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Gathering Information for Watershed Ecological Assessments: A Review of Ten Watershed Assessments

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NOTICE

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FOREWORD

This document was originally prepared by Jackie Little and David L. Eskew of TN&Associates, Inc. for U.S. EPA, ORD, NCEA, under contract no. 68-C6-0024. The report was edited and revised by Joseph P. Schubauer-Berigan, Randall J.F. Bruins, and Victor B. Serveiss of U.S. EPA, ORD, NCEA. The document outlines and reviews the various types of information used in 10 different watershed assessments. Data tables are included that describe the data types, sources of data, data reliability, and study contacts as well as other information used in each of the 10 assessments. The document summarizes how the information was collected, used and evaluated by each of the 10 watershed assessments and outlines some of the types and sources of data that are available. The purpose of this report is to provide those conducting watershed ecological assessments with an introduction to the types and sources of information that are available and have been used by others in conducting such assessments. This document is intended for ecologists, hydrologists, biologists, geologists, engineers and water resource managers seeking assistance on gathering, organizing and analyzing data to improve the use of sound science in watershed scale decision making.

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ACRONYMS AND ABBREVIATIONS

AFS	AIRS Facility Subsystem
AIRS	Aeromatic Information Retrieval System
ARS	Agricultural Research Service
BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
BLM	Bureau of Land Management
BMP	Best Management Practices
CCC	Cape Cod Commission
CDH	Colorado Department of Health
CDNR	Colorado Department of Natural Resources
CDW	Colorado Department of Wildlife
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFF	cartographic feature file
cfs	cubic feet per second
CWA	Clean Water Act
CWQCD	Colorado Water Quality Control Division
CWQS	Colorado Water Quality Standards
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality
DLG	Digital Line Graph
DNR	Department of Natural Resources
DOC	Department of Commerce
DOE	(Washington State) Department of Ecology
DOH	Department of Health
DOW	Division of Wildlife
DWR	Department of Water Resources
EROS	Earth Resources Observation Systems
ESDLS	EPA Spatial Data Library System
ESRI	Environmental Systems Research Institute, Inc.
FERC	Federal Energy Regulatory Commission
GAP	Gap Analysis Program
GICS	Grants Information and Control System
GIRAS	Geographic Information Retrieval and Analysis System
GIS	geographic information system
GLIS	Global Land Information System
GPS	global positioning system
HUC	hydrologic unit cycle
IBI	Index of Biological Integrity
ICI	Invertebrate Community Index
IDWR	Idaho Department of Water Resources
IHA	Indicators of Hydrological Activity
IR	infrared
MIWB	Modified Index of Well-Being
MSS	multispectral scanner

ACRONYMS AND ABBREVIATIONS cont.

NAPP	National Aerial Photography Program
NASA	National Aeronautics and Space Administration
NCEA	National Center for Environmental Assessment
NERL	National Exposure Research Laboratory
NHAP	National High Altitude Program
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRCS	Natural Resources Conservation Service
NRDSS	Natural Resources Decision Support System
NSDI	National Spatial Database Infrastructure
NSLRSDA	National Satellite Land Remote Sensing Data Archive
NTIS	National Technical Information Service
NWI	National Wetlands Inventory
NWQA	National Water Quality Assessment
NWS	National Weather Service
OEPA	Ohio Environmental Protection Agency
PCB	Polychlorinated biphenyl
PCS	Permit Compliance System
POC	Pollutants Of Concern
P&PF	Planning & Problem Formulation Reports
RCRIS	Resources Conservation and Recovery Information System
RF1	Reach File Version 1.0
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SCS	Soil Conservation Service
SCWRC	South Carolina Water Resources Commission
SDLS	Spatial Data Library System
STATSGO	State Soil Geographic Database
STORET	Storage and Retrieval of U.S. Waterways Parametric Data
TDML	total daily maximum limit
T&E	threatened and endangered
TIGER	Topologically Integrated Georeferenced Encoding System
TM	thematic mapper
TP	total phosphorus
TRIS	Toxic Release Inventory System
TVA	Tennessee Valley Authority
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDOI	United States Department of the Interior
U.S. EPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey

ACRONYMS AND ABBREVIATIONS cont.

USNPS	United States National Park Service
VADEQ	Virginia Department of Environmental Quality
WATSTORE	Water Data Storage and Retrieval System
WBLMER	Waquoit Bay Land Margin Ecosystems Research
WBNERR	Waquoit Bay National Estuarine Research Reserve
WDNR	Wisconsin Department of Natural Resources
WERA	Watershed Ecological Risk Assessment
WQCD	Water Quality Control Division
WSDOE	Washington State Department of Ecology

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1. INTRODUCTION

1.1. STUDY OBJECTIVES

This report is intended to assist watershed assessors in the gathering of information for watershed ecological risk assessments. Ecological risk assessment can improve the monitoring and assessment process in watershed scale evaluations and add scientific rigor to management decisions. Using this approach, environmental managers can better protect environmental resources by accurately and efficiently prioritizing and managing environmental risk. One important aspect of the watershed ecological risk assessment process is the collection of many different types of watershed information, a sometimes daunting task. By examining 10 watershed assessments in various stages of development, this report demonstrates by example how other assessors have approached the data collection problem. Information on the types of data collected and the data sources used is compiled and summarized.

1.2. BACKGROUND: THE IMPORTANCE OF WATERSHED ECOLOGICAL RISK ASSESSMENT

Streams, lakes, rivers, estuaries, groundwater and other aquatic resources are among our most valuable assets. They support a wide range of human activities. They are an important source of drinking water and water for agriculture, industrial and recreational activities. They also have important ecological values. Besides comprising critical habitat for countless species of animals and plants, they also provide important ecological services, such as degrading and detoxifying toxic chemicals and nontoxic organic wastes. Perhaps most importantly, by transforming and transporting chemicals, nutrients, sediments and other elements, these waters provide critical links within and

between landscapes and ecosytems. Surface and ground waters also link impacts from human activities in watersheds to adverse effects in rivers, lakes and estuaries down gradient and potentially far removed from the source of the impacts.

Great strides have been made in reducing loads of a number of Pollutants Of Concern (POC) to lakes, rivers, estuaries and groundwater over the past 20 years. Much of this progress has been achieved through legislation and enforcement that has focused on specific industries and point sources of pollution. Although this approach has been highly successful, particularly for toxic chemicals, the quality of aquatic habitats in many parts of the United States is still declining (U.S. EPA, 2000a). For instance, the 1994 U.S. EPA National Water Quality Inventory indicated that 23% of streams, 43% of lakes and 47% of estuaries surveyed were listed as impaired. In comparison, the 1998 survey (U.S. EPA, 2000b) indicated an increase in two of three of these categories (35% of streams and 45% of lakes listed as impaired) and little change in the third (44% of estuaries listed as impaired). Finally, evidence from the recent NOAA Estuarine Eutrophication Survey (Bricker et al., 1999) indicates that 89% of the U.S. coastal estuaries show signs of impairment.

It is increasingly clear that a larger-scale watershed approach that addresses changing land use patterns, habitat alteration and loss, non-point source pollution, over enrichment, hydrologic modification, and sedimentation is necessary to prevent further degradation of public water resources. The Watershed Approach, a larger scale approach that is organized around the guiding principles of partnerships, geographic focus, and management based on sound science and data, is being used more frequently to address environmental problems (U.S. EPA, 1996g). In contrast to the pollutant-by-pollutant approaches of the past, the Watershed Approach incorporates a

comprehensive strategy which enables the interested parties who must live with environmental decisions to participate in making them. This is especially important since watersheds usually cross political boundaries. The Watershed Approach seeks to involve local government, users of watershed resources, environmental groups, those believed to be causing environmental problems and the public in the process of developing solutions to problems. This approach ensures that participants better understand problems, identify with and accept goals, select priorities and choose and implement solutions.

Once the partnerships and hydrologic boundaries are established for watershed management, the challenge is to incorporate sound science into the watershed management process. This is difficult because multiple physical, chemical and biological stressors resulting from multiple human activities impact numerous ecological resources, through a network of inter-related environmental conditions. In addition, political, economic and social factors based on subjective value judgments also are usually part of the decision process.

Ecological risk assessment is a process to collect, organize, analyze and present scientific information to improve the use of science in decision making. U.S. EPA's Risk Assessment Forum developed a general ecological risk assessment methodology, *Framework for Ecological Risk Assessment* (U.S. EPA, 1992), and subsequently expanded the guidance in *Proposed Guidelines for Ecological Risk Assessment* (U.S. EPA, 1996a) which was finalized in 1998 (*Guidelines for Ecological Risk Assessment*, U.S. EPA, 1998). These documents define ecological risk assessment as a process for organizing and analyzing data, information, assumptions, and uncertainties to evaluate the likelihood that one or more stressors are causing or will cause adverse ecological

effects. Briefly, the risk paradigm has three analytical components: problem formulation, analysis, and risk characterization. During problem formulation, the assessors, in an active dialog with risk managers and other interested parties (stakeholders), consider what is known and not known about a problem and its setting, while explicitly addressing uncertainty. It is during this phase that an attempt is made to integrate the available information, develop a conceptual model, establish assessment endpoints and devise an analysis plan. During the Analysis Phase, an attempt is made to characterize both exposure to stressors and ecological effects. Characterization of exposure and effects includes technical analysis and evaluation of stressor-response relationships of ecological receptors. During the first two phases of the process, data required for the assessment are acquired and the results of the assessment are monitored. These processes are completed iteratively as needed. During the final phase of the assessment, the Risk Characterization Phase, risks are estimated, described and communicated to the risk managers and stakeholders. Key to the success of the process is keeping the process transparent and maintaining an active dialog between the risk assessors and managers and the stakeholders.

