plans, the planners must assess the alternatives and their environmental implications (Step 5). This assessment must include a high level of public involvement especially in the identification and discussion of mitigation measures and unavoidable adverse impacts. In accordance with Section 208 of the Act, the WQM planning agency is required to involve the public, including interest groups, elected officials and other interested persons. The planning agency will want to involve advisory groups in both formal (workshops and public meetings) and informal (liaison, correspondence) ways. In many areas it will be necessary for the planning agency to present plan alternatives and environmental assessments as part of an education and information program, and to obtain citizen participation in local policy development and decision-making. Outputs of the planning agency, including their methodology, should also be described at public meetings and made available in depositories.

It is the planner's responsibility to make the data comprehensible to the public. Pie-charts, bar graphs and other graphic displays are often useful ways of presenting aggregated data in publications and at public meetings. It may also be useful to array the results of the environmental assessment for each plan alternative by impacts in the social, technical, political and legal/institutional areas. It will often be necessary to interpret the numbers involved and restate them in terms more familiar (or relevant) to the audience. Examples would include expressing financial expenses in per capita terms, or explaining what the effect will be on the tax rate and on the average tax bill. Expenditures for areawide purposes can be compared to other public expenditures such as a new school or library if it is a capital expense; or to policemen's salaries or the cost of trash collection if it is an operating expense. This way of presenting data will also assist the public in thinking about water quality management as a tradeoff issue.

The final step is the actual plan selection. The environmental assessment at this point is a documented reference of the various environmental impacts analyzed throughout the planning process.

ADDITIONAL REFERENCES

Each of the following chapters provides references to further reading on specific aspects of the environmental assessment process. The list of references provided below is of a more general nature.

An Approach to Evaluating Environmental Social and Economic Factors in Water Resources Planning. Water Resources Bulletin Vol. 8 No. 4 page 724. Aug. '72. Back issues available at $4.00 per copy fron Dana Rhoads, American Water Resources Association, St. Anthony Falls, Hydraulic Lab, Mississippi River at 3rd Ave., S.E., Minneapolis, Minn. 55414.

Direct Environmental Factors at Municipal Wastewater Treatment Works. Ernest Leffel. U.S. EPA, Washington, D.C.

Intermedia Aspects of Air and Water Pollution Control. Report No. EPA 600/5-73-003. U.S. EPA, Washington, D.C., August 1973.

Physical Impacts: A Guidance Manual for the Assessment of Physical Impacts due to Highway Facility Improvements. U.S. Department of Transportation. Washington, D.C., 1975.

Preparation of Environmental Impact Statements: Final Regulations. U.S. EPA, 40 CFR Part 6. Federal Register, Volume 40, Number 72, Part III, April 14, 1975.

Preparation of Environmental Impact Statements: Guidelines, CEQ. 40 CFR Part 1500. Federal Register, Volume 38, Number 147, Part II, August 1, 1973.

Secondary Impact of Regional Sewerage Systems, Volume I. Department of Community Affairs, State of New Jersey. Trenton N.J., June 1975. Copies available from Division of State and Regional Planning, 363 West State Street, Post Office Box 2768, Trenton, N.J. 08625.

Environmental Impact - Proceedings of the ASCE Urban Transportation Division, May 21 - 23, 1973. American Society of Civil Engineers, 345 East 47th Street, New York, New York 10017.

Secondary Impacts of Transportation and Wastewater Investments: Research Results. Report No. EPA 600/5-75-013. U.S. EPA, Washington, D.C. July 1975. NTIS PB-246-085.

Secondary Impacts of Transportation and Wastewater Investments: Review and Bibliography. Report No. EPA 600/5-75-002. U.S. EPA, Washington, D.C. January 1975. NTIS PB-246-084.

Environmental Planning and Assessments of Water Quality Management Plans and Projects. EPA Region I Boston, Massachusetts 02203.

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WATER QUALITY AND QUANTITY IMPACT ASSESSMENT

Many of the elements of a WQM plan will have direct impacts on both water quality and water quantity. That changes in water quality will occur requires no elaboration, since, for the most part, WQM plan elements are designed to improve water quality. Changes in water quality will occur, for example, by the use of land to dispose of municipal wastewaters formerly discharged to a stream. This could significantly change the rate of streamflow if the wastewater represented a significant fraction of the streamflow prior to the use of land disposal. Similarly, there may be circumstances in which the collection and detention of urban runoff could significantly influence the pattern of flood flows in a stream. Table 2-1 lists some of the ways in which alternative WQM plan elements may impact water quality and quantity.

This chapter presents guidance on the key questions and methods to perform an assessment of the water quality and quantity impacts resulting from the implementation of a water quality management plan.

Key Questions

- How will the quality of streams or lakes be affected by the implementation of the WQM plan in relation to the goals?
- How will groundwater be affected by the implementation of the WQM plan?

Table 2-1 - Relation of Water Quality Management Plan Elements to Water Quality and Quantity

SOURCE OF POLLUTION	WQM PLAN ELEMENTS
Municipal and industrial effluents	• Treatment and discharge to surface water and groundwater • Disposal on land
Storm sewer (including "combined sewer") discharges	• Temporary storage of discharges • Best Management Practices
Urban runoff (non-sewered)	• Regulation of land use • Street sweeping • Best Management Practices
Residual wastes applied to land	• Sanitary landfill • Sludge application to land
Other nonpoint sources - Construction - Agriculture - Silviculture - Mining	• Regulation of land use • Best Management Practices • Temporary storage of discharges with subsequent on-site treatment

<u>RELATION TO WATER QUALITY</u>

- Change in temporal and spatial distribution of physical, chemical and biological constituents of water.

<u>RELATION TO WATER QUANTITY</u>

- Change in temporal and spatial pattern of flow
- Change in distribution of flows to surface water and groundwater

- To what extent will high quality water be preserved and protected from degradation?

- To what extent will environmentally sensitive areas, such as wetlands, be protected?

- Have the effects of projected population and land use changes been incorporated in the future estimates of water quality?

- Have the Federal and State water quality standards been used as an environmental goal?

- What present or projected water uses will be affected by the implementation of the WQM plan?

Guidance in answering these questions is found not only within this chapter but also in the following chapters on land use and ecology. In addition, EPA has published the Areawide Assessment Procedures Manual* which also provides guidance in answering these questions. The assessment process is highly interrelated with complex causes and effects that cannot be dealt with one media or one issue at a time.

Many techniques discussed below in the context of water quality and quantity impact assessment will be among the same techniques used to form alternative plan elements. This is to be expected inasmuch as alternative plans are designed to cause water quality changes (or to preserve high water quality) and these changes cannot be planned for without an assessment of both water quality and quantity. Planning for water quality changes, as a function of waste loads, requires an assessment of existing and projected water quality and quantity that is similar to the assessment of the impact of plan elements. Thus, much of the effort required in conducting an assessment of water quality and quantity impacts may actually be carried out in the course of formulating and designing the alternative WQM plan elements. Also, much of the data collected and processed during plan formulation will be useful in the assessment process and for the public presentation of water quality and quantity impacts.

WATER QUALITY AND QUANTITY PARAMETERS

The Federal Water Pollution Control Act Amendments of 1972 provide a goal for evaluating the impacts of WQM plan elements on water quality. As elaborated in the EPA Guidelines for State and Areawide Water Quality Management Program Development (Chapter 3), plans should be designed to meet the national 1983 water quality goals for swimmable and fishable where attainable. This requirement for meeting the national goals has been (or will be)

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Areawide Assessment Procedures Manual, EPA-600/9-76-014, July, 1976, Municipal Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45768.

translated by each State into more specific physical, chemical or biological requirements given in terms of the water quality standards (e.g., turbidity, dissolved oxygen, fecal coliform). Thus, the assessment of the effects of WQM plan elements on water quality must reflect the water quality parameters (e.g., permissible levels of suspended solids) used in specific State standards. In evaluating elements of the plan, the assessment should indicate the extent to which the State standards (and national water quality goals) would be met or progress made toward meeting standards if the plan were implemented. It should also evaluate the associated ecological impacts of doing so.

The conceptual basis for evaluating changes in water quantity and changes in water quality for which standards do not exist, (e.g., ground-water quality) is less straightforward. In these instances the parameters that should be used in conducting the impact assessment are those that indicate the extent to which current and projected water uses will be attained (e.g., drinking water supplies). It is not sufficient to report the results of such impact assessments in terms of changes in various physical, chemical and biological indicators. In order that the impact assessment be useful in decision-making, it is necessary that these parameter changes be reported in terms of how they will influence the amount of water available for various uses.

A report entitled Quality Criteria for Water and issued by the U.S. Environmental Protection Agency (July, 1976) includes information on various physical, chemical and biological indicators and their relationship to various categories of water use.

CONDITIONS FOR WATER QUALITY ANALYSIS

"Design Conditions" are of critical importance in conducting an impact assessment of future water quality levels. Most State water quality standards specify a particular low streamflow condition to be used as the basis for designing point source controls and for reporting estimates of future water quality. In contrast, design conditions relevant to nonpoint sources have generally not been specified. Moreover, because the nonpoint sources often exert their principal effects during wet weather conditions, the appropriate design conditions for nonpoint sources might well be different from the design conditions for point sources. It is necessary that the design conditions used in making estimates of future water quality be clearly indicated when they are used.

The EPA Guidelines emphasize the design conditions likely to present the greatest stress to fish, shellfish and aquatic wildlife in the study area. In choosing the critical design conditions, traditional stream analysis often makes use of a low flow/high temperature design condition (e.g., the once in 10-year, 7-day low flow). This flow condition may be appropriate for a steady-state stream analysis involving constant rates of point source pollutant discharge. However, choice of design flow conditions may also take account of such factors as ice cover and seasonal point source discharge which may cause more severe stress on life in the stream than occurs at low flow.

Wet weather or high flow conditions may be appropriate for analysis of nonpoint discharges and such intermittent point source discharges as storm sewers. Such factors as intensity and duration of rainfall, time since previous rainfall, pollutant accumulation rates (including effect of cumulative build-up of pollutants on bottom life in streams), and stream flow previous to rainfall are factors which affect pollutant loading and resulting water quality. There are no commonly accepted procedures for choosing design conditions based on these factors. Water quality problems which accumulate over time, such as those caused by sediment or nutrients, should be considered by addressing the total mass loads over an extended period of time rather than analyzing the design condition.

Therefore, a range of flow, meterological and seasonal conditions should be considered in choosing design conditions. In general, for point sources, continuous discharges present the worst pollution under low stream flow conditions; for nonpoint sources, critical conditions will be rainfall-related, but may occur under a variety of flow conditions.

WATER QUANTITY AND QUALITY ASSESSMENT METHODS

The assessment of water quality and quantity is usually associated with some technique that involves the use of a model. The word "model" as it is used here has a very general definition. It refers to simple numerical formulas, the utilization of which requires nothing more than pencil and paper, as well as to highly developed packages of complex mathematical expressions requiring the use of a digital computer.*

Most of the techniques discussed in the sections on estimating changes in water quality and quantity involve the use of mathematical models to forecast changes. As a matter of convenience, some of the terms commonly employed in describing such models are introduced below. Mathematical models used in water quality and quantity impact assessment consist of equations based on principles used in physics, chemistry and other sciences and on the analysis of much empirical data. A modeling exercise involves the specification of "inputs" and the use of the model to generate "outputs". For example, the inputs for a model commonly used to forecast stream dissolved oxygen (DO) levels consist of information characterizing the stream and the waste loads entering the stream. The model consists of an equation that transforms the inputs into outputs, i.e., the dissolved oxygen levels downstream of the waste loads.

Before a model to forecast dissolved oxygen can actually be used with

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* <u>Evaluation of Water Quality Models: A Management Guide for Planners,</u> EPA Report Number (600/5-76-004)

confidence it must be "calibrated". This generally involves using inputs and outputs corresponding to an observed (or historical) condition to refine model components (or, more typically, to estimate some of the inputs) so that the model outputs match "reasonably well" with the relevant observed output conditions. A portion of the historical record not used for calibration purposes is sometimes used for "verification" (or validation") purposes; this involves use of a calibrated model to yield outputs which are then compared with relevant observed outputs. The extent to which the forecasts agree with the observed data provides an indication of the models' validity.

As a practical matter, the importance of model calibration and verification cannot be overestimated. It requires that data representing model inputs and outputs over some historic period of record be available. Indeed, much of the effort required in using well established models that are widely available in the form of computer programs relates to these calibration and verification steps. When no data are available, the use of these models may still be possible. Under these cricumstances, the requisite input data for the model can be based on professional judgement, the use of handbook-type information and a limited program of field sampling. Clearly the result of such a modeling exercise may represent little more than an educated guess of future water quality or quantity conditions.

In using a mathematical model for prediction purposes, the inputs are representative of some future expected condition (e.g., point sources after wastewater treatment plants are implemented) and it is assumed that the model provides an appropriate description of how inputs are transformed into outputs under these future conditions. The level of confidence placed in the predictions depends on the extent to which the model has a history of yielding outputs that correspond closely to those actually observed.* The water quality and quantity models relevant to water quality management planning vary greatly in terms of their extent of verification. Some such models have been used for generations, and their outputs are accepted with some confidence. Others are in the "research and development" stage and have not been subject to verification under a wide variety of circumstances. For the most part, the various models are generally applied by hydrologists (water quantity models), and sanitary engineers (water quality models). The discussion that follows indicates how various water quantity and quality models might play a role in both the development of WQM plan alternatives and in the assessment of the plan and where more detailed information on the use of various modeling techniques can be obtained. The discussion opens with quantity models since the outputs of these models are a necessary input to the quality models. In some cases, the models incorporate both quality and quantity components.

BASELINE DEVELOPMENT

Before describing the methods available for estimating changes in water quantity and quality as a result of alternative WQM plan elements,

*It is important to note that "good" models in unskilled hands can yield bad results and relatively untried models with sound professional judgment can yield good results.

it is important to establish a baseline of water quantity and quality conditions. The baseline can be used as a comparison against the impacts of alternative elements in the WQM plan. There are several sources of data available from which to construct baseline conditions. These include:

- River Basin Plans -- produced by the States under the requirements of Section 303(e) of the FWPCA Amendments of 1972.
- A description of water quality -- produced annually by the States under the requirements of Section 305(b) of the FWPCA Amendments of 1972.
- National Pollutant Discharge Elimination System (NPDES) information -- prepared by dischargers and available through the State or EPA under the requirements of Section 402 of the FWPCA Amendments of 1972.
- Ongoing waste treatment facilities plans -- prepared locally under the construction grant requirements of Section 201 of the FWPCA Amendments of 1972.
- Previous waste treatment facility plans -- prepared locally under 18CFR and Section 3(c) of the Water Quality Act of 1965.
- Surface water records -- prepared annually for each state by the U.S. Geological Survey -- includes extensive water quantity data and some water quality data as well.
- Urban Studies programs -- prepared by the U.S. Army Corps of Engineers.
- Flood Plain information -- prepared by the U.S. Geological Survey, the U.S. Army Corps of Engineers, and HUD's Federal Insurance Administration.
- Water pollution and quality data information, Storage and Retrieval (STORET) system -- maintained by the Environmental Protection Agency.
- State and local water supply studies and wastewater management studies.

These and other related sources of information can provide a baseline inventory of pollution sources and water quantity and quality conditions. Many of these sources contain projections of these conditions which will provide a baseline projection without the implementation of the WQM plan alternatives. For the information sources that contain no such projections. the methods described in the following sections on estimating changes in water quality can be used to project conditions without the implementation of the WQM plan alternatives.

WATER QUANTITY IMPACT ASSESSMENT

The "hydrologic cycle" is the term used to describe the movement of water: from the atmosphere to the earth (precipitation); along and beneath the earth's surface; and from the earth to the atmosphere (evaporation and transpiration). Elements of a WQM plan involving point source controls can significantly affect the hydrologic cycle by, for example, relocating points of discharge of wastewater flows and modifying large areas of land (e.g., when land disposal of wastewater is employed). The effects of nonpoint source controls on the hydrologic cycle may be even more significant. For example, to the extent that land use controls and land management techniques are employed, the possibilities for bringing about significant changes in land surface characteristics are major. Another example relates to the collection and detention of storm runoff. Here also, the changes in the hydrologic cycle can be quite dramatic.

The assessment of how particular WQM plan elements affect the hydrologic cycle may require that the effects of plans on the relationship between precipitation (typically rainfall) and runoff be analyzed. It also may require that the effects of plans on the existing natural and man-made drainage patterns be examined. Both types of effects may need to be examined in an integrated way, and this type of examination can be made using computerized watershed simulation models. By way of introduction to such models, the discussion below provides background information and indicates the portions of such models that are likely to play a critical role in assessing the changes associated with the implementation of WQM plans. In choosing a model it is generally recognized that the simplest procedures which can produce acceptable results should be used. Simple procedures are often used at the outset to produce an understanding of the general behavior of the system and more sophisticated techniques are then used to produce more detailed information where necessary.

Rainfall-Runoff Relations

A water particle reaching the ground during precipitation may find its way to a watercourse by any one of three principal routes: surface runoff (overland flow), interflow (lateral movement in soil) and groundwater flow. In describing the flow contributing to a watercourse, a two-part division is often used, namely, groundwater (or base) flow and storm runoff. The latter consist of both interflow and surface runoff.

The measure used to describe water quantity is the rate of flow at a given location and over a given time period. The rate of flow (referred to as "discharge" or "flowrate") is generally expressed in units of cubic feet per second (cfs). The time period involved depends on the purpose of the analysis; for some purposes it may be sufficient to estimate changes in average annual or monthly flowrates, whereas for others, the peak flowrate over a short time period (e.g., hours) may be called for.

Elements of a WQM plan that significantly affect the land surface can alter the distribution of precipitation between surface runoff, interflow and groundwater. Two of the key variables that influence this distribution are: infiltration, the passage of water through the soil surface into the soil; and depression storage, the water retained in puddles, ditches and other depressions in the soil surface.

Perhaps the least sophisticated approach to estimating the effects of land surface changes on surface runoff involves the use of the so-called "rational formula". This formula uses a direct relationship between flow rate in cfs and the rainfall intensity in inches per hour and the drainage area in acres. The coefficient in this direct relationship is the runoff coefficient expressing the ratio of the rate of runoff to the rate of rainfall. Details regarding the application of the rational formula, including circumstances under which it is appropriate, are given in textbooks on hydrology. Although the rational formula has been shown to be deficient in all but the most uncomplicated cases involving very small watersheds, it continues to be widely used because of its simplicity and because it utilizes input data that is often easily obtainable.

More sophisticated analyses of the effects of land surface changes on the relationship between rainfall and runoff involve the concept of a hydrograph, a plot of water flowrate versus time at a particular location. Such analyses, which account for changes in land surfaces on inflitration and depression storage, are embodied in the computer simulation models discussed in a latter section.

Land surface modifications resulting from alternative elements of a WQM plan can have a significant effect on the characteristics of surface runoff. The increase of impervious area, a common result of urbanization, increases the peak flow and decreases the time during which peak flow occurs. In addition to increasing surface runoff, increases in the extent of impervious area may also affect groundwater recharge and the extent to which groundwater can be expected to contribute to streamflow during low flow periods. Groundwater recharge rates may also be affected by modification to existing drainage networks caused by alternative WQM plan elements.

Routing of Flows to Stream Channels

Elements of a WQM plan may influence water quantity by affecting the rate at which water is transmitted across the land to stream channels.

This may be especially significant where plan elements involve the installation of sewer systems, major changes in natural drainage patterns by means of land use changes, or both.

There are a wide variety of methods that can be used to examine the effects of changing the existing drainage pattern on flowrates, or more precisely, on the hydrographs resulting from a given precipitation event. These methods, typically referred to as flood routing procedures, estimate various characteristics of runoff as it passes over the land surface and through natural and man-made drainage networks. The methods generally take, as given, a hydrograph representing inflow to an area and compute the hydrograph representing the associated outflow from the area.

All flood routing techniques rest on one form or another of the so-called "equation of continuity", i.e., inflow to a given area minus the outflow from the area equals the change in storage within the area. The continuity equation is generally solved simultaneously with a second equation. The various forms that are used for this second equation are what distinguishes the many available flood routing techniques.

A widely used technique, the Muskingum method, employs the equation of continuity together with a direct relationship between storage within a reach (or area) and the inflow and outflow to and from a reach (or area). The coefficients in this relationship are a storage time constant and a weighting factor. The values of the coefficients are computed using observed inflow and outflow hydrographs. The values are then used to transform an expected future inflow hydrograph to its associated outflow hydrograph.

More sophisticated approaches to the flood routing problem involve solving the equation of continuity together with the so-called "equation of motion" (i.e., an expression for the law of conservation of momentum). These approaches can be used to route flows in a wide variety of physical systems; however, they generally require the use of a digital computer to solve the equations of motion and continuity.