Ecological risk assessment has been applied successfully and extensively in source- and pollutant-based approaches (such as those focused on particular chemical contaminants), yet its place-based applications (such as those conducted on a watershed-wide scale) are still limited (U.S. EPA, 2000a). General guidance for applying ecological risk assessment in a watershed context is currently being developed (e.g. see Serveiss et al., 2000). In these larger scale risk assessments, the analytical focus shifts to hydrologically defined drainage basins rather than politically defined boundaries or individual point-sources. Analysis at the watershed scale includes all the

land that drains into a stream, lake, estuary, wetland, or other water-body, thus integrating all the activities that occur within the watershed. In large river basins such as the Mississippi, using a hydrologically driven analysis allows aquatic risks to be evaluated and managed in an integrated manner even when the cause and effects of the impacts are separated by large distances (e.g., eutrophication of estuaries, coral reefs and other coastal habitats). This approach also provides a basis for management of complex multi-state, multimedia (air, land, and water), multi-stressor environmental issues. Ideally, ecological risk assessment applied hierarchically within the spatial context of watersheds, landscapes and regional basins should better protect aquatic resources.

Watershed Risk Ecological Assessment (WERA) integrates the collective benefits of the Watershed Approach and Ecological Risk Assessment to improve the use of science in watershed scale decision making. The approach provides watershed management groups with a logical and systematic method to incorporate scientific information into decision making (Serveiss et al., 2000) and places an increased emphasis on community involvement (U.S. EPA, 1996b,g, 1997a,b). Use of WERA should encourage scientists and resource managers at the local, state, and federal levels to form partnerships, which can be used to identify and manage risks and help insure the protection and sustainabilty of healthly, viable, watersheds.

1.3. ORGANIZATION OF REPORT

Section 2 of this report presents and explains the primary information sources, including World Wide Web addresses, for the key categories of information needed for most watershed ecological risk assessments. Used in conjunction with Appendix A,

Section 2 constitutes a useful reference for the acquisition of watershed data; the remainder of the report serves as supporting information.

Section 3 explains the steps that were followed in selecting, acquiring and analyzing the 10 watershed studies that serve as the basis for this report.

Section 4 provides background information on each of the 10 watershed studies, to allow an appreciation of their variety in terms of physical setting, purpose and approach. The same information, with additional detail, is presented in tabular format in Appendix B.

Section 5 summarizes the approaches used by the 10 watershed studies to address each of the key information categories. The same information, with additional detail, is presented in tabular format in Appendix A.

Section 6 lists references to literature cited in the report.

Section 7 contains a glossary of terms related to watershed data acquisition (refer also to the front-matter listing of Acronyms and Abbreviations).

2. DATA SOURCES FOR WATERSHED RISK ASSESSMENT

Section 2 of this report presents and explains the primary information sources, including World Wide Web addresses, for the key categories of information needed for most watershed ecological risk assessments.

2.1. WATERSHED/SUBWATERSHED BOUNDARY

A watershed is the area of land in which rainfall drains to a common point. It is a fundamental management unit that federal and state agencies are using to protect and restore aquatic ecosystems. A common approach for watershed boundary delineation is the use of hydrologic unit maps (Seaber et al., 1987). The coverage is available online from metadata file links, at no charge, in Spatial Data Transfer Standard (SDTS)

format and in ARC/INFO Export format. It may be retrieved as a single file for the entire United States or by water resources region. The data for this coverage was originally collected for the Geographic Information Retrieval and Analysis System (GIRAS) to provide the U.S. Geologic Survey (USGS) National Water Quality Assessment (NAWQA) study units with an intermediate-scale river basin boundary. The data sets are intended to support watershed analysis within U.S. EPA and may be accessed using U.S. EPA's BASINS 2.0 watershed analysis system. This system provides users (with ESRI's ArcView® software) with the capability of performing rapid subwatershed delineations on-screen using a digital elevation model (DEM) display and a mouse. Another method of delineating watershed boundaries from a DEM basemap has been developed for the Texas environmental regulatory agency (the Texas Natural Resource Conservation Commission). The application is being developed by ESRI (http://www.esri.com/) and the University of Texas using ArcView Version 3.0 with the Spatial Analyst extension.

2.2. STREAM REACHES

U.S. EPA's Reach Files are a series of national hydrologic databases that uniquely identify and interconnect the stream segments that comprise the country's surface water drainage system. Reach delineation is important in watershed analysis because the attributes which define connectivity also provide hydrologic ordering of stream locations. This allows the user to know what is upstream and downstream of a given point in the stream network. The three versions of the Reach File (RF1, RF2, RF3-Alpha) were created from increasingly detailed sets of digital hydrography data produced by USGS. U.S. EPA enhanced these datasets by assigning a unique identifier to each stream segment (i.e., the Reach Code). The codes provide a common

nomenclature for federal and state reporting as required under the Clean Water Act. Reach File Version 1.0 (RF1) supports broad-based national applications. Reach File Version 2.0 (RF2) added a new level of reaches to RF1. Development of Reach File Version 3.0-Alpha (RF3-Alpha) is currently underway. It will provide a more comprehensive, nationally consistent, hydrologic database consisting of both spatial and attribute data. Currently, data in the RF3-Alpha file is unvalidated and the developers recommend that a conservative approach be taken when processing and applying these data. The unique reach code assigned to each reach has been linked to several U.S. EPA national databases, (e.g., STORET, http://www.epa.gov/OWOW/STORET/), Water Quality Sampling Sites, Municipal and Industrial Facility Discharges, and Drinking Water Intakes). Files RF1 and RF2 may be accessed using U.S. EPA's BASINS 2.0 watershed analysis system (http://www.epa.gov/ost/basins/gisdata.html).

2.3. OTHER WATER BODIES

Other water bodies refers to waters other than streams and rivers, such as lakes or wetlands. Sources of wetland data are discussed below in Section 2.13. Complete digital line graph (DLG) hydrography data coverage of the United States is available at both the 1:250,000 scale and the 1:2,000,000 scale from USGS (http://water.usgs.gov/data.html). "Cartographic Feature Files" are also used to delineate other water bodies.

2.4. MAJOR ROADS, COUNTY AND MUNICIPAL BOUNDARIES

Both small scale (coarse resolution) mapping from the National Highway Planning Network (1:2,000,000) and larger-scale (finer resolution) DLGs (1:1,000,000 and 1:250,000) from the Topologically Integrated Geographic Encoding and Referencing System, or TIGER data (from the U.S. Census Bureau,

http://tiger.census.gov/) are available to delineate major roads and municipal boundaries.

2.5. BEDROCK/GROUNDWATER HYDROLOGY

The underground flow of water can be an important analytical component in watershed studies. In many locations, underground flow (base flow) can account for a significant portion of the downstream river flow. The primary source for base flow information is USGS open-file reports (http://water.usgs.gov/ogw/). However, when groundwater is a significant pathway, additional information is usually required, such as an intensive, site specific mapping and monitoring effort.

2.6. PRECIPITATION, EVAPORATION AND WIND SPEED

Meteorological data are available from NOAA (http://www.nws.noaa.gov/oso/fospage.shtml) and the USGS (http://water.usgs.gov/). One online source which has compiled data from the National Climatic Data Center (http://www.ncdc.noaa.gov/) archives, state climatologists, and published literature is the Historical Climatology Network (HCN), available at the Oak Ridge National Laboratory web site (www.ornl.gov). This data set extends through 1994 and reports monthly total precipitation and temperature data from 1219 weather stations that have at least 80 years of data collection. The information is searchable by state.

2.7. NPDES OUTFALLS (EFFLUENT LOCATION AND CONCENTRATION)

The Non-point Discharge Emission Standards (NPDES) program (http://www.epa.gov/OWM/gen2.htm) was established by the Clean Water Act. The Act makes it illegal to discharge pollutants from a point source into surface waters without a permit. Regulated by U.S. EPA, NPDES permits define compliance monitoring and reporting requirements and establish site-specific discharge limits. NPDES permits

regulate sanitary waste, toxic pollutants, and other pollutants such as nitrogen. To ensure compliance by NPDES permit-holders, U.S. EPA reviews permit data and inspects discharge points.

To track NPDES permit information, Permit Compliance System (PCS) was developed in 1974. PCS is a national management information system containing data from issued NPDES permits and NPDES-permitted facilities. PCS tracks the issuance, limits, and monitoring data of NPDES permits. The PCS database can be accessed from the U.S. EPA web site (http://www.epa.gov/owm/npdes.htm). A PCS Query Form and User's Guide is provided.

2.8. FLOW GAUGING AND/OR STREAM GRADIENT

Stream velocity, gradient, and discharge are components of baseline water quality. Velocity (cm/s) is measured in terms of the distance water travels in a unit of time. Gradient (cm/km), or slope of the stream bed, is one of the determining factors of velocity. Discharge is the quantity of water that passes a given point in a unit of time (cfs). The most common source for flow information is the USGS open-file reports. The Water Storage and Retrieval System (WATSTORE, (http://ak.water.usgs.gov/Publications/Water-Data/WY96/watstore.htm) is an online national database maintained by the USGS that contains historic and current stream flow data. Processed records from the WATSTORE data base are available online in the Hydro-Climatic Data Network (HCDN, (http://water.usgs.gov/GIS/metadata/usgswrd/hcdn.html) for the period 1874 to 1988 (Slack and Landwehr, 1998). Each of the 1659 sites has daily, monthly, and annual mean discharge values, and minimum and maximum values.