Descriptions of the more commonly used routing procedures are given in textbooks on hydrology. One or another of the various routing procedures is typically employed as a component of the watershed simulation models discussed in a later section.

Groundwater Flows

Changes in surface water flows can influence the levels of groundwater tables. Increases in the extent of impervious area can reduce groundwater recharge by reducing direct infiltration of precipitation. Groundwater recharge also may be decreased by drainage works which divert stream flows from recharge areas and/or reduce natural stream-bed recharge. The latter can occur when drainage works include the lining of natural stream channels and/or the use of storm sewers. In addition, groundwater recharge may be decreased if the time period during which flooding occurs decreases as a consequence of changes in drainage networks and changes in the extent of impermeability. For aquifers underlying flood plain lands, flood flows can be an important source of recharge water.

Changes in the quantity of surface water available for recharge can be estimated using the above mentioned techniques for estimating changes in surface water flows. Given the estimated changes in flows available for recharge, it may then be possible to estimate changes in groundwater flows. This typically involves the application of the law of conservation of mass and Darcy's law, a relationship between the movement of groundwater and various aquifer characteristics (e.g., the coefficient of permeability, and the slope of the groundwater table). Details regarding the use of mathematical models to analyze groundwater flows are given in textbooks on groundwater hydrology.

Although highly sophisticated models for estimating the changes in groundwater flow exist, they may be difficult to apply. Aside from the cost of conducting a mathematical modeling study effort, the data required to characterize groundwater aquifers (e.g., to estimate the coefficient of permeability) may not be available for the aquifer in question. Because a data-gathering program can be expensive to carry out, it may not be feasible to obtain the requisite data within the time frame of WQM plan preparation.

Computerized Watershed Simulation Models

In instances where the effects of a WQM plan on water flow rates are expected to be significant, it may be appropriate to employ one of the many existing computerized watershed simulation models. Many of these models allow for the integrated analysis of changes in rainfall-runoff relations and modifications in drainage networks. At least one such model, the Hydrocomp Simulation Program (HSP), also allows for an analysis of the effects of WQM plan elements on groundwater recharge. Such computerized watershed simulation models provide the basis for an evaluation of the effects of implementing the WQM plan elements on water quantity.

Computerized watershed simulation models have been formulated on the supposition that some elements of the hydrologic cycle are sufficiently well understood to provide the basis for a general representation of the movement of water within a watershed.

Computerized watershed simulation models, must be calibrated to fit the circumstances of the particular watershed under study. This is done using data gathered in connection with past hydrological events (e.g., inflow and outflow hydrographs associated with past floods) and the particular physical characteristics of the watershed (e.g., soils, topography). The calibration should, in principle at least, be followed by a verification exercise in which the model's predictive abilities are formally tested. Often, however, there is a paucity of data, and the data that does exist is used entirely for model calibration. Model validity is often assumed on the basis of experiences in using the model for forecasting under other, similar circumstances.

There are literally dozens of different watershed simulation models that have been programmed for solution on digital computers. Consequently, a complete overview of available models is beyond the scope of these guidelines. Wide ranging "user-oriented" overviews of available models have been prepared.* These reports contain summary information on the following aspects of computer models relevant to forecasting changes in water flows that may result from WQM plan elements: computer language and hardware requirements, availability, previous applications, strengths, weaknesses, limitations of use, input data requirements, outputs provided and sources of additional information.

Table 2-2, which contains only a small fraction of the information summarized by Brown, makes note of four of the more widely used computerized watershed simulation models that may be useful for assessing the impacts of WQM plans. Two of these, the MIT Catchment Model and the Hydrocomp Simulation Program, are available from private consulting firms; the other two are available from government agencies. The Table provides a brief indication of how these models can be used and contains sources of additional information.

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Hydrocomp, Inc., 1975 Hydrocomp Simulation Program Operations Manual, 4th Edition, Palo Alto, CA.

Brandstetter, Albin, August, 1974, Comparative Analysis of Urban Stormwater Models, Battelle Memorial Institute, presented at the Short Course Applications of Storm Water Management Models, University of Massachusetts, August, 1974.

Brown, J.W. et al., 1974, Models and Methods Applicable to Corps of Engineers Urban Studies, Miscellaneous Paper - 74-8, U.S. Army Engineers Waterways Experiment Station, Hydraulics Laboratory, Vicksburg, MS.

Table 2-2 - Summary of Information on Four Computerized Watershed Simulation Models*

Model Name	Source of Information	Availability	Principle Uses	Source of Reference Materials
MIT Catchment Model (MITCAT)	Resources Analyses, Inc. 1050 Massachusetts Ave. Cambridge, Mass. 02139	"Use fee" charged per simulation run No fixed lease fees or monthly charges	- Simulates runoff hydrographs from urban and rural basins - Flood event simulator - No groundwater flow component	Leclerc and Schoake (1973)
Hydrocomp Simulation Program (HSP)	Hydrocomp, Inc. 1502 Page Mill Road Palo Alto, CA 94304	Available on lease from Hydrocomp	- Simulates runoff hydrographs from urban and rural basins - Continuous simulations over long time periods - Has groundwater flow component	Hydrocomp, Inc. (1975)
Storm Water Management Model (SWMM)	U.S. Environmental Protection Agency Attn. Harry Torno, Staff Engineer Office of Research and Development Washington, D.C. 20460	Available from U.S. Environmental Protection Agency	- Simulates performance of urban storm drainage systems - Used in storm system design - Flood event simulator - No groundwater flow component	Huber et al. (1975) and Metcalf and Eddy, et al. (1971)
Urban Stormwater Runoff Model (STORM)	The Hydrologic Engineering Center U.S. Army Corps of Engineers 609 Second Street Davis, CA 95616	Available from Hydrologic Engineering Center	- Used in reconnaissance level studies for planning urban storm water controls - Employs unsophisticated rainfall-runoff and routing procedures	U.S. Army (1975)

*Source: Brown, J.W. et al., 1974, Models and Methods Applicable to Corps of Engineers Urban Studies Miscellaneous Paper - 74-8, U.S. Army Engineers Waterways Experiment Station, Hydraulics Laboratory, Vicksburg, MS.

The models mentioned in Table 2-2 give some indication of the enormous range of watershed simulation models currently available. Of the computer-based models noted, the Hydrocomp Simulation Program is perhaps the most ambitious in terms of the range of issues that can be analyzed, the length of continuous simulation that can be provided, and the extent of data resources required. The Urban Runoff Model is perhaps the least sophisticated of the four. With the exception of MITCAT which is being improved at this time, each of the models noted in the table is capable of forecasting the quality of surface runoff; this aspect of the models is taken up in the section below on water quality impacts. Further details on computerized watershed models can be obtained by consulting the references cited in Table 2-2, and more generally, by consulting recent textbooks on hydrology.

WATER QUALITY IMPACT ASSESSMENT

Elements of a WQM plan related to point and nonpoint source are designed to effect changes in water quality. The specific parameters used in assessing effects on water quality should include parameters contained in the relevant State water quality standards. Although standards differ between States, there are a number of parameters commonly used in assessing water quality.

For point sources involving municipal wastewaters, the water quality parameters commonly used to characterize effluents are: biochemical oxygen demand (BOD), total dissolved solids (TDS), suspended solids (SS), pH, coliform bacteria, residual chlorine, and compounds of nitrogen and phosphorous. Detailed discussions of these parameters are available in EPA's Quality Criteria for Water, July 26, 1976 and standard textbooks on sanitary engineering. The parameters used in characterizing industrial processes are generally determined by the nature of the industrial process involved. Details are given in specialized textbooks on industiral wastewater treatment methods.

Water quality parameters relevant to nonpoint sources have been described in the following categories of nonpoint sources: urban storm runoff, agriculture, silviculture, mining and construction.* Table 2-3

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Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollutants, EPA Report Number 430/9-73-014.

Sartor, J.D. and Boyd, G.B., 1972, Water Pollution Aspects of Street Surface Contaminants, EPA Report No. R2-72-081

Sartor, J.D. and Boyd, G.B., 1975, Water Quality Improvement Through Control of Road Surface Run-off, Water Pollution Control in Low Density Areas; Proceedings of a Rural Environmental Engineering Conference, University Press of New England, Hanover, N.H., pp. 301-316.

Urban Stormwater Management and Technology: An Assessment, EPA Report Number 670/2-74-040.

Methodology for the Study of Urban Storm Generated Pollution and Control, EPA Report Number 600/2-76-145.

Table 2-3 - Principle Water Quality Parameters Affected by Nonpoint Sources*

WATER QUALITY PARAMETERS	CATEGORIES OF NONPOINT SOURCES
Solids (total and suspended) and sediment loads	Agriculture (especially cropland), construction, surface mining, silviculture, urban land, landfill/land disposal activities
Biochemical oxygen demand	Crop debris, livestock wastes, forest litter, petroleum wastes used in construction, urban land, landfill/land disposal activities
Salinity (total dissolved solids)	Irrigation return flows, neutralized acid mine drainage
Acidity	Acid mine drainage (especially coal mines)
Heavy metals (e.g., lead, mercury, zinc, arsenic)	Mining operations, hard rock mine drainage
Coliform bacteria	Livestock wastes, landfill /land disposal activities
Nutrients (compounds of nitrogen and phosphorous)	Fertilizers, livestock wastes, urban land, landfill/land disposal activities
Pesticides	Agriculture, silviculture, construction

* Based largely on information presented by EPA in Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollutants (EPA-430/9-73-014).

provides general information on parameters commonly used to characterize water quality impacts from nonpoint sources.

A fundamental issue in assessing water quality impacts concerns how the concentration of a given pollutant (in both time and space) is affected by elements of a proposed WQM plan. The state-of-the-art in making quantitative forecasts of such effects varies greatly for the different water quality parameters. The distribution of some parameters, notably sediments, TDS, BOD, dissolved oxygen (DO) and coliform bacteria, has been studied for several decades and can be estimated using well established quantitative methods. The distribution of other parameters, particularly the compounds of nitrogen and phosphorous, has been extensively studied in the past decade. There are a number of ongoing research efforts aimed at developing mathematical models to forecast the behavior of compounds of nitrogen and phosphorous in water courses, and to forecast the effects of such behavior on aquatic ecosystem variables like algae and zooplankton. Finally, the distribution of some water quality parameters, e.g., heavy metals and pesticides, is so complex that mathematical models that yield reliable forecasts do not yet exist.

Another important characteristic of the state-of-the-art of water quality forecasting concerns the notion of time. The simplest and most widely used forecasting techniques are those which deal with point sources discharging into natural watercourses under steady state conditions (i.e., waste loads and receiving water characteristics are assumed to be constant over time). More sophisticated techniques have been developed over the past decade for dealing with non-steady state conditions, e.g., waste loads that exhibit cyclic variations and discharge into receiving waters with time-varying characteristics. This aspect of nonpoint sources, together with the fact that nonpoint sources have only been subject to intensive study for about a decade, significantly complicates the task of assessing changes in water quality associated with nonpoint source controls.

A final characteristic of the state-of-the-art of water quality forecasting relates to the type of receiving water involved. The most highly developed techniques involved forecasting the effects of a change in waste input discharged directly to a natural water course; the least highly developed techniques involve the water quality of surface runoff passing over nonpoint sources. Even within the highly developed techniques treating the effects of point sources discharging to water courses, there are striking differences in the ability to forecast. The simplest, and most well understood water courses are streams; in these instances the transport of pollutants can reasonably be assumed to be dominated by the average flow of the stream, and not by dispersion effects. Where dispersion effects are significant, as in the case of estuaries and lakes, the modeling task requires increased sophistication. For complex estuary and lake systems, the forecasting of water quality changes may not be possible without a major effort. In this case the assessment of alternative elements of the WQM plan may have to rely on professional judgment rather than a modeling analysis.

Quality of Storm Runoff

A thorough review of available techniques for forecasting the quality of storm runoff and urban runoff has been prepared by EPA, and others (see citation on p. 2-14). These documents provide background materials that are essential to forecasting water quality changes associated with storm runoff. One of the central themes in these reports is that sediment plays a principal role in estimating the quality of storm runoff. This is especially true when the followinging nonpoint sources are involved: agriculture, silviculture, construction and urban land. Sediment represents a pollutant itself (suspended solids) and plays a pivotal role in the transport of other forms of pollution (e.g., BOD).

There are virtually dozens of quantitative models that have been developed to forecast sediment yield, especially the sediments from agricultural lands. For the most part, these methods estimate sediment yield from a given area over a fairly long time period (e.g., a month or year) and do not correlate the sediment yield from a given area with water quality in natural water courses. An illustration of the techniques available is provided by the "Universal Soil Loss Equation" (USLE), which is widely used in estimating soil erosion from pervious areas. The USLE provides an estimate of the annual soil loss per unit area as a function of several factors describing soil type, slope, etc. It's usefulness is limited however by factors such as lack of data and inability to predict water quality.

Three of the four models listed in Table 2-2 can be used to estimate various water quality parameters for storm runoff. (The one exception, the MIT Catchment Model, is currently being extended to include water quality.) The water quality output from these models takes the form of "pollutographs", i.e., plots of water quality parameter levels versus time at a given location. One of the major difficulties in using these models, aside from the fact that they have not been widely verified, is that the data required in "calibrating" for a given watershed is often unavailable; such data must include both quantity and quality information for individual short term storm events. The paucity of such data has long been recognized as a key factor limiting the development of models to forecast the quality of storm runoff.

Quality of Streams

In sharp contrast to the task of forecasting the quality of storm runoff, the task of forecasting changes in steady state stream quality caused by changes in some types of waste inputs is relatively straightforward. This is the case for pollutants that do not decay, or for pollutants like BOD that can be assumed to decay in accordance with a simple "first order" reaction, i.e., a reaction in which the rate of decay is considered to be proportional to the concentration of the substance.

Of the various situations involving the estimation of stream quality changes, the simplest is the case of a constant source of "conservative", i.e., non-decaying waste (e.g., total dissolved solids in irrigation return flows) entering a stream flowing with a constant rate of discharge. In this instance, as in all assessments of water quality in natural waterways, the law of the conservation of mass plays a central role. The mass balance equation for this case indicates that the mass of substance entering a given stream segment equals the mass of substance leaving the segment. The principal result is an equation giving the downstream concentration of the conservative substance in terms of the flows and concentrations of the waste source and the stream flow entering the segment.

The next most sophisticated case is a steady state situation involving a single point source emitting a pollutant that can reasonably be assumed to decay in accordance with a first order reaction (e.g., BOD, coliform bacteria). In this instance, the equation for the law of conservation of mass can be solved to give a relationship that indicates how the concentration of water pollutant in the stream varies with changes in the waste input, stream velocity and distance downstream from the point of waste discharge.

The next level of sophistication in the assessment of changes in stream quality involves water quality parameters that can only be estimated by solving a coupled set of equations. The most common example involves the estimation of dissolved oxygen and requires the simultaneous solution of two mass balance expressions, one for DO and one for BOD.

For the case in which steady state conditions prevail and the only significant oxygen sources and sinks are atmospheric reaeration and BOD, respectively, the solution is the widely used "Streeter-Phelps" equation. This type of analysis of BOD and DO has been extended to deal with far more complex situations in which the following have an influence on DO: scouring and sedimentation of organic materials, benthal deposits of oxygen demanding materials, and the respiration and photosynthesis of plant life.

The use of the "Streeter-Phelps" equation has become so widely accepted, that a manual* has been prepared providing basic data and graphical solution procedures. This manual permits the rapid computation of estimates of pollutant concentrations for conservative substances and for water quality parameters like DO, BOD and coliform bacteria under steady state conditions.

For situations that require the estimation of changes in the aforementioned water quality parameters in complex settings (e.g., nonsteady state conditions), it is common to employ computer models that consist of general solutions to the relevant mass balance equations. An example is provided by QUAL-1,** a very general model. To apply QUAL-1 to any particular stream system it is necessary to calibrate the model and to provide the relevant input parameters characterizing expected future conditions of stream geometry, waste inputs, decay rates, etc. The outputs from QUAL-1 consist of temporal and spatial description of one or more of the following: conservative substances, BOD, DO and temperature.

Quality of Estuaries

Concern for estuaries and their water quality is heightened by the great biologic fertility of the waters, where sweeps of the tides mix salt water with fresh water twice a day. In analyzing the water quality impacts of a WQM plan that encompasses an estuary, the assessment should concentrate on the biological parameters that are important in characterizing breeding areas. This assessment is made more complicated than fresh water bodies by the impact of salt water and the complex motion of the estuarine waters.

The analysis of the quality changes in estuaries resulting from changes in waste inputs is very similar in concept to the analysis of quality changes in streams. In both streams and estuaries mass balance equations play the central role. The analysis of estuaries is more complex because the mass balance equations must account for the existence of two significant mechanisms of pollutant transport. One of these is transport via the average motion of the water flow, also know as "advection". It

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* Hydroscience, Inc., 1971 Simplified Mathematical Model of Water Quality, prepared for U.S. Environmental Protection Agency, Washington, D.C.

** Texas Water Development Board, 1971 Simulation of Water Quality in Streams and Canals; Theory and Description of the QUAL-1 Math Modeling System, Austin, Texas is generally considered the only significant transport mechanism in the analysis of stream quality. The second is "dispersion"; i.e., the spread of pollutants caused by turbulent diffusion, velocity gradients, tidal effects and density differences.

As in the case of the analysis of quality in streams, the analysis of quality in estuaries is commonly carried out for conservative substances, pollutants that decay in accordance with a first order reaction, and DO; the latter involves coupled mass balance equations for BOD and DO. More complex pollutants (e.g., various forms of nitrogen) are amenable to quantitative forecasting procedures but, as in the case of streams, this may require a more extensive, research type study effort. The previously sited manual, Simplified Mathematical Modeling of Water Quality, provides detailed procedures and graphical aids for dealing with conservative substances that decay according to first order reactions and DO. These procedures are restricted to steady state conditions for "one dimensional models"; i.e., models for which advection and longitudinal dispersion are the only signifcant pollutant transport mechanisms.

As in the case of stream quality analysis, computer models exist to aid in the analysis of more complex situations (e.g., non-steady state conditions and cases where dispersion in more than one direction must be accounted for). An example is provided by the FWQA Dynamic Estuary Model (DEM)*, where it is necessary to divide the estuary into segments, calibrate the model, and provide the requisite input data characterizing future conditions for estuary geometry, dispersion, reaction rates, etc. The outputs from DEM consist of temporal and spatial distributions of one or more of the following: conservative substances, substances that decay in accordance with first order reactions and DO.

Quality of Other Receiving Waters

Because streams and estuaries are the principal aquatic environments serving as receptors of point and nonpoint sources of waste to be controlled by elements of a WQM plan they have received emphasis in this discussion. Clearly, however, they are not the only receiving environments subject to waste inputs. The discussion below touches briefly on the kinds of forecasting methods used in analyzing the effects of waste inputs on the quality of other types of receiving waters.

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Feigner, K.D. and Harris, H.S., 1970, Documentation Report - FWQA Dynamic Estuary Model, Federal Water Quality Administration, U.S. Department of the Interior, Washington, D.C.

Coastal Water Quality

Communities near the coast commonly discharge their wastes into estuarine waters or directly into the ocean. A well developed class of models exists for estimating the concentration of pollutants (e.g., coliform bacteria) in the "sewage plume" caused by direct discharges to the near shore ocean environment.*

Lakes and Reservoir Quality

There are relatively few simple mathematical procedures that can be used to analyze the response of lakes and reservoirs to changes in waste inputs. Such simple analyses might involve, for example, the use of mass balance concepts to analyze conservative substances entering a completely mixed lake. Simple situations like this one are, however, not commonly encountered in practice.

Typically, the analysis of water quality in lakes and reservoirs** is made exceedingly complex by a number of factors. One is the circulation of flow generally follows a three-dimensional pattern. Three-dimensional hydrodynamic models that can be used to analyze the circulation patterns in lakes and reservoirs exist, but they cannot be applied without conducting a major study effort. The same comment applies to water quality; in this instance, the complications result because of factors like thermal layering and complex mixing.

In the context of WQM planning, the only kinds of analyses of lakes and reservoirs that appear feasible are those which rest on major simplifying assumptions and the professional judgments of specialists in sanitary engineering and limnology. It may be possible to use data on thermal layering to segment the lake, so that it may then be subject to a careful mathematical modeling effort. More than likely, however, expert professional judgment, supplemented by mathematical procedures, will provide the basis for assessing water quality impacts.

Algae assay procedures can play a useful role in analyzing lakes and reservoirs. Information from the EPA National Eutrophication Survey may also prove useful in assessing water quality impacts in lakes.

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* Ortolano, L. and Brown, P.S., 1970, The Movement and Quality of Coastal Waters: A Review of Models Relevant to Long Island, New York, Report # CEM 4047-411, Center for the Environment and Man, Inc., Hartford, CT.

** Elder, R.A., Krenkel, P.A. and Thackston, E.L. (eds.), 1968, Proceedings of the Specialty Conference on Current Research into the Effects of Reservoirs on Water Quality, Tech. Report No. 17, Dept. of Environmental and Water Resources Engineering, Vanderbilt University, Nashville, Tenn.

Groundwater Quality

As in the case of lakes and reservoirs, the assessment of water quality changes in groundwater systems will likely rest on the professional judgments of experts, in this case experts in geochemistry. Groundwater quality prediction models are generally much more crudely developed than surface water models. Highly sophisticated mathematical hydraulic models are available, but these lack the ability to predict mass transport of absorbed or partially soluble compounds because of the difficult chemistry involved. Additionally, surveys of groundwater conditions are expensive because of the great number of observation wells required to establish flow direction and existing water quality.

An overview of the types of approaches followed by groundwater specialists in assessing the impacts of changes in waste inputs is provided by Walton.*

EPA is currently sponsoring a project by the U.N. Scientific Committee on Problems of the Environment (SCOPE) to evaluate existing groundwater models. This study will be completed in 1977. For more information contact the U.S. EPA Robert S. Kerr Environmental Research Laboratory, P.O. Box 1198, Ada, Oklahoma 74820.

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* Walton, W.C., 1970, Groundwater Resource Evaluation, McGraw-Hill, N.Y.

3

LAND USE IMPACT ASSESSMENT

The impact of water quality management plan alternatives on land use activities may be significant for at least two reasons. First, by influencing the spatial distribution, time phasing, size or form of land use activities, the WQM plan will affect the way a community may achieve its non-water quality related goals such as housing or transportation. Second, the manner in which land use activities are developed, located and operated will affect the generation and discharge of pollutants. Therefore the land use impact assessment of alternative elements of a WQM plan must accomplish two objectives. The agency should assess impacts of the plan on new development in a community: the amount, location, cost, function, population served, sequence in which development will occur, implications for the continued operation of existing activities. In some instances changes in land use activities resulting from water quality management plans result in impacts in other media (e.g., air quality impacts from altered transportation patterns). The land use assessment must provide the basis for the environmental assessment of air, water, vegetation, wildlife, and visual quality. These impacts are discussed elsewhere in this handbook. This chapter discusses impacts to land use activities which affect their ability to meet the non-environmental goals (e.g., housing and transportation) of the area. In some communities where there is an adopted (and implemented) community land use plan (or policy) the WQM planner may be able to use the plan as the basis against which impacts are measured. In addition, some limited guidance is provided regarding information which may be useful in assessing the environmental effects of land use changes.

In this chapter the term "land use" describes those physical structures and activities which are built or operate on the land (residences, stores, industries, farms). For the purpose of the assessment the "physical boundaries" of the activity will often extend beyond the actual physical structure (e.g., a building) and include the associated roads, site development and construction activities.

The characteristics of the land itself will affect both the range of activities which may occur on it as well as the impact on the environment from those activities. Implementation of measures to protect critical environmental areas (e.g. wetlands) may affect the recreation options available to a community and/or influence the cost of housing which is developed.

However, land does not have to be "critical" in order to affect the environmental impact of land use activities. For example, soils vary in their drainage characteristics influencing the amount and quality of water which passes through it. The relationship of these physical characteristics to water quality are discussed in the Water Quality chapter. They are also summarized in the Parameters section of this chapter because they can influence the development potential of particular land areas.

Key Questions

- What changes will occur in the manner in which land use activities are constructed, operated or managed over time?
- How will the amount, form, function, location, density, cost, timing, of the development of new activities be affected by the WQM plan?
- Will existing development be affected by the water quality management plan?
- How may the WQM plan affect the development potential of different areas; including critical environmental areas?
- Which segments of the population would most likely be affected by these impacts?

LAND USE ASSESSMENT PARAMETERS

Because land use is not only related to environmental assessment but also to achievement of other community goals, there are an undetermined number of parameters which could be considered depending upon local priorities. Each community will have to study its own priorities and make sure that they are reflected in the land use assessment. In this section the parameters are described. How they are to be used is discussed in subsequent sections.

The parameters which will be important to measure include: "critical" land areas, existing land use activities, form, function, location and timing of new land development, and the manner in which these activities will be developed, operated and managed. Communities may further define these parameters depending upon local priorities. A community which was interested in developing a water based tourism and recreation economy might add, "amount of developable waterfront land" as a parameter; a community which had an agricultural based economy may want to identify "prime" agricultural lands; a community with a large senior citizen population wanting to enhance opportunities for mass transit may choose to emphasize "residential density"; a central city may choose to identify land use changes which indicate increased or decreased housing opportunities.

Several of the land use parameters are not entirely exclusive of each other. For example, in a selected community a particular land use activity (e.g., single family residential) may always be developed the same way (e.g., five acre minimum lot size with septic tanks). The activity and the manner in which it is developed are presented separately here to emphasize the importance of not only considering the activity, but, also how it is developed and managed. Further, not all of the parameters represent a single identifiable number which can be easily measured. In many cases it will be trends that are important. A decrease over a ten year period of new housing starts from 70% to 20% single family, may be more significant than the absolute number of new housing starts.

Because physical land characteristics are so closely related to the suitability of the land for different activities (e.g., waste treatment, agriculture), some of these characteristics are summarized in Table 3-1. Except in those communities where these are expected to be large scale development changes, detailed analysis of these characteristics will be confined to the Water Quality chapter. References to sources of more detailed information are footnoted in this chapter and located at the end of this chapter.

Physical land characteristics are significant because they help to determine:

- The ability and speed with which the soil transmits or holds water and nutrients affecting both the quantity and quality of ground and surface water;

- The susceptibility of the soil to movement (e.g., erosion, landslides, or subsidence, etc.) and thereby its suitability for development and changes in sediment loadings in streams.

- The type of vegetation which could be supported affecting erosion potential and wildlife habitats.

- The desirability and feasibility of the soil as building foundation or environment for subsurface structures (e.g., sewers).

These characteristics* include: texture, structure, internal drainage, infiltration, absorption capacity, permeability, and acidity-alkalinity. There are many other soil characteristics which are significant depending upon the purpose of the analysis. They include depth to water table, slope, flooding, plasticity, shrink-swell potential, etc. However, for the purpose of the WQM plan assessment, the following parameters are most significant either as a factor in land use suitability, in wastewater treatment, in ground and surface water quality, or in providing a habitat for vegetation and wildlife.

Critical Land Areas

The definition of critical land areas varies according to the purpose for which the determination is made. Definitions include: rarity, significance as a wildlife habitat, importance to the quality and supply of drinking water, and public safety as in the case of flood plains and seismically sensitive areas. Certain types of areas commonly accepted as critical have been the subject of more specialized study, as well as of specialized development requlations.** Examples of such areas include:

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* Environmental Geology: Conservation, Land Use Planning and Resource Management, by Peter T. Flawn, Harper and Row, N.Y., 1970, p.67. For an excellent discussion of soils and their role in wastewater treatment, see, Wastewater Treatment Systems for Rural Communities, by Steven N. Goldstein and Walter J. Moberg, Jr., Commission on Rural Water, Washington, D.C., 1973.

** Performance Controls for Sensitive Lands: A Practical Guide for Local Administrators, prepared by the American Society of Planning Officials for the U.S. Environmental Protection Agency, Washington, D. C., March 1975, EPA-600/5-75-005.

Table 3-1

PHYSICAL LAND CHARACTERISTICS

Texture: the size of the soil particles and the percent of sand, silt and clay in the soil. This will affect the ability of the soils to hold air and water, the likelihood of expansion with increased moisture, chemical reactions, the way nutrients are held and recycled and the rate with which water will move through it.

Soil Structure: the natural grouping of soil particles (also called aggregation). This is a significant parameter in determining the infiltration of water into the soil, and the movement of water through the soil (permeability).

Infiltration: the entry of water into the soil; a function of texture, structure, ground cover, mineral and moisture content.

Absorption Capacity: the amount of liquid the soil can hold. The soil structure is a key parameter in this determination. The size of the soil particles and pores, as well as the relationship between the pores, will determine the amount of surface tension and in turn the water retention capacity and permeability of the soil. Porosity is the name given to the total volume of pore space present in a given volume of rock or soil.

Permeability: a measure of the ease with which water may move (percolate) through soil. The open spaces within the soil are the key factor in determining the permeability. Permeability is expressed as a rate of water movement (e.g., feet per second). Permeability is significant in terms of evaluating the drainage capacity of the soil and is an important parameter if effluent is going to be discharged to the ground. Because effluent is treated as it passes through the soil, the amount of time it takes to reach ground or surface water will affect the degree of treatment it receives.

Acidity-Alkalinity: the acidity and alkalinity of the soil measured by the pH. The degree to which a soil is acidic or alkaline is important in determining the type of plants it can support and also the chemical effects on subsurface structures such as pipelines.

Erosion Rate: the rate at which soil erodes, a function of the rate of precipitation, the length and steepness of the slope, the infiltration capacity of the soil and the resistance of the surface. The presence of ground cover will be significant in determining erosion. Erosion is important in water quality because of the potential for sediment to contain pollutants (e.g., oil, pesticides), as well as the implications for slope stability.

- Wetlands
- Woodlands
- Aquifers
- Hillsides
- Coastal areas
- Flood plains

In order to be able to assess alternative WQM plan elements it will be important to first map "critical" areas and to identify the implications of such areas for development (e.g., structural controls for flood plain development, landscaping requirements for hillsides, limitations on impervious surfaces in wetlands areas).

Location, Timing and Changes in Land Use Activities

The activities for which land will be developed (either because of or in spite of a WQM plan) will be significant, in part, because of their direct pollution generating potential. Often categories of land use activities are related to estimations of "waste loadings", "water consumption", etc.

Knowledge of the activities is also important because of other community goals. Development of new industry will have implications for the in-migration of new workers and their families, for transportation services, for new housing and the price of existing housing, etc. The proximity to central city areas of land under development for residential uses will affect transportation demand, the cost of the housing and the segments of the population likely to be served by it. If that same land was developed for another activity (e.g., recreation) it would have an entirely different effect.

The relationship between different activities (e.g., density of housing, industrial parks, multiple use developments) will have implications for energy use, accessibility, transportation demand, etc.

Knowledge of which activities are being replaced due to plan implementation is also significant. If agricultural land is gradually being replaced by development, the economy of the area, the types of pollutants generated, the fiscal balance etc. will change. If inner city areas are changed from low to high density residential use, the cost of housing, the demand for goods, and services, and the demographic mix of the area will also be affected.

Development Activities

It is not sufficient to merely categorize land use by function. There are other characteristics of activities which will be important. These include: the manner in which development actually occurs (e.g., construction practices); physical characteristics of development (e.g., lot size, percent of lot covered, landscaping); and waste management characteristics (e.g., septic tanks, landfills). These characteristics are important because they influence the amount of permeable surface (affecting runoff), the amount of open space for dispersion of pollutants and separation of incompatible uses, the transportation requirements (affecting air quality and runoff quality) etc.

The form of waste treatment will also be an important determinant of land use. Clearly sewer systems connected to municipal or regional waste treatment systems will tolerate a higher density of development than will septic systems. Finally, the activities associated with development (construction, site preparation) may influence the cost of development or the ease with which particular sites are developed.

LAND USE ASSESSMENT METHODOLOGIES

There is an enormous variety in the range of methodologies which are available to assess land use changes and the suitability of different land areas to development. There are detailed engineering studies and procedures to measure the various soil parameters, and complex models to determine the spatial allocation of land use. Some of these techniques may have been used as part of the WQM planning process.

The use of such complex and detailed methodologies for the purposes of most of the WQM plan assessments is unnecessary. Rather, the WQM planner will have to develop an understanding of the forces shaping development trends and patterns in the area and will have to interpret this understanding in the framework of strategies which are developed through the WQM planning process. There is generally a large amount of data locally available which, if carefully interpreted, can indicate land use trends.

This section concentrates on those sources of information generally available at the local level. Additional references to more detailed and sophisticated methods are provided throughout and at the end of this chapter, and planners can refer to these depending upon the particlar priorities and problems within their area.*

There are a large number of classification schemes for soils.** These classification schemes are documented in numerous geology and engineering reference books. Because each system was developed for a different purpose they tend to weigh soil properties according to varied criteria (e.g., as a foundation for a highway, suitability for certain crops, etc.). Before using a specific scale for the WQM assessment, the planner should briefly investigate the original purpose behind its development.

The Soil Conservation Service is a good source of information regarding local soil characteristics.*** Soil surveys, prepared by the SCS (often in cooperation with State agricultural experiment stations and other government jurisdictions), generally describe the local soils and their limitations for different purposes. Soil surveys and maps will generally be adequate for planning and WQM assessment purposes. However, for determining the suitability of a particular site for a designated use, more detailed engineering analysis would be required.

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* Areawide Assessment Procedures Manual, Volume II, Appendix C, Land Use Data Collection and Analysis, EPA-600/9-76-014, July 1976, Municipal Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45768. Includes a description of land use data requirements and sources. Land Use Information for Water Quality Management Planning, Water Planning Division, U.S. Environmental Protection Agency, Washington, D.C., 20460, August 1976

** American Association of State Highway Officials Soil Classification, the Unified Soil Classification (Casagrande Classification, Bureau of Reclamation, U.S. Army Corps of Engineers), and the U.S. Department of Agricultural Textural Classification.

*** Guide for Interpreting Engineering Uses of Soils, USDA, Soil Conservation Service, November 1971, available from Supt. Documents, U.S. Government Printing Office, Washington, D.C. 20402, as cited in Goldstein and Moberg, op. cit.

Soil color is also a useful indicator of both soil drainage and the presence of organic materials. There are numerous field and laboratory engineering procedures which exist for analyzing specific soil samples, including mechanical analysis in the laboratory to determine particle size, and percolation tests to measure absorption properties for septic system location. In addition, there are many equations available to measure erosion, rate of infiltration, evapotranspiration, etc. For most of this analysis, data concerning precipitation (available from the Weather Bureau), ground cover (see chapter on Ecology), soil characteristics (SCS) and slope (USGS) are necessary. It will often be possible however, to rely on previous local experience and soil surveys, unless the assessment was looking at the use of a specific site for a particular purpose (e.g., land disposal of effluent). Most of this information will be primarily applicable to the Water Quality and Ecology chapters.

Critical Land Areas: Information concerning the location and description of critical land areas is often available from the State or from local universities and organizations. If slope is the significant factor in determining that an area is critical, the USGS is a source of topographical information. For areas which are located in either the coastal zone or flood plain, data and plans prepared through the Coastal Zone Management Program or the National Flood Insurance Program may be of use.

In determining critical land areas, the planner will have to be careful to note that although the boundaries of the actual area may be clearly defined, there is often a surrounding "buffer" zone which can be significant. Although the zone may not be critical itself, activities located there may impact the "critical" area.

Development Patterns: Although there are numerous models* to describe future development patterns and locate key activities, they are generally costly and time consuming. For most communities which are undergoing growth in an incremental manner the use of such models will be unnecessary. Rather an understanding of the forces at work (e.g., public investments, tax policy, zoning changes) at the local level which influence development trends will suffice. In those areas (e.g., energy development areas) where there may be significant variations from past development trends and patterns, more sophisticated methods may be appropriate.

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* An Introduction to Urban Development Models and Guidelines for Their Use in Urban Transportation Planning; U.S, Department of Transportation, Federal Highway Administration, October, 1975.

The WQM planner will need to identify patterns of land use changes (e.g., agricultural to residential), and areas which are likely to be developed first (e.g., urban fringe or leapfrog development). There are a number of plans, policies and programs which are developed locally and are significant in determining these growth patterns. These include police power regulations (zoning), capital improvements programs and tax policies.** Often these mechanisms do not operate strictly as they were designed. A good example of this is zoning. Although a zoning map may describe the current allowable development potential for an area, local policies regarding rezoning can mean that there will be significant differences between what will happen in an area and the way it is currently zoned. However, by looking critically at the zoning of an area, and perhaps more importantly to the way in which it is modified it will be possible to learn something about development trends.

A determinant of land use development patterns is the capital improvements program of a community. The presence of roads and waste disposal and treatment capacity is often a key factor in not only the amount of development which will take place, but its location.

The development of very large facilities (public and private) is also a factor to note. Large energy facilities (e.g., electric power generating plants, coal mines), government facilities (e.g., military installations) and private industrial or commerical development all will influence population growth and thereby land use trends. It is not always possible to get this kind of information early in the development process, but there are several ways to begin to identify such possibilities. Knowledge of significant energy resources, the presence of large parcels of undeveloped land in single ownership, local tax advantages for industrial development, programs by a Chamber of Commerce or Development Authority all will be an indication of potential land use change.

Tax policy (Federal, State and local) also is a force in directing land use. Federal capital gains and estate tax provisions can influence the conversion of rural farm land to developed use. Similarly, State and local property tax policies will affect land conversion trends. Many States have special programs to protect farmlands.

** For a summary of some of the issues and reports dealing with the role of capital investments and land use see the Fifth Annual Report of the Council on Environmental Quality, 1974.

Most communities have codes and ordinances which detail the way development will occur on a particular site. The zoning ordinance contains specifications for the amount of lot area which can be developed, the number of parking spaces per unit, the height of buildings etc. Subdivision ordinances, and in some communities regulations allowing for planned unit or cluster developments, can provide information regarding the amount of open space and services which may be required as a condition of development. Building codes also play a part in determining building materials and, in some instances, energy demand. Tax policy will affect the intensity of development on a particular site. Once the types of land use development can be classified, it will be possible to estimate waste load generation and to a certain extent, economic and social impacts (e.g., diversity and cost of housing types). Making waste load projections is discussed in the chapter on Water Quality.

There is a large range of methodologies available for assessing the quality of waste disposal techniques as well as travel demand associated with different development patterns. These methodologies include transportation models and engineering studies. In general these models will not be utilized by the WQM planner. Where a local transportation agency may be utilizing such a model, the WQM planner may chose to coordinate with the transportation agency.

BASELINE DEVELOPMENT

The purpose of developing a baseline of land use is to describe what is going to happen in the absence of the plan.

The components of the land use baseline are: land use policies and ordinances which guide development trends, critical environmental areas for which special development practices may be needed, the capacity of infrastructure which is already in place (e.g., roads and sewers), information regarding planned public investments, large undeveloped areas or areas developed at a "low" intensity (e.g., agriculture) and trends towards conversion of such land to development.

The existing land use plan and development ordinances (e.g., zoning, building codes, performance standards, subdivision ordinances, construction codes, etc.), will be primary factors in defining development patterns. This will include the allocation of uses (e.g., commercial, residential, etc.) within the area, as well as current policies regarding site development (grading, lot coverage, landscaping, irrigation practices, etc.). In addition some effort should be made to identify key population groups within the WQM area (e.g., the elderly, low-income groups, tourists, workers) who may be of particular importance to the local jurisdictions. Identification of these groups will allow both the baseline and impact assessment to focus in on more specific land use concerns.

Identification of critical environmental areas for which special attention may be required should include both the specific area as well as any buffer zones needed for its protection. The baseline should describe the development implications for these areas - can they tolerate limited development, if so, have they reached their limit, are there programs and standards for their protection, etc.? Where there is a survey, areas which may have certain use limitations may be identified to allow more detailed analysis of alternative WQM plan outputs which affect either those areas or uses.

Information regarding planned and in place infrastructure, as well as large undeveloped parcels will help to indicate where future developemnt is likely to occur. The projection of future development is a very complex (and fairly uncertain) process. At a minimum such factors as roads and sewers; land availability; Federal tax policy, the economy, and interest rates, (creating incentives for new housing starts and rural to urban land conversion); as well as local development policies will play a role. Roads, sewers and land availability are only suggested as starting points for identifying broad development patterns. This information must be coupled with the knowledge the local planner will have of past trends within the region, of policies in neighboring jurisdictions and of significant events (e.g., large scale resource development) which may be unique to their region. In this way the baseline will present a picture of existing land use, of those factors which govern land use form and trends, of critical land areas, and of locations for which significant change may be most reasonably expected.

IMPACT ASSESSMENT

The assessment* of land use impacts of the alternative WQM plan elements will focus upon how land use trends will be affected through the implementation of the plan. There are individual pollutant sources which will be significant on a site specific basis. However, the environmental impact of land use will be most visible when the cumulative effects of development over a large area are examined. This would include changes in the amount of permeable surface area, impacts of construction practices, changes in the volume and constituents of runoff, etc.

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* Planning Methodologies for Analysis of Land Use/Water Quality Relationships prepared by Betz Environmental Engineers, Inc. for the U.S. Environmental Protection Agency, October, 1976, Contract No. 68-01-3551.

Changes in density will become significant if they allow for different waste treatment and disposal processes. Therefore, for the purpose of environmental impact, the assessment should focus on the impact of the WQM plan on significant activities, critical environmental areas, and the cumulative impact of land use activities over a large area as evidenced by land conversion patterns and development trends.