2.9. STREAM USE, WATER SUPPLY INTAKE AND REGULATED FLOW STRUCTURES

Stream use describes impairments caused by both point and non-point sources according to stream reach. The Clean Water Act Section 305(b) Water Quality Report and database prepared by states is a common source for this information (see http://www.epa.gov/ow/states.html). Section 305(b) requires each state to prepare biennial drinking water use assessment reports. Reports are collected and sent to Congress by U.S. EPA. Each report assesses the proportion of water sources that meet their drinking water designated use, the pollutants that inhibit designated uses, and pollutant sources. U.S. EPA's Waterbody System (WBS) is a state and national database that stores drinking water use assessment information for waterbody units. The WBS is useful in the preparation of Section 305(b) reports. The WBS waterbody categories include estuaries, lakes, rivers, shorelines, and wetlands.

Geocoding locations of waterbodies and their segments with the U.S. EPA Reach File Version 3.0 (RF3) aids in the development of a GIS that can be used for the Section 305(b) reporting process, spatial analyses, and modeling pollutant fate and transport processes. States can use the PC Reach File (PCRF) or ARCINFO software to create GIS layers of waterbody locations. Once GIS coverages are indexed or linked to RF3 subsets, a desktop mapping software such as ArcView GIS can be used to view, manipulate, query, and analyze the data. Geocoding waterbodies to RF3 is a state task.

2.10. STREAM WATER QUALITY

Stream water quality is an essential component of a baseline monitoring program. The watershed studies follow a general pattern of piecing together available data from all available federal (STORET), state, and university sources.

STORET (http://www.epa.gov/OWOW/STORET/), U.S. EPA's largest environmental data STOrage and RETrieval system, contains parametric data from the U.S. Water Quality System and data from biological field surveys, stream flow, and geographical data. There are several methods of accessing STORET data. Individuals or companies can invest in a private account, a request may be submitted through the Freedom of Information Act, temporary access may be granted to contractors, U.S. EPA approved access for non-U.S. EPA government agencies may be approved, and access may be granted for U.S. EPA employees. Contact STORET User Assistance at 1-800-424-9067 for help on requesting data and for information on STORET user training, or send an email to STORET@epa.gov.

U.S. EPA first released BASINS, Better Assessment Science Integrating Point and Nonpoint Sources, in September 1996. Developed in ArcView GIS, the BASINS system integrates national spatial, environmental monitoring, and point source data with assessment, environmental interpretation, and modeling tools. BASINS is used to evaluate watersheds, water quality, and point and non-point sources. BASINS includes data on water quality monitoring, bacteria monitoring, fish and wildlife advisories, and the Clean Water Needs Survey. Sites contributing point source data include IFD, Superfund's National Priorities List (NPL), PCS, and the Resources Conservation and Recovery Information System (RCRIS). Some of the spatial data integrated with BASINS includes state and county boundaries, roads, hydrologic unit boundaries, soils,

elevation data, federal and Indian lands, RF1 and RF3, land use, land cover, and urban areas. BASINS 2.0 can be downloaded from the U.S. EPA web site at www.epa.gov/OST/BASINS.

2.11. STREAM SUBSTRATE, STREAM BIOLOGICAL COMMUNITIES

Stream substrate and biological community data are endpoints in many watershed assessments and are fundamental components of a baseline monitoring program. Ideally, sampling sites should measure both water quality parameters and aquatic biological communities at the same location. Monitoring is frequently conducted by states, and data availability varies by state and locality.

2.12. ENDANGERED SPECIES

Locations and habitat requirements of threatened and endangered species are frequently considered in watershed assessments. Locational data generally are available from Natural Heritage programs (http://www.heritage.tnc.org/) in state government and in recovery plans developed by the USFWS (http://endangered.fws.gov/recovery/index.html). Often exact locations are not known, particularly in remote areas, or they are considered too sensitive for publication. In the latter case, known locations are described by county.

2.13. WETLANDS

The most common source of information used for delineating wetlands is the 1989 National Aerial Photography Program (NAPP, http://edc.usgs.gov/glis/hyper/guide/napp), based on National Wetlands Inventory (NWI, http://www.nwi.fws.gov/) classification (Cowardin et al., 1979). Attributes include flooding regimes and wetland type. Another source for wetland maps is the wetland inventory conducted by the Natural Resources Conservation Service (NRCS).

Aerial photography is available from the National High Altitude Photography (NHAP) program. From 1980 to 1986, cloud-free aerial photographs of the 48 contiguous United States were taken centered on 7.5 minute quadrangle maps at 40,000 feet. The NHAP was later renamed the NAPP. Aerial photographs for NAPP were taken at 20,000 feet altitude centered on maps that were one-quarter of a 7.5 minute quadrangle. Photographs are in black-and-white or color infrared. The goal of NAPP is to cover the United States on a 5-year cycle. The spatial resolution of NAPP/NHAP film is 1 to 2 meters. Original and working master archives are maintained by the EROS Data Center (http://edcwww.cr.usgs.gov/eros-home.html), Sioux Falls, South Dakota, and by the USDA Aerial Photography Field Office (APFO, http://www.apfo.usda.gov/).

2.14. RIPARIAN CHARACTERISTICS

The riparian zone is a distinct ecosystem that forms at the waters edge. It is periodically inundated by high water and influences the stream ecosystem. The riparian zone can be mapped from remote sensing data and aerial photographs.

2.15. SOIL CHARACTERISTICS

Soil data provide baseline information for the calculation of potential sediment load. Sediment load is frequently identified as a stressor. It can impair or eliminate fish habitat, impair water quality for municipal and agricultural use, increase stream temperature, and reduce intergravel dissolved oxygen.

The primary source for soils data is county soil survey maps developed by the SCS (now NRCS, http://www.ncg.nrcs.usda.gov/nsdi_node.html). They were mapped at the 1:20,000 scale. The soil survey maps were generalized and digitized and are available at 1:250,000 for the United States in the State Soil Geographic Data Base

(STATSGO, http://water.usgs.gov/GIS/metadata/usgswrd/ussoils.html). Attributes for each map unit include soil composition, soil properties, and interpretations. The STATSGO database is not detailed enough to make interpretations for local areas in a county. It is appropriate for the regional, multi-county, or river basin scale. NRCS Field Office Technical Guides (county level) are also sources of information for non-point source best management practices (BMPs).

2.16. LAND USE/LAND COVER

Regional land use/land cover data provide useful background information about a watershed. The most common source is the Land Use Data Analysis (LUDA) Program (USGS), which collected data in the late 1970's and early 1980's. The source materials were black-and-white NHAP, collected at 1:80,000, and compiled at 1:125,000. Another land cover classification effort, the Coastal Change Analysis Program (C-CAP, http://www.csc.noaa.gov/ccap/), is in the process of mapping groundcover along the nation's coastal zone using a combination of satellites, aircraft, and field work. Groundcover being classified includes forested areas, wetlands, submerged lands, and all areas in between. The U.S. EPA also maintains a National GIS Spatial Data Base (http://www.epa.gov/ngispr/).

2.17. SUPERFUND SITES/LANDFILLS

Information about Superfund Sites and their locations can be obtained from the U.S. EPA Superfund Program (http://www.epa.gov/superfund/index.htm).

2.18. LOCAL POPULATION ESTIMATES

The TIGER Mapping Service (U.S. Census Bureau, http://tiger.census.gov/) is the most common source of Census statistical data. The categories of data contained in TIGER include states, counties, highways (labeled), streets (no labels or addresses),

some parks, congressional districts, railroads, tracts and block groups, rivers, water bodies, military sites, and Indian reservations.

3. METHODS USED FOR SELECTING AND ANALYZING TEN EXAMPLE WATERSHED STUDIES

3.1. GENERAL APPROACH

This study extracted and compiled information about the data sets and data sources used for 10 watershed risk assessments in an effort to identify, compare and contrast data sources that can be used in the Problem Formulation and Analysis phases of a generic watershed ecological risk assessment. The study was organized into three phases. Phase one included: selection of the study sites; gathering, comprehensive review and categorization of supporting documentation; and development of a data matrix in which the first dimension was the information category and the second dimension was a series of issues or questions related to that information category. In phase two of the study, a data matrix was filled out for each site by reviewing available documents. The final phase of the study, included revising each data matrix based on in-depth interviews with the individuals who worked on the assessment and returning the completed information summary and matrix to the study manager for verification. In preparing the summary data matrix, special attention was given to emphasizing any difficulties that were encountered, such as lack of information on critical categories, poor quality of information, and information bias. The completed matrix is presented as Appendix A; additional information on each watershed study is compiled as Appendix B.

3.2. WATERSHED SELECTION

A total of 10 watershed ecological assessments were selected. Five were under study by the U.S. EPA Risk Assessment Forum and reports had been completed

covering the planning and problem formulation (P&PF) phase at the time the current study was initiated. The WERAs include Big Darby Creek, OH (http://www.epa.gov/ncea/bigdarby.htm); Clinch River Valley, VA (http://research.esd.ornl.gov/CRERP/INDEX.HTM); Waquiot Bay Estuary, MA (http://www.capecod.net/waquoit/era.htm); Middle Platte River Floodplain, NE; and Middle Snake River, ID (http://www.epa.gov/ncea/midsnake.htm) (Figure 1). A literature search was conducted to help identify 5 additional watershed ecological assessments for analysis (Figure 1). Abstracts found in following databases and time ranges were examined: Enviroline from 1970 to November, 1997; NTIS from 1964 to 1997; Pollution Abstracts from 1970 to November 1997; Aquatic Sciences Fisheries Abstracts from 1978 to November 1997; Federal Research in Progress (FEDRIP) up to October 1997; Dissertation Abstracts Online from 1961 to December, 1997; and Conference Papers Index from 1973 to 1997. The keywords used to search the literature were separated into four major subject categories; physical setting, biological resources, waterbody, and landuse (Table 1). The search strategy required that one term from each of the four categories be found in the title, key words, or abstract of the database record. The search of Enviroline, NTIS, Pollution Abstracts, and Aquatic Sciences Fisheries Abstracts yielded a total of 514 “hits”, and the search of FEDRIP, Dissertation Abstracts, and Conference Papers Index yielded 22 “hits”. From the 536 “hits”, the second set of five watershed assessments were selected based on the following criteria: study area at the watershed spatial scale, use of an integrative analytical approach at the watershed scale, methodology with an analytical component that has been described in the literature, use of a Geographical Information System (GIS), unique environments or

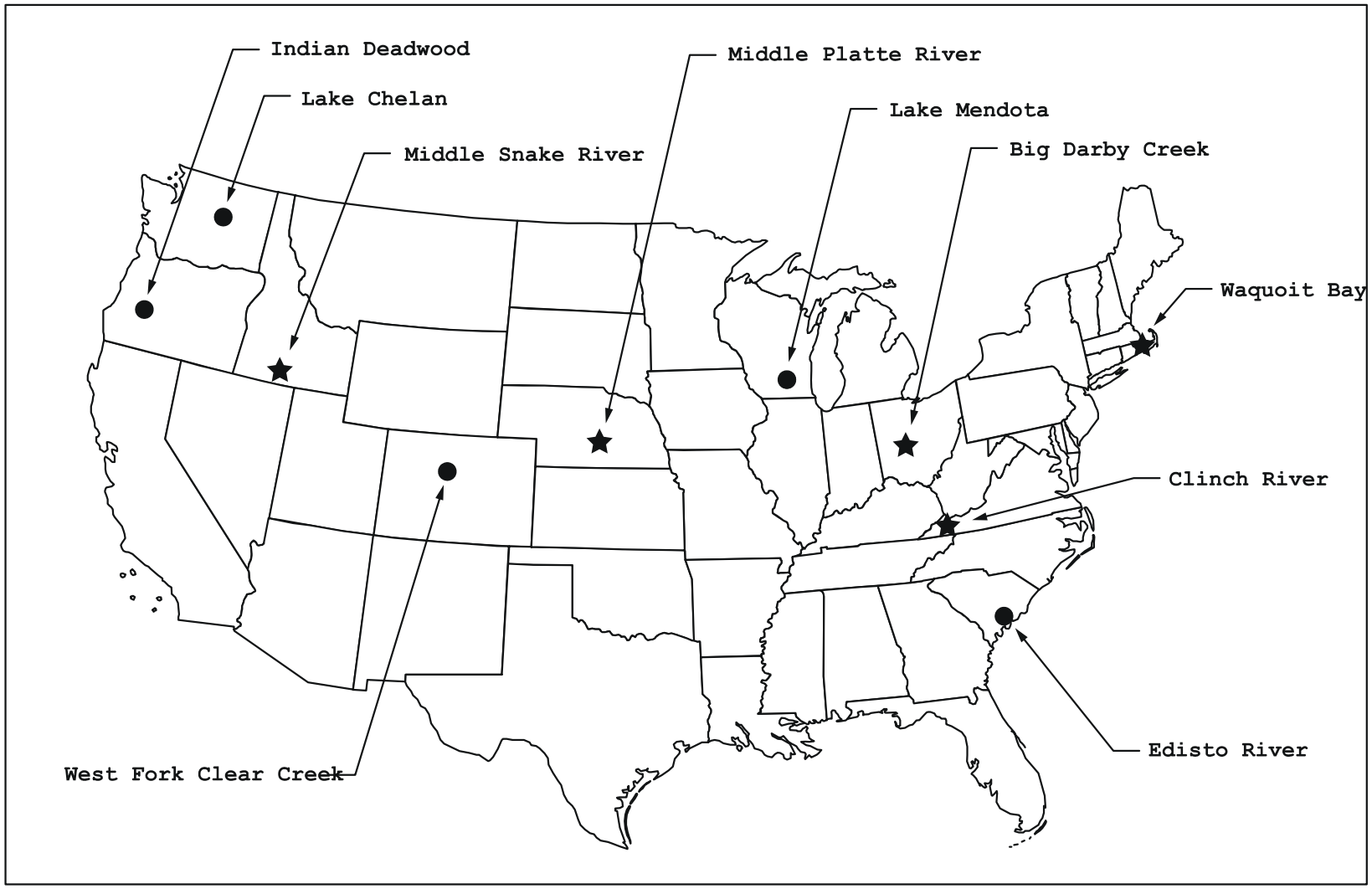
Indian Deadwood
Lake Chelan
Middle Snake River
Middle Platte River
Lake Mendota
Big Darby Creek
Waquoit Bay
Clinch River
Edisto River
West Fork Clear Creek

FIGURE 1

Map showing the location of the watersheds selected for study. The 5 U.S. EPA Risk Assessment Forum WERA sites are represented by stars and the 5 additional sites indicated by the circles.
regions of the United States not represented in the WERAs, and involvement of local,

state, or federal authorities.

TABLE 1

Key Words Used for Electronic Literature Search

Physical Setting	Biological Resources	Waterbody	Land Use
watershed	ecosystem	river	land use
basin	biodiversity	floodplain	management
drainage	aquatic ecology	estuary	water quality
landscape	ecoregion	geomorphology	
	ecological risk assessment		

The five additional watershed case studies identified for analysis from the process described above were (Figure 1):

- two state studies, Edisto River Basin, South Carolina (http://www.dnr.state.sc.us/water/envaff/river/rivercor/edisto.html), and Lake Mendota, Wisconsin (http://www.dnr.state.wi.us/org/water/wm/nps/pdf/mendota.ps.pdf);
- two Total Maximum Daily Lead (TMDL) studies, West Fork Clear Creek, Colorado (http://www.epa.gov/OWOW/tmdl/cs3/cs3.htm), and Lake Chelan, Washington (http://www.epa.gov/OWOW/tmdl/cs11/cs11.htm); and

- one USFS study, Indian/Deadwood, Oregon (http://www.fs.fed.us/r6/siuslaw/).

3.3. DEVELOPING THE MATRIX

Once the 10 watersheds were selected, supporting documentation was obtained from the primary contact (Table 2). After a comprehensive review of these documents, information contained in each study was categorized for entry into a data matrix presented as Table A-1. The first dimension of the matrix was the information category, and the second dimension was a series of issues or questions related to that information category. Information categories, which appear in Table A-1 as bolded, upper-case titles dividing the rows, are of two types: base mapping requirements and analytical data. Base mapping coverages included a geographic management unit (i.e., river basin, watershed boundary, subwatershed boundary), major hydrology (i.e., map of stream reaches, other waterbodies), major roads, and political boundaries (i.e., county, municipal). Analytical data included bedrock geology/groundwater hydrology, meteorology (precipitation, evaporation/wind speed), hydrology (NPDES permitted outfalls, flow gauging/stream gradient, stream use information, water supply intake locations and descriptions, regulated flow structures, streambed substrate, and stream water quality), aquatic biological resources (fish hatcheries, stream biological communities, endangered species), terrestrial biological resources (wetlands, riparian corridor characteristics, soil characteristics), land use/land cover; historic land use (present and historic), Superfund sites/landfills, and local population estimates.

Six questions were asked about each type of information listed above, and the responses constitute the columns of Table A-1:

Question 1. Was the information ***obtained*** for this assessment?

Possible responses: no/not needed, no/not available, no/plan to obtain, yes

TABLE 2

Contacts for Each Watershed Study

Case Study	Primary Contact	Affiliation	Phone and Email
Middle Snake River	John Yearsley	U.S. EPA Region 10, 1200 Sixth Avenue, Seattle, WA 98101	206-553-1532 yearsley.john@epa.gov
Middle Platte River Floodplain	Bob Fenemore	U.S. EPA Region 7, 901 N. Fifth St., Kansas City, KS 66101	913-551-7745 fenemore.robert@epa.gov
Waquoit Bay	Christine Gault Patti Tyler	Waquoit Bay NERR, PO Box 3092, 149 Waquiot Hwy., Waquiot, MA 02536 U.S. EPA Region 1 60 Westview Street Lexington, MA 02173	508-457-0495 x101 cgault@capecod.net 781-860-4342 tyler.patti@epa.gov
Clinch Valley	Jerry Diamond	Tetra Tech, Inc., 10045 Red Run Blvd., Suite 110, Owings Mills, MD 21117	410-356-8993 jerryd@ccpl.carr.org
Big Darby Creek	Susan Norton Susan Cormier Marc Smith	U.S. EPA, NCEA, (8623-D), 401 M St., SW, Wash., DC 20460 U.S. EPA, NERL, 26 W MLK Dr., Cincinnati, OH 45268 Ohio EPA, 1685 W. Belt Dr., Columbus, OH 43228	202-564-3246 norton.susan@epa.gov 513-569-7995 cormier.susan@epa.gov 614- 836-8771 marc.smith@epa.state.oh.us
Lake Chelan	Steve Butkus	Washington Department of Ecology, PO Box 47600 Olympia, WA 98504	360-407-7241 stbu461@ecy.wa.gov
West Fork Clear Creek	Bruce Zander	U.S. EPA Region 8, 999 18th St., Suite #500, Denver, Co 80202	303-312-6846 zander.bruce@epa.gov
Indian/Deadwood Watershed	Craig Snider	USFS, Siuslaw National Forest, 4077 Research Way, PO Box 1148, Corvallis, OR 97339	541-750-7077 cbsnider@fs.fed.us