There are a variety of ways in which land use activities may be affected by the outputs of the WQM plan. Areas in which erosion and sedimentation problems affect the water supply may require implementation of measures which control construction activities. This may influence both the ease as well as the cost of construction. Protection of hillsides may require implementation of grading and erosion controls, which limit the developable area of the slope. This will affect the cost, as well as the type of activities for which the site is developed. Changing the zoned use of a site (e.g., from residential to industrial) may be significant in terms of additional development which is attracted. The cumulative impacts of such decisions are significant from an economic as well as an environmental perspective.

The adoption of regulations which control the use and development of septic tanks will influence the size of lots which are developed, in turn affecting open space, the cost of housing and the population groups for whom it is available. Finally the location of interceptors* and the capacity of regional waste treatment facilities will affect the location, amount, and timing of development. Although decisions concerning waste treatment location and capacity should reflect rather than drive community land use decisions, often it is difficult to define the specific causal factor. It is therefore useful to review the land use implications of such decisions if they have not been comprehensively analyzed through the planning process. To the extent that interceptor lines are consistent with local land use plans and development policies (e.g., transportation planning), the impact attributable to the plan may be minimal. If such a route goes through farmland for which the community has not contemplated development, the impact will be significant. To the extent that a community is trying to develop a transportation strategy to minimize commuting, it will

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Interceptor Sewers and Suburban Sprawl, prepared by Urban Systems Research and Engineering, Inc., for the Council on Environmental Quality, September 1974.

Secondary Impact of Transportation and Wastewater Investments: Review and Bibliography, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C., EPA-600/5-75-002, January 1975.

be useful to see whether incentives for industrial location are consistent with transportation planning efforts.

Administrative review procedures (e.g., construction permit review processes) which are adopted as part of the WQM plan will primarily provide an opportunity for indepth consideration of special problems which may be associated with either a particular use or site. Unless there is a predesignated list of conditions (e.g., planting requirements) which may be attached to projects, it is difficult to assess the implications for such procedures on land use. However, there are two main ways they can be influential. First, if they increase the uncertainty associated with development and lengthen the approval process, they will influence costs. Second, by the way they define which projects are included in the procedure they might create an incentive for certain types of development.

In order to assess these impacts the WQM planner will have to rely on the data sources previously described.

Some of the factors to note include: the discrepancy between the developed uses and the zoned potential of an area (e.g., a single family residential neighborhood zoned for high rise development); policies regarding rezoning - how often they are granted, if they are given primarily in certain areas, and trends in the kinds of development which are being allowed; individual zoning decisions (e.g., rezoning, special exceptions, and variances) are important to look at because it may indicate incremental development changes which, when viewed as a pattern, are significant. In addition, building permits (the rate at which they are issued, the areas receiving the most applications, etc.) and the number of starts which result can be an indicator of land use trends.

The location and size of interceptor lines, as well as the treatment capacity are significant. Planners should note the population projections which are used in the design of such facilities. Transportation facilities (either in the form of highways or mass transit) are also important for the same reasons. Simply reviewing a capital improvements programs is not sufficient. The WQM planner should look at the capital budget and determine which investments will be made first. As in the case of zoning, it is necessary to look at both the planning documents as well as at the programs and policies which implement the plans. Knowledge of tax programs balanced with an understanding of strong local development incentives, will help assess the potential for development of open space. Alternatively, fiscal policies may contain deficiences that the WQM planner will identify and may attempt to remedy. Finally, events in neighboring communities are significant. A sewer or building moritorium in a neighboring jurisdiction will affect land development in those areas which already have required facilities. The impact of alternative WQM plan elements may be intensified or tempered by actions nearby. Therefore, the WQM planner should be aware of all these factors in assessing land use impacts.

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AIR QUALITY IMPACT ASSESSMENT

Elements of a water quality management plan designed to achieve water quality goals may also have significant effects on a region's air quality. For examples, the disposal of sludge from a sewage treatment plant by incineration has a direct impact on air pollution emissions, while changes in sewer service areas may induce changes in transportation patterns and residential or commerical development and, as a result, affect air quality. Inter-media impacts of water pollution control measures are clearly recognized in Section 208 of the FWPCA Amendments of 1972, the WQM Guidelines published by EPA and in guidance on coordinating WQM planning and regional air quality standards attainment and maintenance planning. For example, the Guidelines state that "The State should make sure that population projections and control strategies developed under the State Implementation Plan (SIP) are consistent with those in the State WQM plan."

This chapter presents guidance on how to perform an assessment of air quality impacts resulting from the development water quality management plan alternatives.* There are several key questions to be answered in an air quality assessment.

Key Questions

- Have consistent land use and population projections from local and state planning agencies been incorporated into estimates of both air and water quality?

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* A general reference on estimating the impact of land use on air quality is Land Development and the Natural Environment: Estimating Impacts, Dale L. Keyes, The Urban Institute, April 1976.

- What changes in air pollutant emissions and resultant air quality concentrations will be caused directly or indirectly from the implementation of the WQM plan?

- Will the implementation of the plan cause air quality to deteriorate significantly below present conditions in areas where the air quality is better than Federal or state standards?

- Will the implementation of the plan cause air quality to violate the national ambient air quality standards or State standards?

- What measures could be taken to minimize adverse air quality impacts?

In answering these and related air quality impacts questions, the WQM planning agencies are urged to involve local and State air quality planning and maintenance agencies in the area. This point is covered in more detail later in this chapter.

With the exception of air pollution emissions generated directly by a waste treatment sludge disposal process, most impacts on the atmosphere from elements of a WQM plan are indirectly the result of land uses. Many measures which may be adopted as part of a WQM plan will affect the nature of land use and the timing of land use development. The WQM plans are expected to consider such controls as zoning, subdivision regulations, conservation easements, building codes, development permits, hillside regulations, discharge permits, sewer hookup regulations, septic tank ordinances, and so forth. These controls will in turn affect the rate and direction of land development and therefore the air pollution resulting from various land uses. In assessing the air quality impacts of land use changes, the following use categories should be analyzed: commercial and residential uses which generate air pollution primarily as a result of space heating; industrial uses which generate air pollution as a result of both space heating and industrial processes; transporation facilities which may serve industrial, commerical or residential land uses and which generate air pollution as a result of automotive, truck and bus travel; and energy resource development and energy production necessary to serve all land uses.

The resulting air pollution from these land uses can be analyzed in terms of the resultant ambient air quality concentrations, that is the level of pollution in the surrounding air (e.g., parts per million or micrograms per cubic meter) or in terms of pollutant emissions (e.g., tons per unit area per year or pounds per hour from a smokestack). It should be recognized that ambient air quality is the sought after measurement because known adverse affects are based on ambient concentrations. Pollutant emissions may be estimated based on pollutant generating activities. It is also possible to convert emissions to ambient concentrations through dispersion models which are discussed later in this chapter. The criteria against which air quality impact should be measured are meeting or bettering air quality standards. These standards have been set by the Federal government (and in some instances made more stringent by State governments) to protect public health and to improve public welfare.

AIR QUALITY ASSESSMENT PARAMETERS

The Clean Air Act, as amended, requires States to develop plans to implement national ambient air quality standards established by EPA. Individual States have the opportunity to establish more stringent standards. The national or State standards provide a basis for evaluating the impact of alternative elements of a WQM plan on air quality. The national standards (listed in Table 4-1) are based on measures of the following six pollutants, commonly used as indicators of air quality. The state-of-the-art regarding the sources and effects of these pollutants are contained in various EPA publications including the "Air Quality Criteria"* documents for each pollutant.

- Hydrocarbons (HC) are substances whose molecules contain only hydrogen and carbon atoms. The significance of hydrocarbon emissions relates principally to their role in the production of photochemical smog. They are emitted mainly as a result of the partial combustion of fossil fuels. Transportation activities, industrial processes, power plants, and space heating are major sources of hydrocarbons.

- Carbon Monoxide (CO) constitutes the single greatest pollutant, by weight, in the urban atmosphere. It is a colorless, odorless, tasteless gas which can cause dizziness, unconsciousness, or even death, by lessening the ability of blood to carry oxygen. It results from the incomplete combustion of hydrocarbons and its main source is the automobile (internal combustion engine).

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Several of the "criteria" documents were published by the National Air Pollution Control Administration, a predessor agency to EPA. An EPA example of these documents is Air Quality Criteria for Nitrogen Oxides, EPA Report AP-84, January 1971.

- Nitrogen Oxides (NO_x), mainly nitric oxide (NO) another contributor to the formation of photochemical smog, and nitrogen dioxide (NO_2), are formed when nitrogen and oxygen from the air are combined under high temperature. Thus, they are characteristic of any high temperature combustion process such as occurs in an automobile engine or a fossil-fueled electric power plant.

- Sulfur Oxides (SO_x), mostly sulfur dioxide (SO_2) with some sulfur trioxide (SO_3), are emitted when fossil fuels, such as coal and oil, containing sulfur impurities are burned.

- Suspended Particulates is a loose category which includes a wide range of solid or liquid particles which are typically emitted during combustion or from the processing of materials. Some of the deleterious properties of particulates are caused by their chemical composition, while others are merely a result of their existence and their size.

These five are commonly referred to as "primary pollutants" to distinguish them from the so-called "secondary pollutants" associated with photochemical smog. In particular, when nitric oxides and hydrocarbons are together in the presence of sunlight, a partially understood complex series of reactions takes place which results in various harmful secondary pollutants, including nitrogen dioxide (NO_2), ozone (O_3), and peroxyacetyl nitrate ("PAN", CH_3 CO_3 NO_2). Ozone and PAN are usually referred to as photochemical oxidants .

In addition to these six criteria pollutants, the concentration of a number of other pollutants is restricted because of their correlations with extreme health hazards. Among the "hazardous" air pollutants are berylium, mercury, vinyl chloride, and asbestos fibers from a number of sources, such as brake linings, asbestos-asphalt roadways, building insulation materials, etc. Hazardous air pollutants are subject to control through National Emission Standards for Hazardous Air Pollutants. Other pollutants, less hazardous, but with significant effects can be controlled through Standards of Performance for New Stationary Sources.

COORDINATION BETWEEN WQM PLANNING AND AQM PLANNING

The Clean Air Act Amendments of 1970 required States to develop State Implementation Plans (SIPs) designed to meet the national ambient air quality standards. As part of SIP development the States must identify areas that may, as a consequence of current or projected growth rates, have the potential for exceeding the national standards in the future.

Table 4-1 - Summary of National Ambient Air Quality Standards[1]

POLLUTANT	AVERAGING TIME	PRIMARY STANDARDS	SECONDARY STANDARDS
Particulate matter	Annual (Geometric mean)	75 $\mu g/m^3$	60 $\mu g/m^3$
	24-hour[2]	260 $\mu g/m^3$	150 $\mu g/m^3$
Sulfur oxides	Annual (Arithmetic mean)	80 $\mu g/m^3$ (0.03 ppm)	-
	24-hour[2]	365 $\mu g/m^3$ (0.14 ppm)	-
	3-hour[2]	-	1300 $\mu g/m^3$ (0.5 ppm)
Carbon monoxide	8-hour[2]	10 mg/m^3 (9 ppm)	(Same as primary)
	1-hour[2]	40 mg/m^3 (35 ppm)	
Nitrogen dioxide	Annual (Arithmetic mean)	100 $\mu g/m^3$ (0.05 ppm)	(Same as primary)
Photochemical oxidants	1-hour[2]	160 $\mu g/m^3$ (0.08 ppm)	(Same as primary)
Hydrocarbons (nonmethane)	3-hour (6 to 9 a.m.)	160 $\mu g/m^3$ (0.24 ppm)	(Same as primary)

1 The air quality standards and a description of the reference methods were published on April 30, 1971 in 42 CFR 410, recodified to 40 CFR 50 on November 25, 1972.

2 Not to be exceeded more than once per year.

3 ug/m^3 = micrograms per cubic meter
mg/m^3 = milligrams per cubic meter
ppm = parts per million

For these potential problem areas, the States must develop air quality maintenance plans which are similar to water quality management plans.

Water quality planning and air quality planning are so closely interrelated that EPA has published guidelines on procedures for coordination between air quality maintenance planning and the state and areawide water quality management program.* The air and water plans are interrelated both in terms of their impact on one another and in terms of their comparable planning approaches. While the goal of each planning and implementation program is to improve the quality of the environment, the focus on a single medium may result in conflict with attaining standards in the other medium. If care is taken to coordinate the development of these two programs, the environmental plans produced can be mutually supportive.

The degree of coordination between air and water planning is one measure of the WQM planning agency's efforts towards developing an air quality impact assessment. In many instances the designated WQM planning agency will rely on a parallel State or local air quality planning agency to determine the impact of water quality planning on air quality. The respective planning agencies should consult early in the WQM plan development to determine what part of the air quality assessment the air quality agencies can provide, and what resources and funds will be made available to them by the WQM planning agency to assist in this task. It should be kept in mind that most air quality planning agencies have limited funding and to have an adequate analysis, the WQM planning agency should expect to provide some additional resources.

Coordination of the planning programs is also necessary to assure a proper evaluation of air quality conditions. Such planning coordination should include:

- Joint reviews of the WQM planning process and the air quality planning process;
- Periodic reporting and reviews of plan outputs;
- Joint participation in advisory committee roles;
- Coordinated search of baseline data and data formats for economic, demographic, land use and other areawide information;

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* Procedures for Coordination between Air Quality Maintenance Planning and the State and Areawide Water Quality Management Program, EPA, Program Guidance Memorandum SAM-8.

- Coordinated projections of economic, population and land use information.

The following three categories of state and local agencies have completed or are in the process of completing long-term forecasts of air quality:

- State and local air quality agencies responsible for development and implementation of SIPs.

- Other State and local agencies designated by governors pursuant to 40 CFR 51.58 to do air quality maintenance plans.

- Metropolitan planning organizations responsible for assessing consistency between areawide transportaion plans and programs and SIPs.

Additional guidance on coordinating other planning efforts with air quality plans can be found in guidelines prepared jointly by EPA and the Federal Highway Administration.*

AIR QUALITY ASSESSMENT METHODS

There are basically three broad approaches for analyzing the WQM plan impacts on air quality. The first method is restricted to an analysis of pollutant emission changes (e.g., the change in tons of sulfur dioxide emitted per year in the area). This technique allows for a rapid comparison of plan alternatives without actually calculating the ambient air quality that would result from those emission changes. However, if air quality standards are being met or are projected to be met in the future, then the relative comparison between emission levels for alternative WQM plan elements would provide an indicator of air quality impacts.

The second approach is an analysis of air quality by use of an atmospheric simulation or dispersion model. It is doubtful that a water quality management planning agency can undertake such an analysis on its own; but it is quite possible that through an agreement with an air planning organization, it could conduct an air quality impact assessment via an

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* Guidelines for Analysis of Consistency Between Transportation and Air Quality Plans and Programs, EPA and FHA, April, 1975.

atmospheric dispersion model. Such models consist of mathematical equations which are based on scientific principles used in physics (diffusion, dispersion), meteorology (wind patterns, mixing depth) and other principles, such as those governing chemical reactions of sunlight with hydrocarbons and nitrogen oxides to form photochemical oxidants. The inputs for the models are atmospheric conditions and emission inventories of stationary point sources (smokestacks), area sources (home heating emissions uniformly distributed over an area), and line sources (automobiles in a transportation corridor). The outputs are usually ground level concentrations at various points in the area and at various times. As in the case of water models, the atmospheric models must be calibrated for unique atmospheric conditions in the area and for the influence of the area's terrain. Following calibration, the model must be verified by attempting to duplicate measured air quality for a given set of input conditions. There are a range of models available of varying complexity. Many of these are described in an EPA publication on air quality maintenance planning.*

The third method uses both of the first two methods and is dependent upon the development of emission quotas for the planning area.** Emission quotas can take the form of emission allocation planning, district emission quotas, floating zone emission quotas and emission density zoning. All of these strategies provide a link between the control emissions at the source and the attainment and maintenance of the air quality standards at the regional level. The emission quota strategy (although not strictly an assessment process) designates the miximum amount of pollution allowable in any one area of the region based on an analysis of present air quality and the assimilative capacity of the air to absorb additional pollutants without violating air quality standards. Basic to the analysis and implementation of emission quotas are the translation of land uses into pollutant emissions, the conversion of emissions to ambient air quality measures (through atmospheric dispersion models), and the establishment of development constraints to keep within the emission limits. Since the establishment of emission quotas is a complex technique, this method can only be used where such quotas have already been established as an air pollution control strategy. In most areas, either the first or second methods, or a combination of them should be used.

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* <u>Guidelines for Air Quality Maintenance Planning and Analysis Volume 12: Applying Atmospheric Simulation Models to Air Quality Maintenance Areas</u>, EPA Report Number (450/4/74-013).

** <u>Emission Density and Allocation Procedures for Maintaining Air Quality</u>, EPA - 450/3-75-079, June 1975.

BASELINE DEVELOPMENT

As a first step in conducting an assessment of the WQM plan's impact on air quality, it is important to establish a baseline of air quality conditions. This baseline can then be used as a comparison against the impacts of alternative elements in a water quality management plan. There are usually two readily available sources of data from which to construct a baseline. One source is the emission inventory of major stationary area, and line sources of air pollutants, (e.g., smokestacks, commercial areas, and highways respectively). The second is some form of continuous or intermittent measurements of ambient air quality. For most metropolitan areas in the country, EPA maintains information on both emissions and air quality.* In addition, States may have their own emission inventory systems and air quality data systems.

These data have been collected for several years and should provide a reasonable reference for use in baseline comparisons with and without the impacts of the WQM plan. However, those responsible for developing the environmental assessment should check with the State or local air pollution control agency to determine when the NEDS data was last updated and to find out if the State maintains an emission inventory separate from NEDS. Unfortunately, these information sources are for historical data and do not project changes in emissions or air quality. Such projections will have to be made by the WQM planning staff or associated air planning staff, based on the projected change of air pollutant sources in the absence of the WQM plan. For example, population estimates can be used to scale up (or down) the emissions from home heating or use of automobile. Similarly industrial growth (or decline) can be used to vary stationary industrial source emissions with time.** Many areas have or are developing long-term projections of emissions as part of attainment/maintenance planning for air quality. The WQM planning staff should check with the State or local air pollution control agency for these data.

IMPACT ASSESSMENT

As mentioned in the previous section, to analyze the impact of alternative WQM plan elements on air quality, changes in emissions can

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* National Emissions Data System (NEDS), 1975, EPA Research Triangle Park, North Carolina, and Monitoring and Air Quality Trends Report, 1973 EPA Office of Air Quality Planning, Research Triangle Park, North Carolina.

** Guidelines for Air Quality Maintenance Planning and Analysis Volume 7: Projecting County Emissions, Second Edition, EPA-450/4-74-008, January, 1975 (OAQPS No. 1.2-026). See also Volume 13 of the same series, Allocating Projected Emissions to Sub-County Areas, EPA-450/4-74-014, November, 1974 (OAQPS No. 1.2-032).

be used as a surrogate for ambient air quality. The method involved is very straightforward. The WQM planning agency must obtain an up-to-date emission inventory for the area and a set of emission factors applicable to the types of air pollution sources in the area. If no emission inventory has been prepared by a local or State air quality planning organization, then the National Emission Data System (NEDS) can provide a basic inventory for most metropolitan areas in the country. In non-metropolitan areas and where no emission inventory exists, an emission inventory can be developed from emission factors and units of production activity.*

Using the baseline emission inventory developed for the area, and the applicable emission factors, changes in industrial, transportation and residential development caused by the alternative WQM plan elements can be converted to changes in pollutant emissions. For example, in the case of domestic and industrial space heating with natural gas, the emission factor for particulates is "x" pounds of particulates per 1,000 cubic feet of natural gas burned. Therefore, a change in residential development where natural gas is used can be estimated on the basis of average usage of natural gas. Similar relationships exist for transportation and industrial air pollutant emissions as a function of their activity (e.g., pounds of sulfur dioxide emissions per ton of steel production). Based on the estimated changes in industrial capacity due to the WQM plan, a projected emission inventory for industrial outputs can be made to compare the emissions impact of alternative elements of the WQM plan.**

These types of comparisons deal with emissions rather than air quality. Air quality levels are not necessarily directly related to pollutant emissions. However, it may be necessary to limit the air quality impact assessment to the emission inventory analysis due to the short planning period and limited planning resources. If this is necessary, the professional judgment of the air quality planning agency may be sufficient to determine the qualitative relationships between emission and ambient air quality. If there is a severe air quality problem, however, an emission analysis may be insufficient and an ambient air quality analysis may be required.

The use of emission inventory changes is also the basis for an emission quota analysis. However, in this type of analysis a prior calculation

* Compilation of Air Pollutant Emission Factors, #AP-42, 2nd Edition, EPA April 1973.