Case Study	Primary Contact	Affiliation	Phone and Email
Edisto River Basin	William Marshall	South Carolina Department of Natural Resources, 2221 Devine Street, Suite 222 Columbia, SC 29205	803-734-9096 marshall@water.dnr.state.sc.us
Lake Mendota	Carolyn Rumery Betz	Wisconsin Department of Natural Resources, Bureau of Watershed Management, PO Box 7921, Madison, WI 53707	608-266-9262 betzc@dnr.state.wi.us

Question 2. What was the ***source*** of the information?
Possible responses: local/state/federal government agencies (e.g. USFS, Suislaw National Forest, USFWS, USNPS, USGS); university

Question 3. What ***format*** was the information obtained in?
Possible responses: aerial photographs, computer databases, modeling output, GIS data (e.g., DLG, DEM, and TIGER), paper maps (e.g., soils maps, topographic maps), remote sensing data, laboratory measurements, field measurements or monitoring data, literature files

Question 4. What is the ***temporal range and coverage*** of the data?
Possible responses: e.g., 1989-1998, diurnal, annual

Question 5. What is the ***spatial scale or resolution*** of the data? (Note: this is different from the scale of the analysis.)
Possible responses: 1:24,000 scale, 30 meter resolution

Question 6: What were the ***limitations or problems*** with the data?
Possible responses: variable description

4. WATERSHED STUDIES

This section provides background information on each of the 10 watershed studies selected for this analysis, to allow an appreciation of their variety in terms of physical setting, purpose and approach. The same information, with additional detail, is presented in tabular format in Appendix B.

4.1. MIDDLE SNAKE RIVER

4.1.1. Location. The Middle Snake River lies in the west-central Snake River plain of southern Idaho (Figure 2). The upstream study area boundary is Milner Dam and the lower boundary is at King Hill, approximately 160 km downstream where flow shifts from north to west (U.S. EPA, 1996b). The river basin encompasses 22,326 km^2 and includes some of the most populous areas in Idaho.

4.1.2. Study Goals. This reach of the river was identified as one of the most severely degraded in the state. Primary uses of the river are for hydropower, irrigation, commercial fish hatcheries and recreation. This usage has resulted in flow alteration and sediment and nutrient loadings. The primary management goal is to restore the cold water biota and reduce plant biomass in the river. Three assessment endpoints have been identified: growth and recruitment of cold water fish (rainbow trout, white sturgeon, and mountain whitefish), growth and recruitment of endemic, threatened and endangered macro-invertebrates, and reduction in the growth of aquatic macrophytes and algae.

4.1.3. Study Methods and Status. The U.S. EPA risk assessment (http://www.epa.gov/ncea/midsnake.htm) is one component of an integrated effort with the state of Idaho and local officials to address cumulative impacts to the Middle Snake

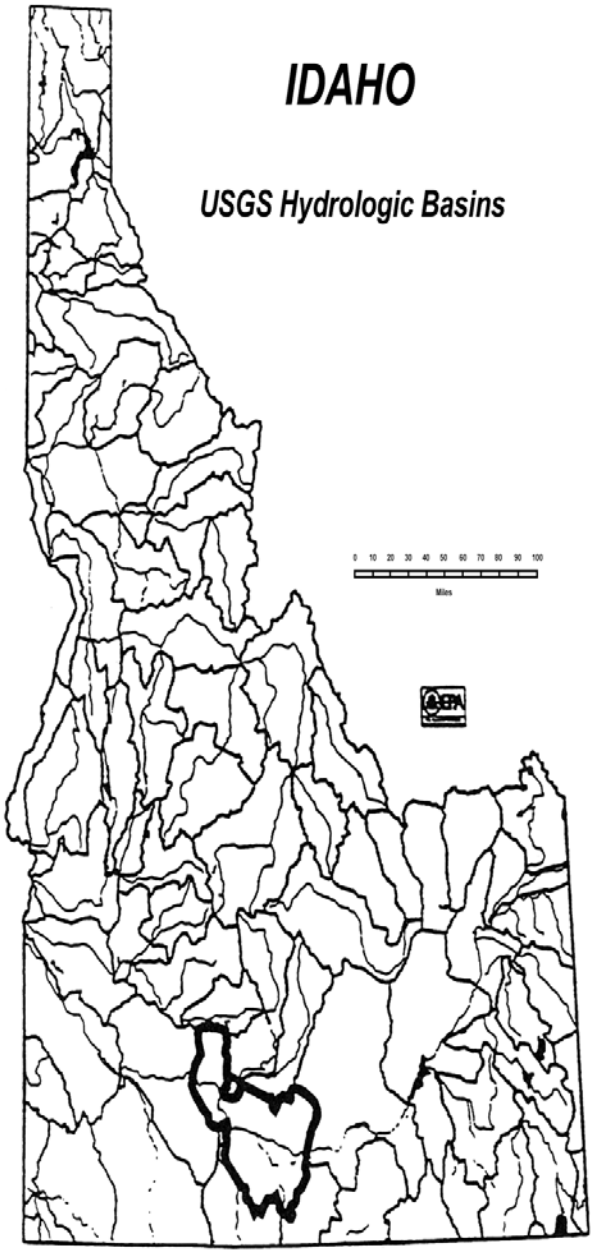

FIGURE 2

Map of the Middle Snake River Study Site (from U.S. EPA, 1996b)

River. Idaho has completed the first phase of a TMDL for total phosphorus and a Nutrient Management Plan (Idaho Department of Health and Welfare, 1996). A group of local officials comprise the Middle Snake River Planning Group, which has served as the policy advisory committee for the Nutrient Management Plan. Idaho State University and the University of Idaho conducted field studies and in-stream testing throughout 1992, 1993, and 1994 to describe the physical, chemical, and biological condition of the river. The draft P&PF was concluded in June 1996. The final risk analysis is being published by NCEA (contact Victor Serveiss serveiss.victor@epa.gov for more information). It should be available by late 2000 (Patricia Cirone, personal communication). The information summary for this study is based on the draft risk analysis report (Yearsley et al., 1998) and discussions with John Yearsley (U.S. EPA).

The primary analytical tool is a water quality model (Yearsley, 1991). The watershed nature of the study is implicit in the modeling approach (i.e., tributary flow into the main stem is a sum of the upstream state variables). There are two components in the risk analysis: exposure analysis and effects analysis. The model simulates the chemical, physical, and biological dynamics in the water column and the benthic plant community attached to or associated with the river bottom. The study area was divided into homogeneous river segments. The water column in the reservoir was vertically stratified to simulate water quality. The model uses a daily timestep to develop cumulative distribution functions of the environmental factors (i.e., temperature, dissolved oxygen, nitrogen, phosphorus, and primary productivity) important to target coldwater species. Probability densities are estimated by monte carlo simulation; model uncertainty were determined by comparing simulation results with field data.

4.2. MIDDLE PLATTE RIVER FLOODPLAIN

4.2.1. Location. The middle segment of the Platte River (the middle Platte River) watershed drains two-thirds of the state of Nebraska. The study area is confined to the floodplain of the river reach from the confluence of the North and South Platte Rivers near North Platte, downstream to the Hamilton and Merrick County lines near Grand Island (U.S. EPA, 1996c). The 200-km reach and floodplain encompasses 2000 km^2. The study area is a vital link in the central flyway for migrating birds. Most of the native habitat has been extirpated or severely altered by agriculture, urban or rural development. Dams and water diversions have reduced the river's natural water flow and sediment depositional patterns. This has resulted in the historic wide, treeless and braided channels being replaced with fewer and narrower channels and woody vegetation becoming established on sandbars. Native vegetation exists in isolated and scattered remnant patches in an agricultural setting.

4.2.2. Study Goals. The study goal is to protect, maintain, and where feasible, restore biodiversity and ecological processes in the Middle Platte River floodplain, thereby sustaining and balancing ecological values with human uses.

Nine assessment endpoints were selected. These include floodplain structure, function and change; open channel configuration and distribution; side channel and backwater connectivity to main channels; wet meadow composition and abundance; sandhill crane and breeding bird abundance; and riverine and backwater invertebrate and amphibian species survival and reproduction. Stressors include altered surface water flow, decreased sediment supply, habitat loss, and floodplain disturbance and development.

4.2.3. Study Methods and Status. The Middle-Platte River Floodplain was selected by EPA for study in 1993. This study was developed using the *Proposed Guidelines for Ecological Risk Assessment* (U.S. EPA, 1996a). The conceptual models and analysis plan were included as part of the Problem Formulation prepared by Dennis Jelinski (Queen's University, Ontario) and currently under review at U.S. EPA Region 7. In addition, Ben Parkhurst (Cadmus, Inc.) has analyzed data for the nine assessment endpoints. The information summary is based on discussions with Bob Fenemore and Marla Downing (U.S. EPA, Region 7).

4.3. WAQUOIT BAY

4.3.1. Location. Waquoit Bay is a tidal estuary located on the southern shore of Cape Cod, Massachusetts (http://www.capecod.net/waquoit/) (Figure 3). The study site boundaries are naturally defined, and the complete watershed, including the estuary, is 53 km^2, 6.5 km^2 of which is surface water (U.S. EPA, 1996d).

4.3.2. Study Goals. Problems include nitrogen enrichment, decline in water quality, loss of eelgrass, decline of shellfish, and an increase in fish kills and mats of macroalgae. Study goals are to reestablish and maintain water quality and habitat conditions in Waquoit Bay and associated wetlands, freshwater rivers, and ponds to (1) support diverse, self-sustaining commercial, recreational, and native fish and shellfish populations; and (2) reverse ongoing degradation of ecological resources in the watershed.