** Guidelines for Air Quality Mainenance Planning and Analysis and Volume 7: Projecting County Emissions, EPA Report Number (450/4-74-013)..

is assumed which relates maximum allowable emissions to ambient air quality and the national air quality standards. These maximum allowable emissions are assigned to each geographic subarea and provide a reference in terms of the emission inventory. This allows for a direct comparison between changes in the emission inventory resulting from the alternative elements of the WQM plan and the maximum emissions allowable under the national or State standards. The calculation of changes in emission inventory are the same as in the previous example. The professional judgment which was absolutely necessary to make the leap from emissions to ambient air quality is supported in this method by the atmospheric simulations that were made to determine maximum allowable emissions.

If an ambient air quality analysis is necessary, an atmospheric simulation model should be use. Atmospheric simulation models can be categorized into three general groups: 1) models dealing with areawide or aggregated emissions only; 2) models requiring specific information about point, line and area sources such as smokestacks, highways and buildings; and 3) models requiring area source emissions allocated on a subcounty basis.* This report also provides specific references on each of modeling techniques mentioned below. The following discussion is presented to acquaint the WQM agency with the methodologies available to assist them in dealing with air quality maintenance planning agencies or State agencies. It is not expected that the WQM planning agency undertake such methods on its own. It is also important to note that air quality maintenance planning may have been established in the area to deal with a specific pollutant, while the WQM plan may affect other or all pollutants. Professional judgment will be required to seek the appropriate level of analysis. The air quality planning agencies at the State, local or regional level can assist in making this determination and should be consulted.

The first category encompasses models which are limited to consideration of only areawide air pollutant emissions. There is no identification of individual point sources or specific area sources. The meteorological input is in terms of very general parameters, such as average wind speed and average mixing height (up to the inversion layer). Air pollution concentrations estimated with such models are either averages for the whole area or are site specific and apply only where there are air quality data. These models include the Rollback Model, the Appendix J $HC-O_x$ Relationship and the Miller-Holzworth Model. These models have limited usefulness for evaluating specific air quality impacts. They

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* For a more detailed discussion, see EPA's Guidelines for Air Quality Maintenance Planning and Analysis, Volume 12, applying Atmospheric Simulation Models to Air Quality Maintenance Areas.

can only determine the impact of total pollutant emissions on air quality. They cannot consider in any way how these emissions or the resulting air quality levels are spatially distributed across an area.

The second class of models is that which considers, in detail, point source, line source, and area source emissions of pollutants. These models have detailed requirements for meteorological inputs and consider complex atmospheric mechanisms for estimating the downwind transport, dispersion and chemical transformation of pollutants. These models can be used to estimate concentrations at any specific site in an area for which estimates are desired. This type of model includes the Air Quality Display Model and the Sampled Chronological Input Model. For cases where there is a lack of detailed point and line source data, the input to these models can be limited to area source emissions, wherein all point and line source emissions are summed in the area sources. It should be noted that such a summation, should it be necessary, will detract considerably from the reliability of the models.

The last class of models is that which addresses only specific area source emissions. This includes the SAI Photochemical Simulation Model and the Hanna-Gifford Model. The SAI model is a sophisticated photochemical dispersion model which does not specifically consider point sources. The Hanna-Gifford model is a simplified area source model for stable pollutants (i.e., pollutants that do not enter into chemical and photochemical reactions). While this model does not consider point and line sources, the impact of point or line sources can be individually determined by the application of a point source model or a line source model such as HIWAY. Both the SAI and the Hanna-Gifford models allow concentrations to be estimated for any of the designated areas.

For those areas with very poor information on the spatial distribution of pollutant emissions, the application of the first type of simulation model (e.g., Rollback, Appendix J Miller-Holzworth) is suggested. Where possible the Miller-Holzworth model is preferred for estimating areawide concentrations of SO_2 and suspended particulate matter. Where oxidant concentrations must be estimated, either the Appendix J or Rollback approach may be necessary.

In those areas where there is detailed information on pollutant emissions (current emissions and projected emissions to 1985), and where it is expected that air quality impacts would be significant, the AQDM, SCIM, APRAC-1A or SAI models may be used, depending on the averaging times and the pollutants to be considered. In those cases where the pollutant emissions projected to 1985 can only be known on an area-source basis, it is recommeded that either the Hanna-Gifford or the AQDM be used.

The data requirements, model outputs and general performance of these various models are summarized in Table 5-2. The summary is structured from the most elementary to the most sophisticated models. In the table, "1's" indicate factors which are the most general or the easiest with which to work -- increasing numbers indicate factors which are more detailed or difficult. The EPA guidelines on "Applying Atmospheric Simulation Models to Air Quality Maintenance Areas" examines the models listed in Table 5-2 in greater detail, discusses the emissions and meteorological requirements to operate these models, and identifies the availability and reliability of these models.

The models discussed here are not the only ones for relating emissions to air quality. Other models which have been summarized in the EPA report are available from private consultants and other governmental agencies. The models discussed in Table 5-2 are those most readily available to air pollution control agencies and representative of the state-of-the-art for atmospheric simulation models.

Table 5-2 - Summary of Simulation Model Characteristics

Model Name	Pollutant Specification	Averaging Time Specification	Emission Data	Meteorological Data	Concentration Estimates	Ease of Use	Availability	Reliability	Applicability to AQM
Rollback	1	1	1	1	3	1	1	3	3
Appendix J	2	3	1	1	3	1	1	3	3
Miller-Holzworth	2	2	1	3	3	1	1	1	3
Hanna-Gifford	2	2	1	2	3	1	1	1	3
Hanna-Gifford	2	3	2	5	2	2	1	1	2
w. Point Source model	2	3	3	5	1	2	2	1	1
w. HIWAY	2	3	3	5	1	2	2	1	1
AQDM	2	2	3	4	1	3	2	1	1
SCIM	2	3	3	5	1	3	3	2	1
APRAC-1A	2	3	3	5	1	3	2	2	1
SAI	1	3	2	5	2	3	3	2	2

Key to Table 5-2

A. Pollutant Specification
   1. Any Pollutant
   2. Specific Pollutants

B. Averaging-time Specification
   1. Any Averaging-time
   2. Long-term Average
   3. Short-term Peak

C. Emission Data
   1. Area-wide Emissions Total
   2. Total emission distributed as finite area sources
   3. Detailed point, line and area sources

D. Meteorological Data
   1. None
   2. Average wind speed
   3. Average wind speed and mixing height
   4. Frequency distribution of wind direction, wind speed, stability and mixing height
   5. Hourly variations of wind direction, wind speed, stability and mixing height

E. Concentration Estimates
   1. Estimates at any specified point
   2. One estimate for each area source grid
   3. One estimate applicable to entire AQMA

F. Ease of Use
   1. Slide-rule
   2. Small computer effort
   3. Major computer effort

G. Availability
   1. Open literature
   2. National Technical Information Service
   3. EPA, upon request

H. Reliability
   1. Can be verified and calibrated
   2. Verification is incomplete, possibility of calibration is uncertain
   3. Questionable, acceptable for crude estimates only

I. Applicability to AQM
   1. Can distinguish between specific source and land use typ
   2. Can distinguish between land use types only
   3. Considers no distinction between sources or land uses

Source: EPA report number (450/4-74-013), Guidelines for Air Quality Maintenance Planning and Analysis Volume 12: Applying Atmospheric Simulation Models to Air Quality Maintenance Areas.

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ECOLOGICAL IMPACTS

Biology, the study of living things, and ecology, the study of the relationship between living things and their environment, clearly encompass concerns covered in other parts of this handbook (land, air, water, etc.). This chapter discusses the ways in which ecological impacts likely to occur from the implementation of WQM plans may be assessed. In a sense, the abundance, quality and diversity of wildlife and vegetation can be used as indicators of the "health" of ecological systems, and will be the major focus of this chapter.

It is difficult, if not impossible, to separate wildlife and vegetation from the physical places in which they exist (habitats) and from their functional role within the ecosystem (ecological niche). The number and distribution of animals is, in part, a function of the plants, soils and climate of an area. In order to understand what is happening (or more importantly what will happen) because of the implementation of a WQM plan it would be useful to identify the major ecosystems present within the planning area and the interrelationships between the component parts, i.e., food producers (green plants), consumers (plant and animal eaters, parasites, decomposer organisms, scavengers) and nonliving components. Once these components are identified, it is then possible to describe how the system functions. The number of species, distribution and abundance of plants and animals; the physical and chemical limiting factors (e.g., weather, toxics); the amount and rate of production of living matter (productivity); and the way in which the system is changing over time describe the "status" of the ecosystem, determine its stability and the way in which impacts to it will be felt. Although a detailed ecological investigation of an area would require analysis of all these factors, for the purpose of most WQM plan assessments it will usually be sufficient to look at major plants and animal populations, food chains, and limiting factors in the environment.

Although certain ecosystems may be commonly recognized as significant because of their "uniqueness", fragility or the presence of rare and/or endangered species, significance can also be defined by the function which the ecosystem provides to man. Wetlands may protect against flooding and help replenish the water supply; woodlands may buffer noise, filter air pollutants, provide a marketable product and a recreational resource; hillsides provide visual amenities (views, variety and recreational resources) and, their disturbance may have undesirable effects (erosion, landslides); even large open spaces may provide a habitat for wildlife and vegetation which may have an educational or aesthetic value because of the relief from development. Landscaping and house-siting considerations associated with new development can contribute to or hinder the diversity of vegetation and wildlife in the community by creating a space in which they may flourish.*

Actions prescribed by water quality management plans have the potential of impacting plant and animal life and the ecosystems in which they exist. For example, the construction of a sewage treatment facility or the development of temporary water storage areas may result directly in the elimination of vegetation or wildlife. Decreasing the flow of a stream may lower the rate of fish production which can have ecological, recreational, economic or scientifically important implications. Still more devastating are wide reaching changes in whole communities of plants and animals which can occur when key environmental changes occur.

There are several key questions to be asked in conducting an assessment of the vegetation and wildlife impacts resulting from implementation of water quality management plan.

Key Questions

- What are the major ecosystems within the water quality management planning area? What are the major forms of vegetation and wildlife?
- What biological significance (e.g., essential link in food chain, rare or endangered species) or relation to community goals (e.g., unique scenic value, recreational or economic resource, air or water quality, public safety, State definitions of "critical environmental areas", etc.) do the ecosystems exhibit?
- How will the elements of the WQM plan affect the natural succession of ecosystems, productivity of primary producers and secondary consumers, abundance of populations, and diversity of organisms at the community level?

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* Performance Controls for Sensitive Lands: A Practical Guide for Local Administrators. EPA 600/5 - 75 - 005, Office of Research and Development.

Unlike environmental considerations of air and water quality where law and long standing custom dictate standards, biological considerations are rarely guided by an established set of criteria. The National Environmental Policy Act speaks in terms of impact characteristics such as short vs. long term effects and irreversible losses. The Endangered Species Act of 1973 (P. L. 92-205) provides for the conservation of endangered fish, wildlife and plants, while the Migratory Bird Treaty Act (16 U. S. C. 701-711) and similar State laws protect the breeding and resting places of migratory birds. In some cases, management objectives as stated by environmental resource agencies (e. g., protection of "critical environmental areas") may be used as surrogate standards for estimating the importance of changes in biological systems or particular species. However, with the exception of endangered species lists, assessments often must rely upon the best professional judgment of biologists and ecologists coupled with input from local citizens.

ECOLOGICAL ASSESSMENT PARAMETERS

In assessing ecological impacts it is important to emphasize that ecosystems constantly change. All man caused impacts must be identified and interpreted within the context of natural changes which cause ecosystems to change and adjust until they reach a state of dynamic equilibrium. An important ecological concept in understanding changes in ecosystems is succession.

Succession is the name given to the process by which natural systems increasingly accumulate and regulate a dependable cycle of nutrients and flow of energy through the system from primary producers (plants) to animal consumers to microbiological recycling groups. In its classic forms, succession may begin on a land base in which the processes of soil formation and the gradual elaboration of plant and animal communities occur as an interrelated process. Succession also occurs in aquatic settings. For example, water bodies (e.g., lakes) will gradually become enriched through the accumulation of nutrients and sediments deposited from the erosion of their surrounding watershed and the accumulation of organic material from successive generations of plant and animal growth. This natural process of increasing nutrients and plant growth is known as eutrophication. The process of eutrophication raises an interesting question because, although it represents a "natural" process (albeit often accelerated due to human intervention) the end point is often perceived as undesirable by the local populace. Given the concept of a dynamic ecosystem and the relationship between the component parts described above, the following parameters should be considered in conducting the assessment:

- Major Forms of Vegetation and Wildlife

Information concerning species of plants and animals and their proportional and geographical distribution in the ecosystem provides a basis for interpreting the stage of succession and whether or not particular biologic communities are representative of regional ecological conditions. In addition, the ability of a particular species with the development patterns which may be associated with a WQM plan should be identified. (The investigator should be sensitive to seasonal fluctuations in conducting ecosystem analyses.)

-- Density is the number of individuals per unit of area (e.g., extent of coverage, number of deer or mature trees/acre). Density is most meaningful when the area is defined in terms of "habitable" space.

-- Diversity is the number of different species present. It is a significant parameter because of the positive correlations between diversity and ecological stability.*

-- Biological Productivity is usually a measure of the rate at which primary producers (green plants) create food (carbohydrates, fats and proteins) that is required for themselves and all secondary consumers in the ecosystem. In some instances, productivity may refer to the rate at which all species or particular species in a community accumulate organic matter. The measurements of productivity are given in total weight or volume (biomass) per unit area per time (e. g., 100 bushels of corn per acre per year) or energy equivalents (e. g., calories per sq. meter per day).

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* In discussing diversity, it is important to note both the number of different species and the abundance or number of individuals within each species.

- Food Chains and Food Webs

  Food chains classically measure the interrelationship between primary producers (green plants) and the several levels of animal consumers. Most contemporary descriptions carry the process from plants and consumer groups to the bacteria and fungi that finally break down ecosystem wastes into basic mineral constituents for recycling back to primary producers. Because in any one ecosystem there are often several food chains, the relationship between and combination of all the food chains is referred to as the food web. Although it is not necessary to describe the entire food web for all the systems within the WQM planning area, information describing the food chains for animal and plant populations which have commerical, biological (e.g., endangered species, unique), or recreational (e.g., sports fishing) significance would be useful. The important thing to remember is the interdependencies between components of the food web and the potential of "indirectly" affecting an organism determined to be significant by affecting a component of its food chain.

- Interrelationships with Non-Living Matter

  Plants, animals and microbes influence the chemical composition of air, water and soil and moderate the physical forces of nature on the earth's surface. The chemical equilibrium of gaseous elements is affected by organisms in the air, land and water. By-products of plant and animal activity also change the nutrient quality of soil and water by removing or adding such substances as nitrogen, phosphorus, calcium, iron, and sulphur. Furthermore, the physical presence of plants can reduce erosion, dampen the force of waves and currents, slow winds and alter the temperature of the air. Outputs of the air, water, and land impact assessments are also inputs to the assessment of vegetation, wildlife, and habitat impacts. To the extent that the outputs of alternative elements of a WQM plan affect the range and quality of habitats, they will affect the vegetation and wildlife present. Species tend to spread out with the availability of suitable habitat; however, this tendency is checked by a number of factors. "Barriers" and "highways" (natural and man-made) which inhibit the spread are parameters to note as part of the assessment.

ASSESSMENT METHODS

The major decision facing the planner regarding methodology is the amount of information necessary in order to develop a reasonable understanding of the character of natural occurrences and the influence which human action will place on that character. Professional judgement and a thorough awareness of community interests are the yardsticks with which to measure the required level-of-effort on information gathering. Two basic sources for ecological data: existing sources or original field study can be used.

Before embarking upon an original field study effort, the planner should first take advantage of any existing data or studies. This may include efforts to map critical environmental areas, perhaps undertaken for another purpose (e. g., flood plain management, an environmental impact statement), in depth studies of a particular species or site, as part of a university effort, or an inventory of significant plants and animals as part of a federal or State fish and wildlife program or a local planning effort. In any event, in order for this data to be useful, the planner should already have a series of questions or data needs against which the data can be compared. This is important to avoid the situation of over-emphasizing an area merely because there is a data base on it. Existing data sources typically include the scientific literature (abstracts, journals and books), public and private professionals, universities, knowledgeable local individuals and groups .

Good baseline data is available through many public agencies and institutions. The Soil Conservation Service generally can supply maps and in some cases baseline information for local areas related to soils and their productivity, origin and use. Topographic maps can be obtained from the U. S. Geological Survey for selected areas. Standard black and white aerial photos can be obtained through Agricultural Stabilization and Conservation Service. Indices of forest growth can be obtained from the U. S. Forest Service. State and Federal Fish and Wildlife Agencies also have many ecological research reports. It is likely that most WQM planning areas contain Federally sponsored projects that have NEPA impact assessments and assembled data. There may also be equivalent impact studies done for State projects in those States having environmental statutes similar to NEPA.

Some Federal agencies have specialized research institutions that offer reports on natural systems or physical features of the environment. Some of the most applicable are:

- U. S. Army Corps of Engineering, Waterways Experiment Station

- U. S. Fish and Wildlife Service, Office of Biological Services

- U. S. Geological Survey

- U. S. Coast and Geodetic Survey

- U. S. Forest Service, specialized regional research units

- U. S. Park Service, regional research units

- Department of Agriculture, Agricultural Research Service, Cooperative States Research Service, Agricultural Experiment Stations at each Land Grant University

- Smithsonian Institute, Science Information Exchange

As part of the literature search,it is useful to review the indices and compile a bibliography for further investigation. These indices are published annually with the first year of publication in parenthesis followed by a brief abstract of the topics covered, and a statement on how the material is indexed. Five of the most common indices are as follows:

- Bibliographic Index (1937): A cumulative bibliography of bibliographies. Included are bibliographies published separately or as parts of books and pamphlets; also, bibliographic material from about 1900 periodicals. Indexed by subject.

- Biological Abstracts (1927): Consists of abstracts and indices to biological research literature from approximately 7600 journals throughout the world; affording optimum retrieval of pertinent references within all areas of biology. Indexed annually by author, subject, biosystematic and cross indices with detailed instruction on how to use them.

- Biosis: List of periodicals indexed for Biological Abstracts.

- Biological & Agricultural Index (1916): Subject index to periodicals related to biology and agriculture; also indexed by title of article, author, and journal.

- Dissertation Abstracts (1938): A monthly compilation of abstracts of doctoral dissertations submitted by institutions from U. S., Canada, and Europe. Cumulative key word and author index.

Although in many instances research findings will be published in scientific journals or by local institutions, often study results can be obtained only from the individuals who have performed the work. Researchers are often reluctant to simply pass on information to impact assessors. Therefore, when individual scientists have long experience in the area, it may be advisable to employ them as specialized consultants for parts of the impact assessment.

Data collection may range from simple gathering of existing data (species lists, soils surveys, topographic maps, etc.), to complex statistical designs used to organize field data collection. Regardless of the strategy used for the collection of baseline data, it is important that a methodology, however simple, be formulated to outline the problem and set forth objectives for the assessment. The methodology should lead to the determination of significant impacted ecosystems in the affected region.

It is common that specialists in the life sciences must rely on knowledge about the physical and chemical qualities of the environment to understand the behavior of the biological part of the ecosystem. Therefore, the work of the physical scientists or engineers must be co-ordinated to the needs of the life scientists. For instance, engineers working with water quality and hydrologic models can usually present information to aquatic ecologists necessary for understanding baseline conditions or forecasting changes in the biota from anticipated water quality improvements. Engineers, however, do not usually use all the same parameters for their studies as do aquatic ecologists. Adapting water quality models to include data needed by both aquatic biologists and engineers can eliminate redundant research efforts and provide greater congruity of data throughout program planning.

It is important to guarantee that information developed by the ecological team can be expressed in public interest or economic terms which can be understood in the political process. Careful attention to environmental issues as they are expressed by regional agencies or interest groups is necessary in order that the ecological impact team can know in advance what issues are critical. Without such knowledge of the issues, valuable research efforts can be lost as peripheral or unnecessary studies are carried out.

Besides availability and format of data, other problems inherent in using published and unpublished materials include incongruity in terms of the time sequencing of data, and the great variability in where and how data has been collected. In some cases, incongruities make any valid picture of the regional ecosystem almost scientifically impossible. One way of dealing with this data problem is to carry out sufficient investigations to validate earlier research reports by replicating field study experiments. This involves the second source of data -- original study.

Original study usually includes a field effort where the investigator studies the area and describes ecosystems with respect to the parameters discussed earlier. While field study provides information directly related to the impact study area, it is often costly and time-consuming. In order to understand or adequately describe many natural processes, the study should span the annual seasonal changes within which plants and animals carry out their life cycles. However the variance in natural processes from place to place and from year to year means it is not possible to accurately describe general (or average) conditions within an area on the basis of only one year or even several years study. It is therefore usually advisable to avoid original studies that require lengthy fieldwork unless there is a clear expectation that the WQM plan will impact a significant ecological resource whose life requirements are poorly understood and must be fully studied within the time and cost constraints of the impact study.