4.3.3. Study Methods and Status. In 1994, the ecological risk assessment team began work on the conceptual model (http://www.capecod.net/waquoit/era.htm), risk hypotheses, and scope of the assessment. The site is a National Estuarine Research

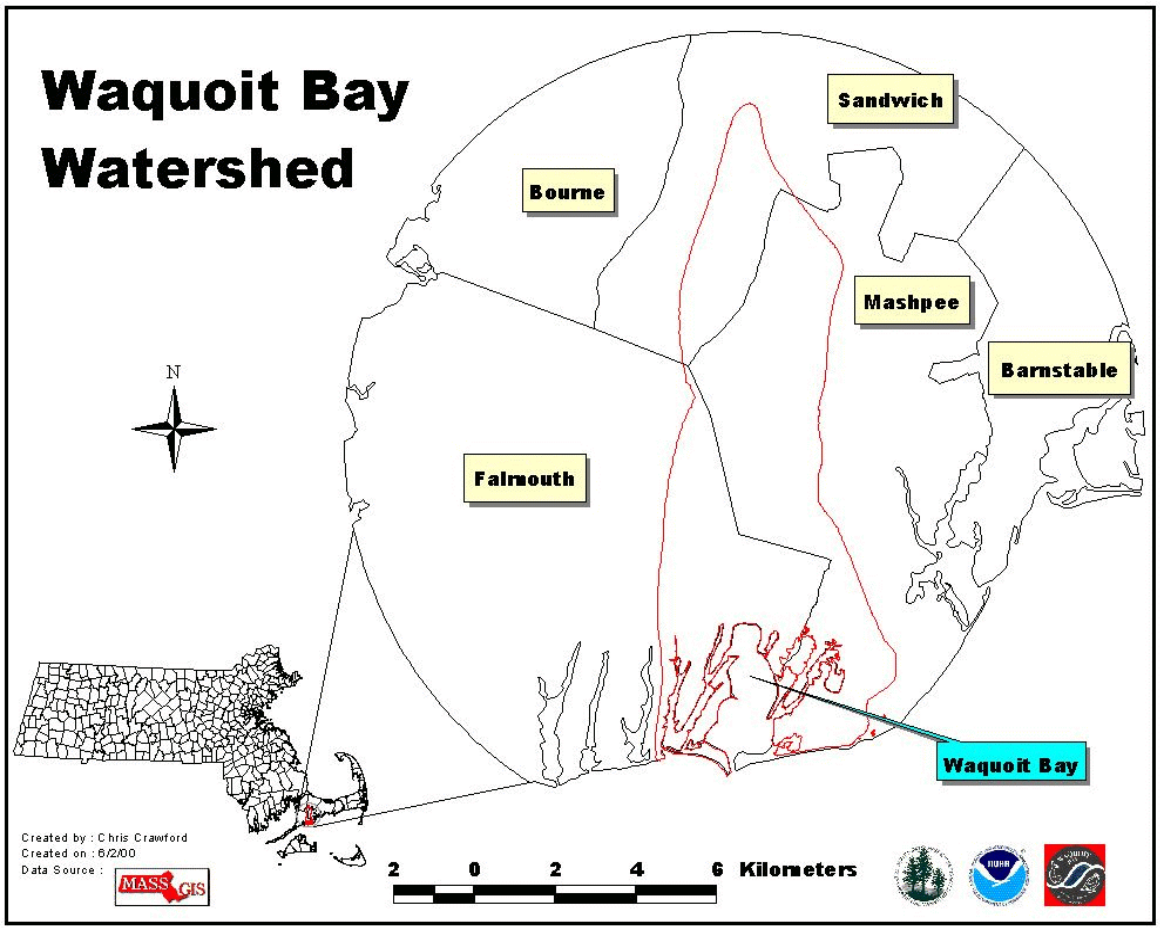

FIGURE 3

Map of the Waquoit Bay Study Site (provided by Chris Crofford, WBNERR)

Reserve (WBNERR), has been extensively studied and has high stakeholder interest. The P&PF was completed in the spring of 1996.

The ongoing analytical phase has two components:(1) the estimation of nitrogen loads, the most important stressor, into Waquoit Bay, and (2) evaluation of the response of eelgrass to nitrogen loading. In support of this effort, Valiela et al. (1997) have developed and verified (Valiela et al., 2000) a regional mathematical model which estimates nitrogen loading to Waquoit Bay. Other ongoing tasks include assessing the effect of salt marsh uptake on nitrogen; adding direct atmospheric deposition; re-evaluating the relationship between the corrected nutrient load and its effect on eelgrass; estimating net loss/gain in excess of dilution; and quantifying the uptake, storage, and recycling of land-derived nitrogen. The updated information summary is based on a discussion with Maggie Geist (Waquoit Bay National Estuarine Research Reserve) and review of several reports which describe the research (Cadmus, Inc., 1995; Sham et al., 1995; Valiela et al., 1997).

4.4. CLINCH RIVER VALLEY

4.4.1. Location. The Clinch River Valley is located in southwestern Virginia and northeastern Tennessee (http://research.esd.ornl.gov/CRERP/INDEX.HTM) (Figure 4). The initial focus of the study is on three pilot sub-watersheds which encompass 1,131 km^2 (U.S. EPA, 1996e). The topography is characterized by dramatic relief, deep stream channels, and high storm runoff. The free-flowing sections of the basin have one of the most diverse fish and mussel assemblages in North America (Ahlstedt, 1984a; Neves, 1991). Many of these species are endemic to this basin due to geographic isolation and destruction of habitat in downstream regions, primarily from impoundment (Ahlstedt, 1984b; O'Bara et al., 1994). Despite its high species diversity,

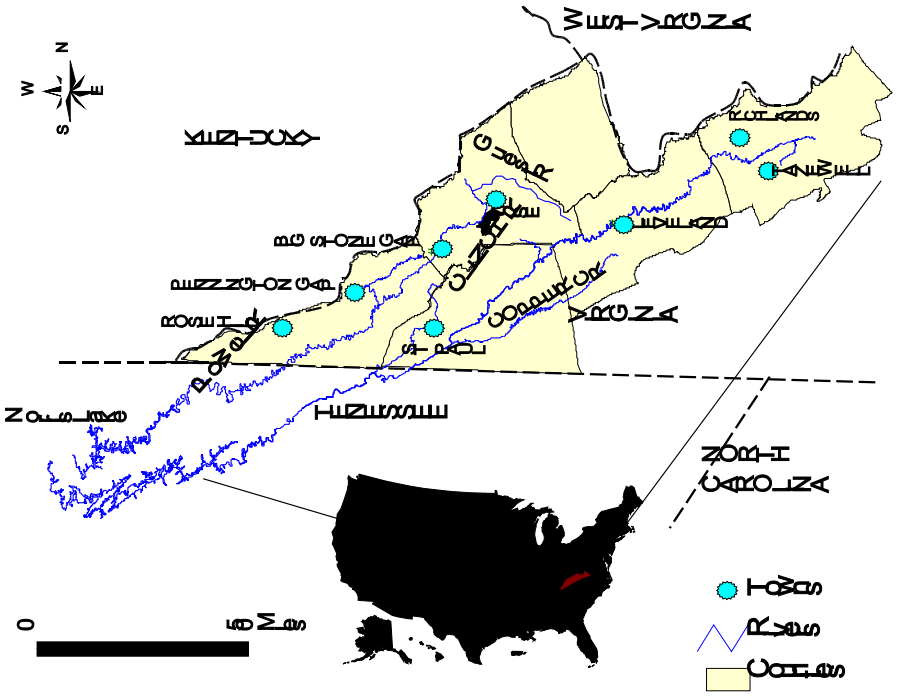

FIGURE 4

Map of the Clinch River Valley Study Site (provided by Jerry Diamond, Tetra Tech, Inc.)

most of the mussel beds and native fish locations in the watershed have declined dramatically or been eliminated. Recent fish and mussel surveys suggest that despite implementing recovery plans for most federally protected species in this basin, there is a continuing decline of rare species in this part of the basin (Jones et al., 2000). Coal mining, agriculture and logging dominate the region. Stressors in the watershed include altered hydrologic flow and a number of non-point source of pollutants such as, acid mine drainage, sediment (from agriculture and logging), coliform bacteria, and toxics. The Clinch and Powell workgroup agreed to focus the assessment on the unimpounded stream segment above Norris Lake, since only that portion of the watershed provided suitable habitat for the fish and mussel species of concern.

4.4.2. Study Goals. The goal of the assessment is to provide scientific information to help implement management actions to maintain or re-establish the unique, native biota of the Clinch and Powell watershed. Examples of actions that will be considered based on the risk assessment findings include:

- Restoring additional abandoned mine lands throughout the watershed.
- Studying further the chemical make-up of discharges from coal mining and processing facilities and the toxicity of these discharges to aquatic species.
- Increasing the extent of forested riparian areas adjacent to and upstream of critical aquatic habitat sites for mussels and fish.

The study goal is to establish and maintain the unique, native biological qualities of the Clinch and Powell surface watershed and subsurface aquatic ecosystem, (i.e., supplement existing recovery plans for threatened and endangered species, particularly mussels, fish, cave fauna), and supporting riparian habitat. Assessment endpoints that have been identified include reproduction and recruitment of threatened and

endangered fish and mussel populations; abundance, diversity and fecundity of cave faunal assemblages (this endpoint is deferred for lack of available data); and riparian corridor integrity.