There are a number of things which can be done to shorten the survey effort and in most cases would be appropriate for the purposes of the ecosystem assessment. Time requirements can be shortened by concentrating on those elements of the ecosystem which tend to accumulate their history on the site. For example, terrestrial productivity can be measured by examining the growth rate of older trees which can yield as much as hundreds of years of productivity analyses. In the case of aquatic environments, it may be possible to analyze the stratified sediments of lakes or streams to gain data on chemical or biological events that have occurred over many years.

Aquatic study is somewhat more complicated because of the difficulty in locating and seeing aquatic organisms. In flowing water or in coastal environments, natural conditions may create physical forces that rapidly shift plant and animal populations and induce wide daily, seasonal or yearly fluctuations in species, population size, productivity, water chemistry and substrate quality. Because of this great variability in the physical environment, field studies must be carried out more often for any given place in the aquatic system than on land. Where one trip to a sample plot in a terrestrial setting may yield all the necessary data, an equivalent aquatic sample area may require weekly or monthly sampling to adequately generalize ecosystem conditions. Again, the rationale for undertaking any study should be reviewed before commitments are made for expensive and time-consuming studies.

Another way of reducing study time is to concentrate on interpreting habitat groupings rather than studying particular species. This is especially true in the case of animals whose wide variation of occurrence, mobility and secretive habits make them difficult to observe. An analysis of habitats can provide a reasonable estimation of the likely occurrence of particular animal species because of their association with particular habitats.

Vegetation, and significant components of habitats can be assessed in a number of ways, ranging from the very simple to the complex. The potential for vegetation can be determined in part from the amount of open space within the area. The type of vegetation present can be determined by actual survey, from aerial photos or other existing studies.

In both terrestrial and aquatic cases, it is often advantageous to use remote sensing techniques* to further reduce the field activity. Conventional black and white, infra-red and high altitude (aerial or satellite) photos and scans can provide regional and site specific data on soils, water, land forms, ecosystem types, productivity and, where time series photos are available, successional changes and trends. Aerial photos are also helpful for reducing preliminary field reconnaissance requirements for sampling designs. The infra-red photographs are also useful to indicate the "health" of the vegetation. Once the amount of vegetation and significant species are determined, diversity and abundance can be assessed by measuring the number of different species present and the number of members of each species per habitable area (density). There are a range of quantitative techniques available for collecting and assessing the vegetation, its quality, diversity and abundance, and for organizing it into meaningful categories by geographic (quadrants) and biological (e. g., trees, shrubs) units.**

Much of the vegetation analysis may be utilized to assess the quality of wildlife habitats. "Highways" (trails, level ground), open space, food and water, a suitable climate as well as the absence of "barriers" to wildlife movement will contribute to a favorable habitat. In addition, it will be necessary to study the quality of the water to determine the suitability for aquatic life.

If habitat analysis, preliminary field survey or previous study indicate the presence of significant wildlife, it may be desirable to assess its density. Most techniques for measuring density involve sampling or limited controlled experiments. Examples include measuring the number of insects caught or birds seen in an hour, capturing and tagging a predetermined number of animals and releasing them, and, on a subsequent day, capturing the same number and determining the proportion with tags. In addition, nests and other signs of wildlife can be used as surrogates. Wildlife can be evaluated according to density and diversity, as with vegetation. Daily and seasonal variation will require attention Once again, biology and ecology textbooks as well as Land Development and the Natural Environment contain discussion of and references to specific techniques.

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* Areawide Assessment Procedures Manual, Volume II, Land Use Data Collection and Analysis, EPA-600/9-76-014, July 1976, Municipal Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Cincinnati, Ohio 45768.

** Land Development and the Natural Environment: Estimating Impacts, Dale L. Keyes, The Urban Institute, April 1976.

BASELINE DEVELOPMENT

Information derived from existing sources and field studies should be organized into a clear baseline description of existing and projected conditions. These conditions would include significant environmental areas (such as wetlands, woodlands, sand beaches, aquifers, etc.), significant vegetation, major forms of wildlife, and areas which may be important to community values such as large open spaces. Sound professional judgment should be used in determining the level of detail and extent of information gathering. Emphasis should be placed on areas where positive or negative impacts are likely.

Lists by themselves are not particularly useful for subsequent impact assessment. In order to be meaningful, the information should be categorized (e. g., rare and endangered species, unique areas) according to criteria which will provide an indication of ecosystem health and therefore of future trends such as density, diversity and abundance. The reproductive characteristics (e. g., birth and death rates) of primary wildlife can be noted and related to the growth curve to identify trends. As previously discussed, much of this information will be available through existing sources. In some instances where States have developed programs for the protection of "critical environmental areas", there may be a data base already prepared on areas within the WQM planning area.

Since ecosystems are dynamic, the baseline should emphasize changes and trends rather than static inventory type descriptions. It is important to describe the dynamics of the habitats of significant species. Baselines should portray the geographical distribution of ecosystem types and provide an understanding of how biological and chemical matter flows between the types. Relative differences in productivity among described ecosystems should also be identified. Major elements of the food web (sources of food and predators), migration patterns (highways) and habitats for significant wildlife should be noted.

Information concerning diversity, the food chain, and growth characteristics will indicate the likelihood for the continuation of current trends. Knowledge of proposed land use changes will help determine loss of any key habitats, disruption of highways and creation of barriers. Similarly expected trends in air and water quality, noise levels, the introduction of new species through additional landscaping, and agricultural practices (e. g., herbicides and pesticides), all will contribute to the continuation or disruption of existing trends.

It is especially important to recognize that there is much uncertainty in the baseline analysis. Care should be taken to identify uncertainty so as to avoid the impression that precise information is being given about complex environmental features which are in no sense fully comprehended by science in any of its forms.

Aids for organizing baseline data and projections and illustrating relationships have been critically reviewed by EPA.* Since there is no one best technique, it is important that the WQM plan administrator and the impact assessment staff review and select the most appropriate presentation method prior to the start of actual work. Anticipating the way the final assessment product will appear should influence the design of research.

IMPACT ASSESSMENT

The process of assessing impacts should focus on evaluating the changes in the ecosystem that were described in the baseline projections.

Assessment of impacts from alternative elements of the WQM plan resulting in specific project sites related to construction or operation activities such as replacements of existing ecosystems by structures is fairly straightforward. These impacts typically have such measurable characteristics as the amount of landscape changed or particular physical or chemical alterations which are qualities of the project itself (e. g., construction of a pier, dredging, heated effluent, etc.).

Assessment of impacts from general development plans or policies are considerably harder to measure with accuracy. For instance, the WQM plan may forecast a large improvement in the quality of surface waters allowing for greater domestic, industrial, or recreational use of water. Accomplishing this aim may result in further expansion of industrial sites, residential and commercial areas, or the creation of new recreational units in the region. Each of these activities will in turn generate changes within the ecology of the region. For example, urban expansion may cause increases in nonpoint source runoff, perhaps off-setting water quality gains from improved point source management. Likewise increased attractiveness of waterbodies may induce more waterfront recreational demand placing greater stress on the shoreline and aquatic plants and animals. In addition, some consideration will have to be given to activities in adjacent areas because of their influence on water quality, land use and habitats.

Identification of ecological changes and their assessment as adverse or beneficial rests on two different approaches: ecological and resource evaluation. Any changes in the system that cause one or more of the following to occur could be considered detrimental:

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* A Review of Environmental Impact Assessment Methodologies, Report No. 600/5-74-002, Office of Research and Development, 1974.

- reduction in the number of species or in specific species designated as rare or endangered,

- alteration in the biomass or number of species in each of the major trophic categories,

- acceleration of the rate of biological productivity over the rate of energy use and nutrient recycling in the system (depending on the season),

- decrease in beneficial use of water (as defined by water quality standards).

As previously discussed, the methods for ecosystem assessment are less well defined than air and water quality models for example. Therefore, the assessment (especially in the areas of productivity, energy use and nutrient recycling) will have to rely upon professional judgement, an understanding of the critical ecosystems and major forms of wildlife and vegetation, as well as of proposed patterns of land use and pollution discharge. For most areas, ecosystem impacts will result from changes in land use development or water quality.

The planner will have to assess how the alternative elements of a WQM plan will affect the conditions identified in the baseline: amount of land classified as "critical", presence of major wildlife and vegetation (determined by looking at changes in open space, in number of mature trees, new landscaping, changes in air or water quality and noise level, introduction of new predators through domestic pets, etc.), and changes in the abundance, diversity or reproductive characteristics of wildlife (determined, in part, by looking at changes in "habitable" areas, food sources, barriers to movement, etc.). In addition, nonpoint source best management practices (e. g., percent of lot coverage, agricultural practices, street sweeping, etc.) should not be overlooked in terms of their impacts. Changes in land use and water quality can be directly related to the specific parameters which have been determined, through the baseline development, to be significant. There have been a number of studies which have attempted to monitor ecological changes which have resulted from urbanization.

Once all of the key changes have been identified, it will be necessary to assess their importance. Clearly, impacts to areas designated as "critical" by the State or local governments for purposes of flood management, water supply, or vegetation and wildlife classified as rare or endangered can be assessed in a rather straightforward manner. Other impacts however are less obvious.

According to the resource evaluation approach, benefits or losses in ecosystem quality are understood in reference to the production of resources having social-economic meaning. Since the values society attributes to resources vary so greatly among individuals and interest groups, it is impossible to assign an absolute value to resource impacts. For instance, a shift in water temperature may change the aquatic community from a cold, to a warmer water system. Sport fish species may change from trout to bass. From the point of view of trout fishermen, the water quality change produced an adverse effect; not so with the bass fishermen.

The best that the planner can do is to recognize that ecosystems can function in several modes and produce a wide range of socially defined resources. It is necessary, therefore, to identify as fully as possible, the variety of social values in the impact area and to evaluate adverse or beneficial changes according persons beneficially or adversely effected by ecosystem alterations.

Public participation is required to develop a judgement on the kind and relative importance of community values. Certainly the ecologists should take part in the public participation activities to help explain the significance of their studies and findings, and to discover public issues that may require further development of ecological impact assessments in social value terms.

Changes in the use of water and land may substitute human activities for existing productive ecosystems. Such a substitution may meet present social needs, but can be interpreted as a trade-off between present need and long term resource production. In other cases, there may be a shift in ecosystem production resulting from changed land use that will, over a time, produce new resources that can be viewed in terms of their long term potential. The trout vs. bass example given earlier is typical in this respect.

The evaluation of irreversible losses is a key problem. Are the ecosystems lost common or rare? Are they important in the region's economy? Are they low or high in the production of resources? Are they critical to the health or productivity of other ecosystems? These and other evaluation questions should be addressed in order that a common sense interpretation of lost environmental values can be presented.

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ECONOMIC IMPACT ASSESSMENT

The economic impacts resulting from alternative elements in a water quality management plan generally fall into three major categories. First, those economic impacts felt by the private sector such as the benefits of clean water for industrial processes, or the costs of waste treatment user fees or the costs of providing pretreatment to industrial effluent; second, those economic impacts felt by various units of local government such as the public cost of street sweeping or the local share of treatment plant construction costs; and finally, those indirect economic impacts that are felt by the public and private sectors of the area as a result of the direct impacts such as a change in local tax revenues (e.g., from property or sales taxes) due to increases or decreases in employment of impacted industries and linked economic activities.*

There are several key questions that usually need to be answered in an economic impact assessment of alternative elements of a WQM plan.

Key Questions

- What is the expected direct employment and other impacts of a proposed policy or other action?
- What other employment and economic activity changes are generated as a result of the direct impact?

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* Other related impacts (discussed later in this section) could include changes in population, income, per capita income, public finances, or other impact categories.

- How are the employment, personal income and population effects likely to be distributed geographically in the impacted area?
- How are these impacts likely to be distributed among various economic classes or social groups?
- What are the fiscal management impacts on local units of government; that is, how are future local and public revenues and costs likely to change?
- What changes in personal income (primarily wages and salaries) are expected to occur as a result of the total employment or population impact?
- What population changes are expected to occur as a result of this employment impact?
- What is the result of population age-sex ratios, fertility rates and death rates on demographic characteristics?
- How will these demographic characteristics change the longer term population trends of the area?

The WQM plan will result in an environmental management process which may include some or all of the following elements:

- Municipal and industrial water treatment (e.g., sewers, treatment plants)
- Urban storm water control (e.g., street sweeping, sewer separation)
- Application of industrial pretreatment requirements
- Land use controls (implemented, for example, through zoning)
- Nonstructural urban nonpoint source controls (implemented, for example, through permits and ordinances)

- Management practices to control agricultural, mining and silvicultural sources

- User charges

- Residual waste management (e.g., sludge disposal)

- Cost recovery regulations (for capital and operation and maintenance costs of municipal treatment)

- Pollution control enforcement activities

- Water quality and effluent monitoring activities

For each of these elements (taken either singly or in combination) there may be economic impacts on a project basis (e.g., capital, operating and maintenance costs of treatment plants) and/or more global impacts on the area's economy (e.g., changes in per capita income resulting from industrial pollution control investments, or changes in the tax base resulting from land use controls). These economic effects should generally be assessed (over time) in terms of 1) required capital and operating or maintenance outlays (and in some cases, user charges) by public and private entities; 2) direct production, employment and/or personal income impacts on private firms and public agencies being affected by the WQM plan; 3) the indirect employment and income impacts resulting from the purchases of products and services by these firms and agencies from other industrial sectors; 4) the induced employment and income impact resulting from the purchase of goods and services by those directly and indirectly receiving income from the affected entities; and 5) the overall effect of the plan on public revenues and costs. The total (i.e., direct plus multiplier--including indirect and induced effects) employment and income effects have ramifications on the characteristics of an area (i.e., population, land use, public costs and revenues, and so on).

There is a relationship between each element of the WQM plan and the region's economy. Rather than explore each of these relationships, two examples have been developed which encompass both a direct impact on industry and range of impacts on land use. These examples highlight the potential economic impacts associated with implementing particular elements of a WQM plan. In both examples the emphasis is on the side of negative impacts. Actual WQM plan elements may, of course, have positive economic impacts. The examples are not intended to illustrate the expected direction of impact, but rather the complex interrelationships involved in assessing the impacts on both industry and land development.

Application of Industrial Pretreatment Requirements

Some industrial pretreatment requirements will be established through Federal standards. However, areawide plans can include industrial pretreatment as an option in their plans (i.e., tighter standards or local standards in anticipation of Federal standards). In either case, industrial pretreatment offers a good opportunity to investigate local economic impact.

The instituting of industrial pretreatment requirements would usually impact directly upon industrial water polluters of an area. These could be manufacturing firms with substantial effluent that cannot be satisfactorily handled at the municipal treatment facility due to the chemical effect on the treatment process. Examples might be certain types of firms involved in textile and leather production, metals processing, chemical production, etc.

Industrial pretreatment may require such firms to increase investments in waste treatment and to perform additional operational and administrative activities to improve effluent quality. Such functions entail both initial capital costs and annual operating and maintenance costs. These firms should also have to pay fees for the use of municipal treatment facilities receiving pretreatment effluent.

Some firms may be financially unable to meet the burden of these various added costs. A corporation with several plants producting the same commodity may shift production to a plant in another area where the pretreatment costs would not need to be incurred. Other firms may decide not to locate in this area, or may not expand production of plants already in the area, because of the pretreatment costs. The costs may be different in other parts of the country due to varying local controls. Such decisions would result in fewer area jobs (i.e., workers) than otherwise expected in the future. The loss of employment and production would likely lead to further employment impacts as a result of lower area consumer purchasing power (i.e., the income of workers used to purchase area goods and services) and diminished purchases of area goods and services by manufacturing plants impacted by the pretreatment costs. Each of these reactions would then lead to further rounds of impact on employment and total personal income in the area.

Consequently, a plan requiring industrial pretreatment may result in changes in employment and payroll among firms directly impacted by the regulations. These direct impacts would generate additional employment and personal income impacts (i.e., multiplier effects) in the area. The result would be lower consumer expenditures, less savings, and lower public revenues. In addition, because there would probably be diminished jobs, population might also be lower in comparison to expected future levels due to out-migration or less in-migration than otherwise expected in the future. Water consumption and sewage effluent would be less than otherwise expected in the future because of declines in both population and industrial output. On the other hand, fewer persons could result in lower future total public investment and operating costs than what would be projected without the added cost of industrial pretreatment. Also, industrial pretreatment reduces municipal treatment costs regardless of population changes and decreases the likelihood of treatment plant impacts and/or the release of toxic substances to the environment.

The scenario depicted by the pretreatment example, especially the potential for negative impacts, is more realistic in the case of marginal plants than with healthy plants. In the case of healthy plants, the increased expenditures on pollution control equipment may in fact create a positive economic impact. However, the example is presented to point out the potential consequences of a control measure directed at industry.

Development Controls

Another type of WQM plan element would be the instituting of various development controls. These could include land use controls (for example zoning), sewer moratoria, sewer permit regulations, or other development controls and incentives. Where these controls tend to be used primarily to regulate residential and transportation developments, the types of impact are often similar to those previously discussed. For example, controls on the area's residential development could tend to constrain the size of the total labor pool in an area due to the limitation of available housing. Commercial/industrial growth may continue for some period following the residential controls until the squeeze on labor supply is apparent to firms bidding in the labor market. The immediate effect may be increased wages and salaries. The longer-term effect is likely to be a steady state industrial/commerical employment base and no population change. The impacts would be, as in the previous example, lower gross levels (than expected in the absence of controls) of employment, population, total personal income, consumer expenditures and public revenues (but also perhaps lower public costs). Alternatives to these (or perhaps additional) effects may be longer distance commuting by workers residing outside the area impacted by development controls, or increased population and housing densities (where controls would not totally constrain such growth) in existing residential areas. In the latter case the market price of housing would usually be bid up. Similarly, property values would probably rise and this could result in increased revenues from property taxes (alternatively, tax rates may fall and property revenues remain constant). However, a number of families are likely to be "priced-out", leading to attempts to find satisfactory housing outside the controlled area. Again the result could be "leap-frogging" and longer distance commuting. The total impact may again be gross declines (i.e., compared to what might be expected without such controls) in area employment, population, personal income, and so on.

This development control example is presented to illustrate the complex nature of related impacts rather than the specific direction of impacts. For example the growth of certain industries may be dependent on low density housing and strict controls on residential land uses.

From these two examples it is apparent that there may be important linkages between elements of a WQM plan and economic, demographic, land use and other characteristics of an area. Many examples could be stated and economic impacts may, on-balance, be positive or negative. For example, though not discussed in the above examples, improvements in water quality could lead to economic benefits resulting from an expansion in tourism or retirement communities, or the attraction of less polluting and higher paying industries (including professional service firms) seeking a cleaner environment for management and workers. Property values, particularly along waterways with lowered pollution levels, may also be "bid up," resulting in greater accumulation of local wealth. Other types of local or national benefits could include improvements (as a result of lowered water pollution) that occur in commercial and recreational fishing, other recreational activities, or potable water supplies.

Those reviewing alternatives for a WQM plan should also b of the general likely impact of such policies on the local economy and their ultimate impact on the revenues and expenditures of communities in the area. Also, an assessment should be made of who bears the costs or accumulates the benefits of improved water quality. Certain economic classes or minority groups may, for example, bear the largest protion of costs (e.g., lost jobs and income, or higher taxes) and this should be evaluated.

ECONOMIC IMPACT CATEGORIES

For water quality management purposes, several of the more important economic impact categories are the following:

Employment. This would usually be measured in terms of annual person-years of employment in the area. This measure compensates for part-time and short-term jobs. Sometimes, though, employment statistics are only available at a particular time or on a specific date during the year.

Population. Numbers of persons residing in an area in a particular year. Again, these estimates may only be available on a specific date during the year. (Population and employment are highly correlated and one parameter may be calculated from the other as discussed in subsequent sections of this chapter.)

Income. Generally measured in terms of area annual personal income (defined as wages and salaries, other labor income, proprietors' income, rental income, dividends, interest and government and business transfer payments). Annual earnings (defined as wages and salaries, other labor income plus proprietors' income) may also be used as an indicator of area personal income, especially since there is usually a relatively stable relationship between earnings and personal income.

Per capita income. Determined from annual estimates of total income and population measurements.

Economic activity by sector. This may be measured in terms of annual output (i.e., production value or value added), earnings or employment by appropriate sector (e.g., agriculture, silviculture, mining, manufacturing, services).

Public revenues. Annual public revenues generated in the area.

Public expenditures. Annual public capital and operating and maintenance costs in the area.

Other economic impact categories may be total annual area output (i.e., production value), annual consumer expenditures or retail sales in the area (this provides an indication of local business activity and the frequency with which local revenues are raised via taxes on retail sales), or annual average bank deposits. However, the primary indicators of impact are generally those listed above.

The following sections provide descriptions of approaches and procedures that can be used in providing estimates or measurements of these impact categories as a part of assessing alternative water quality management plan elements. The assumption used in preparing these estimates is that a relationship exists over time (i.e., a trend is established) among many of these factors; for example, between the following kinds of statistics:

- employment and population,
- employment and earnings, or earnings per job by industrial sector,
- earnings and personal income,
- personal income and retail sales,
- population with personal income and public revenues, and
- population and public costs.

ECONOMIC IMPACT ASSESSMENT FRAMEWORK

The WQM plan should assess the impacts of expected alternative plan elements on employment, population, earnings and/or personal income, per capita personal income, industrial activity, perhaps retail sales, and public revenues and costs. In performing these economic impact analyses, it is necessary to analyze the expected impacts both "with" and "without" implementation of the proposed elements of a WQM plan. This type of assessment is essential to estimating the marginal impacts associated with alternative plan elements (singly and in combination). Consequently, it is important at the outset to establish "baseline" projections of primary areawide economic and demographic characteristics. These baseline projections establish the "without" case; that is, what is expected to occur in the areawide economy assuming a continuation of current trends, and conditions excluding (i.e., without) implementation of the WQM plan. The "without" case, or baseline projections, also assumes continuation (as appropriate) of existing public policies in the environmental (i.e., non-208 actions, such as Federal treatment standards) and other fields that may impact upon the local economy.

To determine what is likely to occur as a result of implementing any proposed water quality management plan alternatives, it is necessary to determine the expected impacts of alternative (single and/or in combination) actions, and then to add these calculations to the baseline projection to provide a "new" total estimate (i.e., "with" the proposed action) of future area conditions. In performing this assessment of alternative policy impacts, of critical and immediate importance is to be able to provide good estimates of the expected direct economic impacts of such actions. For example, some plant shut-downs, or plant relocations in or out of the area, might occur sometime in the future (say in one, two, five, or 10 years) as the direct result of a present action. Being able to trace the direct impacts such as these of any proposed action is the basis of the impact assessment. In addition, these direct impacts are likely to result in "indirect" and "induced" (i.e., multiplier) effects stemming from changes in industry product and service purchases and changes in worker earnings. Consequently, these multiplier effects, resulting from the direct impacts, must also be assessed.

The following sections outline procedures or approaches that may be used in 1) developing baseline projections for an area economy and 2) determining the direct and overall impacts in a WQM area of proposed alternative water quality management actions.

BASELINE DEVELOPMENT

Where possible, 20 year baseline projections (in 5-year increments) should be performed for each of the areawide economic impact categories (i.e., employment, population, earnings and/or personal income, per capita personal income, industrial activity, retail sales, and public revenues and costs). Because of time and financial resource constraints, baseline projections would generally emphasize factors such as employment, population, personal income, and employment (or earnings) by major industrial sector.

Preparation of the baseline projections should start where possible by making use of existing employment and population analyses. In general, population projections are linked to employment projects, which are a function of the local economic structure and activity. Of particular importance are those projections already being used by other local planners in the area (e.g., HUD 701, transportation, air quality, etc.). Often a State planning agency would provide the needed local area employment and population projections, and/or there may be local disaggregations of statewide projections based on independent analyses or on assessments performed by these sources or agencies. For example, OBERS* provides historical data and projections to the year 2020 of population, total employment, total personal income, per capita personal income, total earnings, and earnings by industrial sector. These data are available for the nation, each State (and the District of Columbia), 173 BEA (Bureau of Economic Analysis of the U.S. Department of Commerce) economic areas blanketing the nation, the 20 water resources regions and 205 sub-areas of the nation delineated by the Water Resources Council, the 253 SMSA's, the 173 non-SMSA portions of BEA economic areas, and the 205 non-SMSA portions of water sub-areas.

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* U.S. Water Resources Council <u>1972 OBERS Projections: Economic Activity in the U.S.</u> (Based on the Series E Projected National Population), Vol. I-VII, Washington, D.C., April 1974.

These historical data are also generally available from BEA. BEA (Regional Economic Analysis Division) will also contract with local areas to develop or disaggregate these projections for single or multi-county areas. These projections were made in 1970/1971 and care must be used in working with these data. However, this work provides one of the very few examples of a national projection with a series of consistent local projections. These projections are now being revised and should be available in 1977 or 1978.

In some cases, the WQM planning agency may disagree with employment and population projections provided by the State or other sources, or in use by other local planning agencies. In some areas the State may take a very active role in coordinating projections to be used by local agencies, thus minimizing disagreements. But in other States, the agencies may have flexibility in selecting the projections. When the WQM planning agency has some flexibility, it should select projections which have the support of its advisory committees and local political units; which are reasonable and can be defended on technical grounds; and which, to the extent feasible, are compatible with other projections used or prepared locally.

The WQM planning agency should use caution in extrapolating historical employment and population trends to make population projections Since some parts of the country are experiencing rapid changes in population levels and distribution, certain historical trends occasionally may not be adequate for projecting future conditions. Recent economic and social factors, for example,a rapidly declining birth rate and high unemployment levels, should be included in projections of local activity. Such data for counties and other local areas are kept relatively current by appropriate State agencies (e.g., employment service and health departments).

If personal income projections (in constant dollars) for an area do not exist (from the State or other sources) these could be estimated directly from the employment projections. Historical county data are available from the Regional Economic Measurement Division, Bureau of Economic Analysis of the U.S. Department of Commerce on total earnings and earnings per job, and on the ratio of personal income to earnings. Also, projections of these data have been made by OBERS and the Bureau of Economic Analysis for the nation, each State, and many local areas. Consequently, historical data for an area can be compared with other similar areas (or in some cases, as in metropolitan areas, these projections will already exist) and projected approximations can be made of total personal income for an area (i.e., personal income equals employment times earnings per job, times the ratio of personal income to earnings), assuming a continued similarity or relationship between earnings per worker and the ratio of personal income to earnings.

Likewise, BEA and OBERS provide historical data and projections of earnings by industrial sector for a variety of areas. These industrial sectors include the following nine major categories: agriculture, forestry and fisheries; mining; contract construction; manufacturing; transportation, communications and utilities; trade; finance, insurance and real estate; services; and government. In addition, these nine major categories are divided into a number of subcategories. Also, State employment service agencies generally have historical employment data by major industrial sector. Where appropriate, these might be used directly as measures of sector activity (i.e., variations over time of employment and/or earnings by industrial sector), or various procedures, similar to those discussed for estimating and projecting earnings or personal income in an area (e.g., applying ratios such as earnings or output per job to time-series employment data for individual sectors) would be applied.

The resources necessary to accomplish the baseline projections will depend upon the availability and type of any existing projections for a particular area, the availability of technical assistance from the State or other local agencies to work with the WQM planning agency to modify (as needed) any existing projections, or the availability of other pertinent studies (government, university, or private) which may be useful in preparing the needed projections. If no projections exist for a particular area, and only historical data and statewide projections are available from OBERS or a State planning agency, it should still be possible for a single experienced economist with the assistance of another person, to prepare the needed projections within a period of one to two months. These might be prepared by planning agency staff members, a local university, a State agency, consultants, or the Bureau of Economic Analysis in the Department of Commerce. However, some of these may require substantial lead time to develop the projections. BEA, for example, may be overwhelmed with requests for this type of assistance. General sources of data, other than those already noted, would include various publications of the U.S. Bureau of the Census (U.S. Department of Commerce). County Business Patterns provides mid-March estimates of "covered" employment and related first quarter payroll by industrial sector (i.e., for those "covered" by this reporting system) for each county in the U.S. The Census of Population provides detailed employment and income data for a variety of areas, but it is available only in 10-year intervals. In addition, there are various industrial censuses (agriculture, manufacturers, trade, services, etc.) which are performed in about 5 to 10-year intervals, depending on the sector. Data on births and deaths are available from Vital Statistics of the United States, Volume I "Nativity" and Volume II "Mortality" (U.S. Department of Health, Education and Welfare).

IMPACT OF ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

The baseline projections of at least total employment, population, personal income, and industrial sector activity provide the foundation needed to assess the economic impact of proposed alternative environmental actions.

The initial task would, in most cases, be to determine the expected variation in employment in the area due to proposed alternative actions. The direct employment impacts would first be assessed. (Where sector-by-sector earnings projections exist for an area, the preferred approach may be to begin with this data base rather than the employment projections. Such earnings projections are available for many areas, as indicated earlier, from OBERS and the Bureau of Economic Analysis in the U.S. Department of Commerce).* This would require an understanding of the numbers of firms or agencies (or other employing entities) that would be directly affected by a particular WQM plan element, and the degree (e.g., change in production employment, and/or payroll) to which each firm would be impacted. This analysis may be performed on a plant-by-plant basis, or for an entire industrial sector (e.g., mining) or a segment of such a sector (e.g., coal mining, or textile manufacturing) in each area. This analysis should result in an understanding of the direct employment impacts of WQM plan elements on particular industrial sectors in the area economy.

Frequently, it may be necessary to assess these proposed WQM plan impacts on a plant-by-plant basis. This becomes particularly obvious using the "industrial pretreatment requirement" example. In this case it is especially important to estimate 1) the costs of compliance for all firms requiring industrial pretreatment; 2) the likelihood that these costs will be wholly or partly passed on to consumers (through an increase in product price), or absorbed by the producing firm (this would be based on analyses of the market structure of industrial segments in which these firms participate, of the potential use of substitute products, and of other economic factors); and 3) the impact of these costs and possible price increases on the profitability and general financial viability of these firms. One method of obtaining this information would be to go directly to the individual firms and ask for this information. It is likely that these estimates may be understated or overstated by individual firms. Another procedure would be to ask each firm to list specifically how it intends to comply with the proposed pretreatment requirement. This would include an itemized list of expected equipment purchases or other plant actions and a related cost estimate. The results could be checked with equipment suppliers and other sources, and also checked by a competent professional. Most importantly, the results could also be checked and compared with the economic impact studies published by EPA for each industry where effluent limitation guidelines have been promulgated, and similar economic impact studies funded by the National Commission on Water Quality (NCWQ). These studies generally assess the expected impacts on industrial segments by size of firm (e.g., small, medium and large). Consequently, the results

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* Regional Economic Plan for the Old West Regional Commission, March, 1976. Prepared by Centaur Management Consultants, Inc.

of the local area assessment of individual firms could usually be reviewed and compared with results from the studies funded by EPA and NCWQ to determine potential local economic impacts. Finally, one of the best methods to assess local economic impact might be to have a very specialized and knowledgeable consultant in industrial effluent standards compliance talk with plant personnel (either by telephone or preferably during a quick walking tour of each plant) and make estimates of the costs of compliance and other economic impacts.

These expected changes in direct employment or other economic activity will have both indirect (i.e., resulting from the changes in purchases of products and services from other firms or agencies which are used or consumed in production) and induced (i.e., resulting from changes in the purchases of goods and services by those workers directly and indirectly impacted who receive income from the affected firms or agencies) employment impacts on the area economy. These multiplier effects must be taken into account. Such effects may be assessed using a variety of approaches including economic base type multipliers, input-output analysis, or other ad hoc analyses which attempt to derive area multipliers for assessing the total impact of changes in direct employment or earnings. Following are brief discussions of each of these approaches. Neither the approaches or the discussion receive exhaustive treatment, nor is any endorsement of a particular approach intended. Any of the approaches can be utilized as long as they provide reasonable estimates of the expected multiplier effects. There are no definitive statements comparing the accuracies of these models or comparing the confidence levels of model outputs with the resources necessary to construct and operate these models. The planning agency will have to rely on professional judgement in selecting the appropriate technique.

Economic base multipliers derive from the theory that external economic forces constitute the cause of local (or regional) changes, and the internal portion of the local economy (i.e., local consumption of local goods and services) is considered to have a predictable relationship to total economic activity. While economic base type multipliers sometimes rely upon a crude estimating procedure, they offer an inexpensive means for estimating indirect and induced impacts. Data for employment (or income) multipliers for an area may generally be obtained from the area's baseline data (see the foregoing section) on industrial sector activities or from the Bureau of Economic Analysis, Census of Population, County Business Patterns, or State Employment Security Offices.

In determining economic base multipliers, the usual procedure is to separate the industrial sectors of the local economy as to whether they provide products of export (e.g., these generally include manufacturing, mining, agriculture, Federal Government) or of local service (e.g., these generally include trade; finance, insurance and real estate; transportation, communication and utilities; local government; services; and contract construction). There may also be some specialized services in an area that could be termed export. Examples include tourism, power generation for export (i.e., export utilities), financial or insurance centers serving a larger region or the nation, or similar national or regional educational or health centers. The portion of employment (or income) which is associated with the export activities is said to be "basic", and the remaining portion (i.e., "non-basic") is said to be generated by the basic or export activity. Where changes in employment are expected to result from proposed WQM actions, if such job gains or losses occur in an export or basic activity, the economic base approach allows calculation (by using the historical relationship developed between basic and non-basic employment) of the concomitant gains or losses that can be expected in the non-basic or local service sectors of an area. On the other hand, if such employment changes (i.e., job losses) appear to occur in a non-basic (or local service) sector, the economic base approach suggests that the impacted economic activity (and related employment and income) was supporting the area's export or basic segment. Therefore, little additional multiplier impacts can be expected. Also, there is a high probability that the activity would be reestablished elsewhere in the area or near the area, creating little additional if any impact, in order to support the existing economic (i.e., export) base.

An input-output (I-O) analysis is a means of relating interindustry purchases in a single model, showing the consequences to all other industrial sectors of a specified change in one. Such a model can be designed for most any geographical area where satisfactory data can be collected. Analyses performed with I-O models are of value in quantifying changes in an area's industrialization pattern resulting from some specific proposed change in industrial inputs and/or outputs. These occur as a result of implementing a particular environmental action. The input-output approach can be an excellent analytical tool because of the thoroughness and detail involved in the model. The approach offers a relatively precise way of determining multiplier effects. However, unless such a model (of relatively recent vintage) already exists for a particular area, the input-out approach has severe practical limitation. The most crucial limitation for a planning agency is the time and expense involved in collecting the enormous amount of data for such a model. Such a model would also require updating (requiring another large data collection effort) every few years since the coefficients are sometimes not predictable over time.

Ad hoc type models generally trace spending patterns, propensities to consume, and related income generating effects. These models can track the rounds of spending that occur in a local economy and determine the total income and spending impacts related to a primary or direct change in income (or expenditures). A theoretical weakness of the resulting multipliers (i.e., total impacts associated with an increase or decrease in personal income) is insufficient measurements of impacts on local consumption (i.e., induced effects). The requirement for thorough data surveys of a local economy can, in this case, also be very time-consuming and costly.

Applying, then, one of these types of approaches to the direct employment impact determination, provides an estimate of the total (i.e., direct, indirect and induced) expected employment impacts associated with a particular proposed alternative WQM plan action. When this is added to the future employment estimate obtained from the earlier discussed baseline projection, a "new" total employment estimate (i.e., "with" the proposed action) results. Using the historical and projected baseline relationships between employment and population for the area, it should be possible to estimate the expected population change associated with the variation in employment (i.e., population equals employment times the ratio of population to employment, the latter determined from projected historical trends) resulting from alternative actions. When added to the baseline population projection, a "new" future population estimate results. The assumption in this analysis, or procedure, is that employment opportunities drive population. That is, if employment opportunities are generated in an area, this will result in less out-migration, since the natural increase in population would be able to absorb some of these opportunities, and/or increased in-migration would take advantage of these opportunities. On the other hand, fewer job opportunities would result in relatively more out-migration and less in-migration. The gross and net effects depend upon the number of employment opportunities, the local fertility rates and the labor market within and outside the area. Migration is a key factor in employment and population change, data on expected family size of migrants (from U.S. Census or State agencies) will be necessary to estimate expected population impacts. Other data needed to characterize the labor force are age and sex compositions.*

There may, however, be contravening factors to the employment-drives-population assumption (e.g., the area contains a large retirement community unaffected by the employment base) which need to be considered. Commuting patterns should also be taken into account. For example, while the employment base within an area may change, many of the persons holding such jobs may actually reside outside the area. Commuting patterns are available from the 1970 U.S. Census, but estimates should also be made of expected future commuting patterns. The availability, accessibility, and attractiveness of land for residential purposes represent

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* For a further discussion, see Appendices F and H in the Regional Economic Plan for the Old West Regional Commission and Appendix B and Chapter 4 in Development Plan for the Four Corners Regional Commission, February, 1972, U.S. Department of Commerce.

factors to be considered when relating population to employment changes. Similarly, any alternative WQM action may cause the relocation of current or expected economic activities to localities outside of but near to the existing area. However, the population associated with this employment may reside in the WQM area. Finally, the population to employment relationships used in this analysis may need to take into account any unique characteristics of migrants. Changes in the employment base, as indicated above, are likely to generate population changes which result in net in- or out-migration. The family size and other characteristics of migrants may be substantially different from the general population of the area. Data on the historic characteristics of migrants are available from various U.S. Census publications.*

From expected changes in the employment and population levels and characteristics of an area, estimates (see below) can be made of related earnings and personal income changes. The Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce has historic data available on the relationship between employment, earnings, and personal income for each county in the nation. Similar historical and projected (to the year 2020) data, as indicated earlier, are available from OBERS for a variety of areas. Many planning areas may conform closely to some of these OBERS areas, but just as important is the mix and type of industrial activity. It should be possible from historical and projected data to make approximate matches (e.g., on the basis of employment and/or earnings distribution among industrial sectors) between planning areas and nearby or other economically similar areas contained in the OBERS data base. Expected ratios of future earnings to employment and personal income to earnings could then be determined from the OBERS data base for these economically similar areas and applied to the estimated employment impacts associated with alternative water quality management actions. The analysis would also need to take into account any variations that might result from estimating earnings and income by place of work versus by place of residence. The matter is dependent on commuting patterns, and is of primary concern to an area. Also, if particular sectors in a local economy have very high or low earnings to employment ratios, and these appear to be heavily impacted by the proposed water quality management actions, then additional analysis and data corrections may be desirable. Also, projected changes in population and personal income (in constant dollars) could be combined in order to calculate the impact on per capita personal income.

The foregoing projections can be used as the basis for generating estimates of the impact of proposed alternative actions on economic activity (i.e., production or output) by industrial sector, on retail

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* For example, see U.S. Bureau of the Census, Mobility for the States and the Nation, 1970, Subject Report P6(2)-2B.

sales, on public revenues and costs and on other factors that may be of interest to the area. For example, from an understanding of those industrial sectors directly impacted (e.g., by a change in employment) by a particular WQM policy, comparisons can be made with the baseline projections for these "basic" or "export" sectors to indicate expected employment variations due to implementation of a particular policy. Relative change in production could be derived from expected change in employment. The multiplier (i.e., indirect and induced) effects could be used to estimate the effects on "non-basic" or service sectors. Again, relative change in service sectors' activity (i.e., output) could be derived from the estimated changes in employment as determined by the multiplier analysis. Variations in retail sales could be determined from historical and projected data on the relationships between personal income and retail sales for an area (i.e., retail sales equal personal income times the trended historical ratio of retail sales to personal income).

Historical annual retail sales data can be obtained from Sales Management, Inc., Survey of Buying Power. Historical and projected personal income data are available from OBERS, and BEA, or it can be derived from total employment or expected changes in employment. Ratios of retail sales to personal income can be derived from historical data and applied to future projections of personal income and expected variations in this income due to proposed water quality management actions.

Expected variations in the sizes of retail sales, population, economic activity by industrial sector, personal income and other factors could be used to estimate expected changes in local area public revenues and public costs. For example, local public revenues are frequently generated by sales, income, or property taxes. Knowledge of expected impacts on population, industrial sector activity, personal income and retail sales will provide the basis for estimating impacts on these revenues. External revenue sources (e.g., State and Federal) are not likely to be impacted by local policies, except for the availability of particular types of State and Federal funds for certain types of water quality management programs (e.g., treatment plants, sewers, and so on). Similarly, in estimating local area public costs, that is, the need for public facilities and operation/maintenance expansions, population size would be the most critical factor. This would be a primary determinant of service and new facility needs, and from which operating/maintenance expenses could be determined. In addition, particular water quality management policies may have capital cost and/or operating/maintenance cost implications which also need to be taken into account in estimating public cost impacts.

Again, the resources necessary to perform the economic impact analysis will depend upon the number and complexity of each plan alternative (singly or in combination) evaluated, the need for local data collection, and the availability of State or local technical assistance. However, to competently analyze alternatives it might be expected that this would require 2 to 4 professional economists (staff members, university members, or consultants) from 1 to 6 months to complete this task. It should be emphasized, though, that this merely represents a general estimate, and in some instances water quality management alternatives and area economic activity may be such that resource requirements may be greater or lesser.