4.4.3. Study Methods and Status. A risk assessment work group for the Clinch River Valley watershed analysis was convened in 1993. A 1994 survey indicating water quality as a priority concern was adopted in lieu of stakeholder participation. Problem formulation was completed in 1996 (U.S. EPA, 1996e). The analytical phase began in 1998. It was to be accomplished in three stages, using GIS and multivariate statistical analyses. In Stage 1, indices of stress were to be developed from percent of riparian cover versus upland land use and upstream distance of the stressor. In Stage 2, stressor-endpoint relationships were to be quantified using a subset of the measurement endpoints in Copper Creek, a subwatershed with good existing data. In Stage 3, the analysis was to be implemented throughout the upper Clinch and Powell watersheds.

The two assessment endpoints selected in this assessment were: (1) reproduction and recruitment of threatened, endangered or rare native freshwater mussels; and (2) reproduction and recruitment of native, threatened, endangered or rare fish species. If data relating the assessment endpoint to human activities are not available, a surrogate indicator called a measure of effect may be used. Since data on mussel species were limited in this assessment, data on an appropriate surrogate indicator, the fish IBI (an Index of Biotic Integrity for fish based on the mix of species found at a site) may be used. By clearly defining the ultimate focus of the assessment (e.g., mussel species reproduction and recruitment), the uncertainties in the

assessment can be better described (e.g., extrapolating between fish community integrity and mussel response).

The Copper Creek subwatershed assessment addressed two analysis objectives central to this assessment: 1) identify the appropriate spatial scale to test relationships between land use activities or stressors and measures of effect; and 2) identify whether the benthic macroinvertebrate measure (i.e., EPT index) or fish IBI is a reliable surrogate measure of effect for predicting the status of native mussel assemblages. Achieving the latter objective was especially desirable because it was known at the outset of this study that available native mussel data were more limited than either EPT or fish IBI values.

To address the first objective above, Arcview (v. 3.0, ESRI, Redlands, CA, USA) was used to examine several different stream riparian widths and several different distances upstream of each sampling point. Results of pilot analyses indicated that it was useful to analyze biological measures of effect such as fish IBI in relation to riparian corridor integrity, land use and stream habitat quality measures. This analysis also determined the optimal spatial scale to determine the relative influence of riparian corridor or valley agricultural activities on resulting biological integrity or habitat quality at a site. Data were entered into a GIS (Arc/INFO, v. 7.04, ESRI, Redlands, CA, USA) and partitioned in various ways using ACCESS® (Microsoft) to obtain databases that were amenable to various statistical analyses (Statsoft, v. 5.0, Tulsa, OK, USA). Both univariate and multivariate analyses were used to identify relationships between stressors or sources and biologically relevant measures of effect. Data layers included land cover, stream drainages (USGS Stream Reach File 3), road density, locations of point source discharges and mines, fish community integrity (IBI), native mussel species

richness and abundance, macroinvertebrate Ephemeroptera, Plecoptera, and Trichoptera (EPT) family index, and stream habitat quality indices. When extending these analyses to the entire upper Clinch and Powell watershed, sites included were limited to a 350-450 m elevation range to minimize confounding effects of elevation. This information summary is based on an interview with Jerry Diamond (Tetra Tech, Inc.).

4.5. BIG DARBY CREEK

4.5.1. Location. Big Darby Creek drains 1443 km^2 in west-central Ohio (U.S. EPA, 1996f) (Figure 5). The waterbody type is fourth-order stream.

4.5.2. Study Goals. Big Darby Creek is a high-quality ecosystem in a predominately agricultural area, however, industrial/urban Columbus is encroaching upon the headwaters of the watershed. Principal issues in the watershed are conversion of agricultural land to urban use (urban sprawl) and implementation of Best Management Practices (BMPs) for urban and agricultural runoff. A dominant theme in discussions with stakeholders and community groups (http://www.epa.gov/ncea/bigdarby.htm) was the desire to protect and maintain native stream communities. Three management objectives were identified: attain criteria for designated uses, maintain exceptional warm-water criteria in reaches having that designation from 1990 to 1995, and ensure continued existence of native species. Stressors in the watershed include altered stream morphology, increased flow extremes, sediment, nutrients, temperature, and toxic chemicals. Two assessment endpoints were identified. The first endpoint, species composition and diversity and functional organization, is being evaluated using three biological indices: the Index of Biological Integrity (IBI), calculated from attributes of the

FIGURE 5

Map of the Big Darby Creek Study Site (from U.S. EPA, 1996f)

fish community; the Modified Index of Well-Being (MIwb), calculated from the structure, abundance, evenness, and biomass of fish communities; and the Invertebrate Community Index (ICI), calculated from macroinvertebrate community structure. The second endpoint is sustainability of native fish and mussel species.

In addition, four major research components were undertaken by the Big Darby study: development of empirical models to relate the IBI to land use (lead by Steve Gordon, Ohio State University); development of a mechanistic model of runoff to forecast the effect of agricultural management (lead by Andy Ward, Ohio State University); an investigation of implications of the extent and spatial geometry of the riparian zone on stream community structure (lead by Dale White, Ohio State University); and development of an approach to use biological communities to diagnose the principal causes of stress (lead by Susan Cormier and Susan Norton, U.S. EPA).

4.5.3. Study Methods and Status. The results of the Big Darby Creek risk assessment Problem Formulation were recently published by Cormier et al. (2000), as was a recent evaluation of Big Darby watershed ecological status and trends (Schubauer-Berigan et al., 2000). Results related to the four major research components discussed above has also become available recently (see Gordon and Majumder, 2000; Jones and Gordon, 2000; Norton et al., 2000). The risk assessment is currently proceeding to the Risk Characterization phase of the study. The information summary for this study was based on interviews with Susan Norton (U.S. EPA), Susan Cormier (U.S. EPA), and several other study members.

4.6. LAKE CHELAN

4.6.1. Location. Lake Chelan is located in the northern Cascade Mountain Range (Figure 6). It is approximately 100 miles east of Seattle and 50 miles south of the

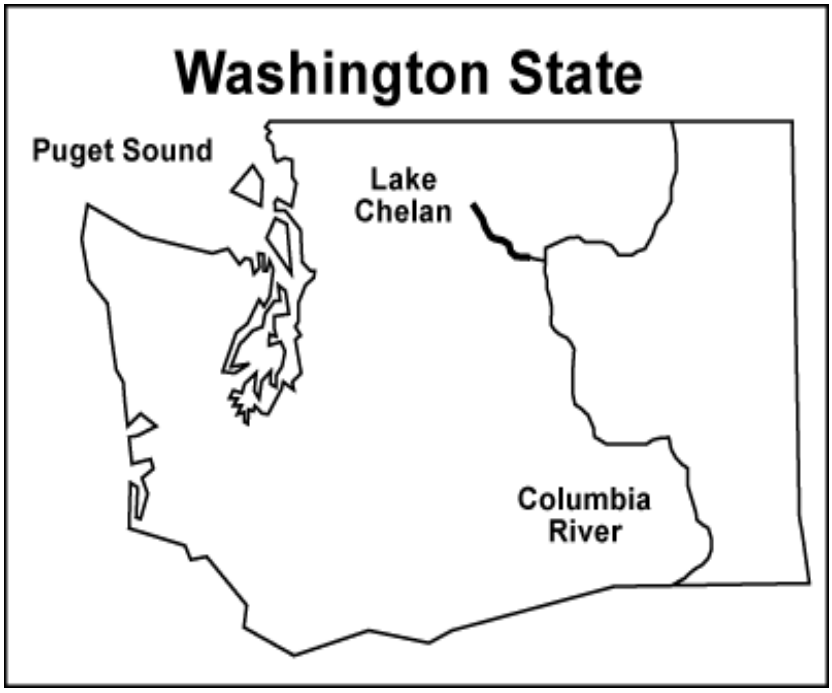

FIGURE 6

Map of the Lake Chelan Study Site (from U.S. EPA, 1994)

Canadian border. The lake is over 50 miles long with an average width of 1 mile. It has a surface area of 134 km^2 and a watershed of approximately 924 mi^2 (2393 km^2). Lake Chelan discharges to the Chelan River at a small hydroelectric dam in the city of Chelan. The dam, which was constructed in 1927, raised the level of the lake by 24 feet. Beyond the dam, the Chelan River flows only a few miles before its confluence with the Columbia River.

4.6.2. Study Goals. Lake Chelan, the longest and deepest natural lake in the state of Washington, is located in a largely undisturbed watershed. The intrinsic value of the lake and the interest of local residents prompted the state to conduct a comprehensive water quality assessment (Patmont et al., 1989). The investigation had three goals: (1) provide baseline data for future comparisons, (2) evaluate existing and potential nutrient sources and their impact, and (3) provide recommendations that would protect the lake's existing ultra-oligotrophic condition as future development occurs (http://www.epa.gov/OWOW/tmdl/cs11/cs11.htm).

Increasing development pressures have raised concerns about maintaining the lake's high water quality. During 1989, in an effort to protect this unique and highly valuable natural resource, the Washington State Department of Ecology (DOE) conducted the Lake Chelan Water Quality Assessment, which attempted to determine nutrient loading limits that would maintain the lake's ultra-oligotrophic condition. A steady-state mass balance model and Monte Carlo analysis techniques were used.

4.6.3. Study Methods and Status. To document the improvements that result from controls, a baseline monitoring program was initiated early in the planning phase. Extensive field investigations were performed from November 1986 through December 1987. An analytical model of phosphorus movement in the Lower Basin was developed

from the field data. Completed in 1989, the Lake Chelan Water Quality Assessment considered seasonal conditions and predictive uncertainties. Based on model results, a 15% or less increase in the average amount of phosphorus discharged to the lake from the lower basin drainage area was deemed acceptable.