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VISUAL QUALITY IMPACT ASSESSMENT

Elements of a water quality management plan may produce outputs which alter the appearance of the community. Of the possible alternative plan elements, some, such as stream channelization or sewage plant construction, may change the physical appearance of the community and therefore the visual quality. Additionally, the results of various plan elements, such as cleaner water (e.g., bluer, clearer) will impact the visual quality as well. Since alternative elements of the WQM plan are designed to address water pollution problems, it is expected that some of the visual impacts will occur as changes in the appearance, form, or composition of water bodies, shorelines or adjacent land areas. Additional impacts can occur however, as a result of land use or development controls which may result from the implementation of WQM plan elements. These controls, for instance, may alter locations of industry, patterns of residential development or use of particular building materials.

Visual appearance includes such identifiable features and community characteristics as natural land forms (water bodies, shorelines), open spaces, patterns of development (grid pattern, cul de sacs), landmarks (historical, natural) and activity centers; essentially, all that is visually perceived by the inhabitants and visitors. These factors contribute to the overall character of a community. This character indicates whether it is old or new, urban or rural. It describes where neighborhoods begin and end and what the important places are. Similarly, the visual environment makes it easier or more difficult to get around and to find local resources.

Persons who live, work or travel through an area use the visual appearance to judge the suitability of a place for living, working or visiting. To assess the impacts that alternative elements of the WQM plan will have on the visual appearance of the community, the WQM planner can determine how community character, as perceived by residents, workers and travelers, will be altered. The planner can make this assessment and present it to the community by projecting the visual appearance with and without the proposed plan alternatives. The community can then assess if the WQM plan alternatives are impacting the visual appearance of the area in a way that coincides with major interests and priorities. In making this assessment, it is important to note that communities are not homogeneous in their values, and choices will have to be made.

There are several key questions to be asked in performing a visual quality impact assessment.

Key Questions

- What are the visual characteristics of the area which are most important to the community?
- How will the WQM plan outputs alter these visual characteristics?
- Are the visual alterations consistent with community objectives?
- Will the WQM plan add new visual elements that are not valued positively?

Concern for the environment has traditionally emphasized natural resource conservation. Impact assessments of water, air, land and biological systems are well defined areas of traditional environmental concern and are dealt with in other sections of this report. Unlike air and water quality impacts, visual impacts have no national standards or controls. However, the need for assessment of impacts on man's visual surroundings has resulted in a variety of methodologies which attempt to standardize the approach to visual quality impact assessment.

The approach used by many landscape architects, urban designers and others to assess visual impacts includes describing a setting by categorizing it into visual components (e.g., landmarks, views, structures). In the case of assessing the alternative elements of a WQM plan, the planner can identify these visual components with pictures or sketches representing a baseline condition and then project the changes which may occur as a result of the plan alternatives. These changes to the visual appearance will result from physical changes suggested in the plan alternatives (e.g., river chan-

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* The Forest Service, U.S. Department of Agriculture has conducted extensive work in the area of visual and aesthetic impact assessment. They are currently preparing a series of practical handbooks on conducting land interpreting such assessments. Several volumes of the National Forest Landscape Management series are now available through the Forest Service.

nelization, construction of sewage treatment plant) or from alterations in land use patterns and biological conditions caused by the projected implementation of elements of the plan. Once a baseline is developed, many methodologies in the field apply a set of criteria to these visual components to determine how they impact the community or region. These criteria serve as standards which enable the planner to measure the plan alternatives. For instance, a common standard of judgment is the uniqueness of a visual component. The plan alternatives may then be rated by the unique features that they maintain. However, such judgments are difficult to make and many of the criteria may be such that they can only be applied by highly trained design specialists.

No attempt has been made in presenting guidance on visual impact assessment as to whether the "leave it to the professionals" approach or a "ask the community what they think is important" type of approach is preferred. Selection of an approach, especially in developing assessment criteria, will have to be left to the judgment of the WQM planning agency and its advisory bodies.

VISUAL QUALITY ASSESSMENT PARAMETERS

Since the visual appearance relates to the quality of life of individuals and the desirability and attractiveness of communities, the parameters or criteria with which to assess impacts are perceived and prioritized differently by different groups of individuals. For instance, some groups may feel that extensive green space is the most important visual factor in an area. Other groups stress the importance of landmarks, developed play space or consistent building styles. The WQM planner will have the difficult task of using professional judgment to incorporate these different priorities into a set of criteria representative of community goals. It is the role of the planner to determine criteria which represent the overall community objectives, not just those of the most vocal groups in the area.

An obvious measure of community concerns about visual quality which can be reviewed by the WQM planners, is the visual controls in use in a community. These controls may be similar to zoning ordinances or possibly a part of them. Examples of such controls are building height limitation ordinances, specification of allowable building materials, setbacks, and sign regulations. Somewhat less common, but possibly more indicative of a community's concern over visual form, are the special visual controls which have been developed in many areas. Examples of these are visual easement programs, historic districts and landmark zones. A review of these controls points out to the WQM planner the geographical and substantive visual quality issues in which citizens have expressed special interest. These issues often hold particular interest and meaning to the community (e.g., historical districts, landmarks, architect reviews). Awareness of the existence of these controls will help guide the WQM planner in developing assessment criteria. For example, new sewer service which will result in further development into an area prized for its landmarks will have to be carefully planned to protect the visual quality of the area. Additional review can be made of local newspapers to determine geographic areas where citizen groups have been involved in preservation or improvement activities.

A direct means of determining community concerns about visual quality is to ask "the community" for its opinions. The planner can hold public meetings where citizens can express what visual components in an area are important to them and how they are important. For instance, citizens may express particular concern over enjoying open space at a waterfront, of retaining the "blueness" of a water body, or of maintaining an open view of a waterway from specific parts of the city. The planner can use this information to develop the criteria by which WQM impacts are judged. Another method of determining similar information is a citizen survey. However, the development, distribution and tabulation of questionnaires is time consuming and rather costly. Additionally, this method does not provide the opportunity for interaction which occurs at community meetings. Surveys also do not enable the WQM planner to contribute professional advice. However, surveys can be designed to reach a very large number of citizens and make them a part of the planning process. To overcome some of the disadvantages of a survey the planner can contact representative organizations in the community who can in turn call their members. Examples of these would be garden clubs, historical societies, and neighborhood associations.

The reason for determining community concerns and priorities regarding visual quality is so that they can be developed into a set of criteria which can be applied to the plan alternatives. The criteria should reflect the community concerns and the professional judgment of the WQM planner, landscape architects, or urban designer. Once it is established that the community is concerned with maintaining the waterfront as open space, for instance, the planner might point out that open space can be active, such as in developed park land, or passive as in undeveloped areas. For instance, the waterfront may be developed with uses that have large open spaces, e.g., an extensive buffer area can be maintained around a sewage treatment plant which leaves the immediate waterfront visually open. The way the criterion is written should specify the particular intent of the community so that alternative plan elements can be compared on a similar basis of community concern. Additionally, the clearer the criteria that are developed, the clearer the impact will be defined.

VISUAL ASSESSMENT METHODOLOGIES

The following Table, 7-1, illustrates four visual assessment methodologies. The methodologies were selected as illustrative of the type of aesthetic studies which are being made in conjunction with general environmental assessments. These methodologies are described in terms of baseline characteristics enumerated, assessment methods used, the types of resources needed to perform such assessments, and how they relate to water quality management planning. They are intended as suggestions for baseline and assessment categories and to spark further thought on areas of aesthetic interest and concern. Some of the methodologies might be applied in whole, in part or in combination, but all should include community input particularly in the assessment criteria used.

The methodologies are tools to identify visual features, forecast change caused by alternative elements of the WQM plan and assess the change in terms of selected criteria. These criteria, if not directly developed by the community, should be understood and approved by it, keeping in mind the diversity of views encompassed by the "community." Alterations in visual appearance profoundly affect citizens and usually evoke vocal reactions. A powerful source of support for the water quality management plan can evolve from a community's acceptance and approval of the visual changes that this plan will bring to its environs.

DEVELOPING A BASELINE

Baseline development will generally result from an inventory of the WQM planning area. Visual features can be classified according to a number of analytical methods discussed in Table 7-1. These methods each categorize natural and man made features which compose the visual environment. These features are discussed separately, as well as together, as parts of intergrated landscapes, e.g., mountains, flatlands, center city, or views from specific locations. All the methods described in the current studies depend on some field reconnaissance for the planner to identify the characteristics relevant to the community. Additional sources for determining important visual features are national, State and local park publications, topographic maps, aerial photographs, and travel guidebooks. The planner can use any or all of the factors discussed in these methods or may select factors which meet the depth and detail determined to be appropriate for the assessment study.

Once the baseline is established, it must be projected over the twenty year period, similar to the horizon of the WQM plan, with the help of land use projections. Since areas of projected land use change may alter visual components, the projected baseline can be determined by comparing the present visual appearance with projected area land use change and development. The changes which will result due to alternative elements of the WQM plan must then be compared with the baseline. This assumes that alternative elements of the WQM plan are known in sufficient detail (e.g., retouched photos, sketches, etc.) to present their visual impact on the baseline appearance. The WQM planner can array the projected visual components in several ways. The format can be in matrix form, landscape sketches, shaded or annotated maps, photographs or models. The approaches to visual assessment suggest specific means to array the baseline of the community's visual appearance. These means are directly related to the method for applying criteria. How the criteria are applied will depend on the methodology selected. Additionally, the level of community concern may influence how the baseline is presented. Controversial visual quality issues may require more graphic representations. The use of basic graphics (maps or charts) often help citizens to visualize the baseline projections and impact areas.

IMPACT ON VISUAL QUALITY

Impacts on the community's visual appearance will be assessed by applying the set of criteria to the projected changes in the baseline caused by the WQM plan alternatives. Since each alternative element of the WQM plan will generate a new projected baseline, the same set of criteria should be applied to each projection so comparisons can be developed. The assessment methodologies in Table 7-1 provide rating systems to compare visual components. Any criteria that are developed by a community can be applied to the baseline and simply rated. For instance, if uniqueness is a criterion, a channeled, concrete shoreline can be rated -1 (or negative), an average mixed use shoreline rated 0 (or neutral), and a wilderness shoreline rated +1 (or positive). Even a simple rating system provides a means to clearly illustrate where visual components will be impacted and what the tradeoffs are between plan element alternatives. However, it should be pointed out that numerical rating systems can have the effect of suppressing information. The WQM planner may want to consider why a visual change is positive, neutral or negative as well as the rating for these values.

TABLE 7-1 -- VISUAL ASSESSMENT METHODOLOGIES

METHODOLOGIES	BASELINE CATEGORIES	ASSESSMENT METHOD	RESOURCES REQUIRED	APPLICABILITY TO WQM PLANS
Burke's Photographic Method	Series of photographs or sketches which illustrate 5 types of views from roadways.	Each view is given a numerical ranking to evaluate how the landscape deviates from the "characteristic" view. +1 - view is superior to the characteristic landscape c - characteristic landscape -1 - man-made object detracts from view n - man-made object is non typical but does not detract x - zone is not visable	Staff person with sketching ability.	This assessment relies heavily on staff judgment and when used for rural areas in conjunction with other methodologies will require sketching to project the baseline.
Leopold's Uniqueness Study	Physical, biologic and human interest features in 46 categories. These categories are grouped under landscape scale (e.g., spectacular scenery, grandeur), degree of wilderness and river characteristics.	Each item in the baseline is assigned a rating based on how prevalent the features are in the area (uniqueness) and the degree of aesthetic interest	Staff person and community input.	Categories used are mainly applicable to wilderness areas. However, the method of uniqueness rating can be used for the WQM assessment with the addition of community input.
Litton's Method	Visual appearance divided into landscape, setting and waterscape units. Each of these units is divided into sub-elements in which the elements are rated by unifying visual appearance using photos, sketches or written lists.	Natural feature components are rated as to unity, variety, vividness. Man-made elements are rated by unifying, focal, enclosing, organizing and modifying/enhancing characteristics.	Staff person.	Technique can provide information on actual impacts of WQM plan. However, needs to be used in conjunction with community input.

VISUAL ASSESSMENT METHODOLOGIES (Cont.)

METHODOLOGIES	BASELINE CATEGORIES	ASSESSMENT METHOD	RESOURCE REQUIRED	APPLICABILITY TO WQM PLANS
Zube's Ranking System	Landscape inventories based on categories of mountains, flatlands, center city, forest, wildland, etc. Visual and cultural qualities of each landscape are further characterized by visual and cultural components, such as rock outcroppings or historic objects.	Landscapes are evaluated for quality of contrast, spatial sequences and water viables. The greater the degree of contrast and diversity of spatial configuration, the higher the value. Additionally, the visual and cultural needs are assessed based on the effects of development on livability, recreational usability and the available water oriented resources.	Staff member with some urban design and landscape architecture training.	Because this study relates to water resources it provides an example of baseline development categories and assessment variables. Methodology also provides an example of regional emphasis to assessment techniques.

(1) Herbert D. Burke, et al., "A Method for Classifying Scenery from a Roadway", reprinted from Park Practice Guideline (March 1968).

(2) Luna Leopold, "Quantitative Comparison of Some Aesthetic Factors Among Rivers", U.S.G.S. Circular 620, Washington, D.C. (1969).

(3) R. Burton Litton, et al., "An Aesthetic Overview of the Role of Water in the Landscape", prepared for the National Water Commission by the Department of Landscape Architecture, University of California, Berkeley (July 1971).

(4) Erwin Zube, et al., Research Planning and Design Associates, Inc., "Visual and Cultural Environment", Appendix N in North Atlantic Regional Water Resource Study for the N.A.R.W.R.S. Coordinating Committee (November 1970).

SOURCE: "Aesthetics in Environmental Planning", EPA Report Number (600/5/73-009) Office of Research and Development.

8

OTHER SOCIAL IMPACTS

The foregoing chapters have discussed the assessments of major direct and indirect impacts that are to be considered in the planning for alternative elements of a WQM plan. In addition, there are other social impacts that may result from a WQM plan. Generally, such impacts are not expected to be so significant as to warrant a detailed assessment. Nevertheless, they should be taken into consideration as part of a complete environmental assessment process. Because the identification and significance of social impacts depends upon local circumstances, it will be the responsibility of the WQM "experts", with the advice of EPA Regional Offices, to determine the significance of various impacts and therefore their required emphasis in the assessment process. Clearly such a determination will require substantial familiarity with local concerns, and must build upon previous public participation efforts.

The social impacts discussed briefly in this chapter are transportation, housing, solid waste collection and disposal, water supply, education, recreation, health care, and safety (police and fire). These social impacts may be either direct or indirect.

- Social impacts may be a direct outcome from alternative elements of the WQM plan or from the process of preparing and implementing the plan. Public involvement in water quality issues is a good example of creating a constituency for continuing water quality which may continue well after the plan itself is complete. Increasing water based recreation opportunities is another such example of a specific and intentional "social" goal integrated into a WQM plan.

- Social impacts may be an indirect outcome of land use or economic change. For example, changes in employment levels may be viewed in monetary terms as an economic impact (discussed in a previous chapter) or as a social impact if altered life styles are considered.

These types of social impact are not intended to be either all inclusive, or totally independent of each other since a social impact may fall into both categories. The purpose of the breakdown is to assist the planning staff in determining what may be considered relevant to a social impact assessment.

It becomes very difficult to always differentiate between social and physical impacts. In addition, any action may have both positive and negative social impacts. Land use changes will alter housing patterns and thereby influence transportation (and air quality). Protection of critical areas (e. g., flood plains) will positively affect public safety and water quality, but may increase housing costs by removing developable land from the market.

Social impact assessment therefore requires a special sensitivity on the part of the WQM planner. First, the planner must be able to identify groups (e. g., tourists, children, the poor) within the community, who for some reason, have special needs which should be considered throughout the assessments. Second, the planner, while performing the physical environmental (e. g., air and water quality) assessments, must be cognizant of how these environmental areas will affect the community's non-environmental goals and objectives. Finally, where there are particular impact areas (e. g., recreation, housing), the WQM planner must be prepared to assess them in some detail and determine how WQM plan implementation will affect them.

The nature of social impacts makes it difficult to say that any given impact is universally positive or universally negative. The value associated with a social impact comes from the priorities set for different local objectives. For example, a change in the demographic composition of an area may in one instance be viewed as a social benefit and in another as a social cost. Within a single area, different sub-groups of the affected population may take different positions on the value of any social impact. Some groups may bear a disproportionate share of the costs associated with a proposed plan alternative while others may receive considerable benefits. The planner should solicit public participation to obtain an indication of the perception of different groups of the distribution of costs and benefits of the WQM plan.

Many of the social impacts which may result from implementation of alternative plan elements are not easily measured in standard units. It is difficult to assign a number to the improved quality of a neighborhood. Even if a number could be determined (for example, using the number of people that perceive their neighborhood as a good place to live), a standard value for that number which would allow a comparison with a similar number derived from a change in employment patterns would be difficult to determine and subject to much dispute.

The way to approach social impact assessment is no different from that presented in the previous chapters. The process starts with the establishment of key questions to be investigated in the assessment based on community goals or concerns. Next certain parameters are identified which can be used to measure and present the social impacts (e. g., number and price of housing units, vehicle miles travelled, waiting times at parks). Assessment methods in these areas are usually not as amenable to quantitative techniques (e.g., atmospheric modeling). In part, this is because although a service may continue to function (e. g., transportation system), its quality (e.g., congestion) may decline. Therefore, expert professional judgement and strong public involvement will be required to establish a credible method. Baselines are established "with" and "without" the alternative elements of the WQM plan. Finally, impacts are assessed in terms of their implications for concerns of high social importance to the community.

As discussed at the outset of this chapter, the occurrence of significant social impacts by implementation of alternative elements of the WQM plan is generally not considered likely. Therefore, only a list of key questions is provided to guide the WQM staff in beginning an assessment of social impacts in their local areas.

These key questions are:

HOUSING AND SOCIAL CONDITIONS

1. What will be the change in number and percent of housing units that are substandard, and the number and percent of people living in such units?

2. What change will take place in the number and percent of housing units by type (price or rent range, zoning category, owner-occupied and rental, etc.) relative to demand or to number of families in various income classes in the community?

3. What number of residents or workers will be displaced by development - and are they satisfied with having to move?

4. What changes will take place in population distribution by age, income, religion, social or ethnic group, occupational class, and household type?

5. What change will occur in the number or percent of people perceiving their neighborhoods as too crowded?

6. What changes will occur in the number or percent of people perceiving their community as a good place to live?

TRANSPORTATION

1. How will vehicular travel times change between selected origins and destinations?

2. Will there be a change in the duration or severity of traffic congestion?

3. What change is likely in finding a satisfactory parking space within a specified distance from home or work place?

4. What change will take place in the numbers and percent of residents with access to public transit within a specified distance of their homes; and the number and percent of employees who can get within a specified distance of work location by public transit?

5. Will there be a change in the rate of traffic accidents?

6. Will there be a change in the number of stores and services, by type, available within a specified distance of people's homes or work place?

7. What changes will occur in the percent of people generally satisfied with local shopping conditions in terms of access, variety and crowdedness?

8. What overall changes will occur in the number of car trips or car miles traveled per person?

9. What changes will take place in the automobile ownership rate for the population? What provisions will exist for non-drivers (e. g., the young, elderly, poor, handicapped)?

RECREATION

1. What changes are expected in the current range of recreational opportunities (public and private) available to community residents?

2. What changes will occur in the levels of services (e. g., congestion, waiting time, cost, etc.)?

3. Will there be changes in access in terms of membership, cost, time of year?

4. What changes will occur in the perceived pleasantness of the recreational experience?

5. What changes are expected in the usage of recreational possibilities as a percent of capacity (e. g., number of people turned away, space per resident, perceptions of crowdedness)?

EDUCATION

1. What changes will occur in the number of students within a specified commute from schools, by schools?

2. What expected number of students will have to switch schools or changing their busing/walking status?

3. What changes will occur in school crowdedness indicated by added shifts, student-teacher ratios, or perceived pleasantness of schools?

4. What changes will occur in special education needs?

HEALTH CARE

1. Will there be any change in the cost and ability to pay for health care services?

2. Will development changes cause a change in demand for special health care services (e. g., older people, mothers, etc.)?

3. Will there be any changes in illness or death rates?

4. Will there be any changes in occupationally related accidents?

5. Will there be any changes in the number or percentage of people who are beyond some specified minutes of travel time from a hospital emergency facility?

SAFETY

1. What changes will occur in the rates of crimes in existing or new community development?

2. What changes will occur in people's perception of their security?

3. What changes will occur in fire incidence rates?

4. What changes will occur in the ratios of fire spread and rescue hazards?

5. What changes will occur in the capacity of municipal safety services (e. g., police, courts, fire)?

Specific guidance in any of these areas of social impact can be found in the following list of references.

ADDITIONAL REFERENCES

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