In 1990, the Lake Chelan Water Quality Committee prepared a water quality plan based on the assessment (Beck et al., 1991). The plan included a list of action items for controlling nutrients and bacteria from on-site septic systems, underground sewer lines, agricultural runoff, and urban stormwater runoff. The water quality plan also included a TMDL analysis for total phosphorus in Lake Chelan (Pelletier, 1991). DOE conducted a monte carlo based modeling analysis based on potential development patterns in different portions of the basin. The most-likely option was chosen and a phosphorus TMDL of 51 kg/day was submitted to and approved by U.S. EPA Region 10 (U.S. EPA, 1994). Additional total phosphorus (TP) loadings to the lake from new development (over the 1986-1987 load) are considered acceptable only if there is less than a 5% chance that such additions will cause in-lake TP concentrations to exceed 4.5 µg/L, the generally accepted value for the ultra-oligotrophic classification. Management goals are expressed in terms of their effect on the lower basin because the lower basin is relatively shallow and consequently more prone to the effects of increased phosphorus loads. The Lake Chelan Water Quality Committee is responsible for implementing and monitoring compliance with the water quality plan. The committee is currently investigating various controls such as sewer line replacement, sewer system extension, boat sewage pump-out facilities, agricultural runoff management, and stormwater management. The information summary is based on an interview with Steve Butkus (Washington State DOE).

4.7. WEST FORK CLEAR CREEK

4.7.1. Location. The confluence of Woods Creek and the west fork of Clear Creek is approximately 8 miles above the town of Empire, Colorado in the southern Rocky Mountains, and is located in U.S. EPA Region 8. The subwatershed above the confluence comprises 19.8 square miles (51.3 km^2). Clear Creek eventually discharges into the South Platte River, downstream of Denver, Colorado.

4.7.2. Study Goals. The West Fork Clear Creek analysis was performed as a TMDL case study (http://www.epa.gov/OWOW/tmdl/cs3/cs3.htm) study to fulfill U.S. EPA's responsibility under Section 303(d) of the Clean Water Act (U.S. EPA, 1988, 1991). The watershed is impaired by trace metals from mining activities at the inactive Urad mine and mill and the active Henderson mine and mill. The primary designated uses of the affected reaches are cold water aquatic habitat and recreation. The waterbody's use as a habitat for aquatic life, however, is most greatly threatened by metal-containing runoff.

4.7.3. Study Methods and Status. The creek is impaired by trace metals from mining activities. A TMDL was calculated using a simple mass balance equation based on the effluent and stream flows and pollutant concentrations in the monitoring data. The TMDL was subsequently incorporated into an updated permit for the Urad mine site that became effective June 1, 1992. The in-place and planned BMP include the plugging of the inactive Urad mine portal, isolation of the tailings from runoff, and installation of toe (groundwater) drains in the tailings piles. Monitoring on West Fork Clear Creek, immediately below Woods Creek, has shown that plugging the Urad mine portal resulted in improved stream biology. A dramatic increase in the density and variety of

macroinvertebrate populations and sharp growth in trout population are a good indication that BMP is helping to achieve water quality objectives.

4.8. INDIAN/DEADWOOD WATERSHED

4.8.1. Location. The Indian and Deadwood watersheds lie in the southern half of the Oregon Coast Province about 27 miles up the Siuslaw River from the Pacific Coast and about 12 miles from Mapleton, Oregon (USDA Forest Service, 1996) (Figure 7). All of the 74,000 acre (3.0 km^2) watershed is within Lane County. The watershed includes Indian Creek, Deadwood Creek, Green Creek and the lower portion of Lake Creek just before it empties into the Siuslaw River. The watershed is bounded by Windy Peak on the east, Taylor Butte and Klickitat Mountains on the north, and Saddle Mountain on the west.

4.8.2. Study Goals. The watershed analysis is intended to provide guidance on how to best implement the Northwest Forest Plan at the watershed scale. The main goal of the aquatic portion of the watershed analysis is to protect the highest concentrations of the best remaining aquatic habitat, especially anadromous salmonid habitat, and those areas that could quickly provide good habitat after improvements were made. The goal for the terrestrial portion of the watershed is to manage the Late-Successional Reserve lands to sustain viable populations of several species associated with mature forests, such as the northern spotted owl, a federally listed threatened species.

4.8.3. Study Methods and Status. Stressors in the study area are fire and logging. Information is maintained for the Siuslaw National Forest in a GIS map of logging and fire activity. The database was initiated in 1980; records after 1980 are accurate. Best estimates were made from old logging records and photographs from the time logging was started in about 1950. Endangered species, including bald eagle, marbled

FIGURE 7

Map of the Indian/Deadwood Study Site (from USDA Forest Service, 1996)

murrelet, norther spotted owl, and the anadromous fish populations, are the assessment endpoints. These endpoints are mandated by the National Forest Management Act, Clean Water Act, Endangered Species Act, and the Northwest Forest Plan.

The Indian/Deadwood watershed analysis was conducted as part of implementing the Northwest Forest Plan (USDA/USDI, 1994). The analysis report was completed in June 1996. With completion of the Indian/Deadwood watershed analysis, 65% of the Siuslaw River Basin (http://www.fs.fed.us/r6/siuslaw/) has been analyzed; the three remaining watersheds were to be completed in 1997.

This watershed analysis is a component of the Aquatic Conservation strategy developed for the Northwest Forest Plan. The purpose of the analysis was to assess current conditions of the forest resources compared with past conditions, and to develop an understanding of the processes, both natural and human-caused, that led to the current conditions. Currently about 44% of the watershed contains late-successional conifer forests which provide habitat to species such as northern spotted owl, pileated woodpecker, marbled murrelet, and flying squirrel. The watershed contains over 360 miles of perennial fish-bearing streams, of which 150 miles are anadromous fish habitat. Stream habitat for these fish species is far below its potential throughout the watershed. The watershed has been extensively characterized, and high-quality information is available.

4.9. EDISTO RIVER BASIN

4.9.1. Location. The Edisto River Basin is a 3120 square mile (8080 km^2) area that includes portions of 12 counties in south-central South Carolina (SCDNR, 1996) (Figure 8). The watershed is drained by the Edisto River, one of the longest free-flowing

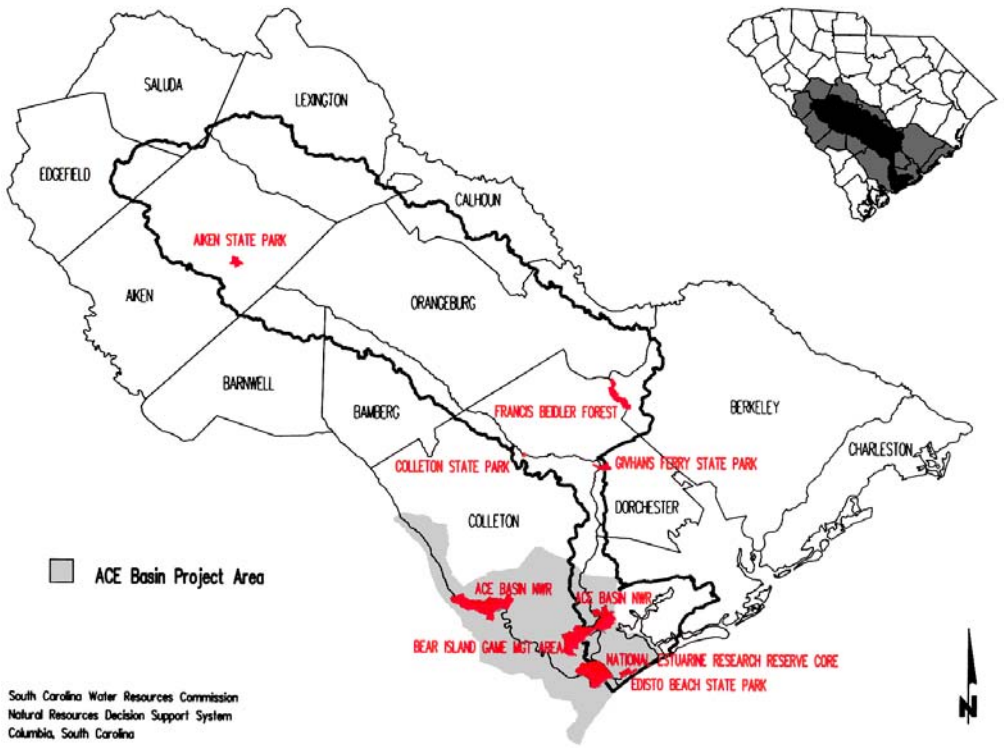

FIGURE 8

Map of the Edisto River Basin Study Site (provided by William Marshall, SCDNR)

blackwater rivers in the United States. The basin extends approximately 130 miles across the coastal plain to the Atlantic Ocean.

4.9.2. Study Goals. The Edisto River Basin Project (http://www.dnr.state.sc.us/water/envaff/river/rivercor/edisto.html) was developed to provide an assessment of the economic, ecological, cultural, and recreational resources of the region and to provide goals and recommendations for the future use and management of these resources.

4.9.3. Study Methods and Status. Stressors include cumulative impacts of human activity in the watershed, particularly intensive forest management and agriculture. Assessment endpoints were defined by the task force committees. Each committee used GIS information to value different land uses from their perspective. A number of management goals were developed by this process. These include: 1) maintaining exemplary water quality, 2) preserving the natural hydrologic regime of the watershed, 3) maintaining large areas of natural vegetation coverage with high connectivity and buffer areas around the streams, and 4) preserving native animal populations, particularly threatened and endangered species (Marshall, 1993).

South Carolina is attempting to automate data integration at the watershed scale of analysis. They are making extensive use of GIS to evaluate the resources of the river basin in an effort to provide recommendations for more sustainable development. The project includes ecological, socioeconomic, and public opinion assessments, citizen participation, resource evaluation, and policy recommendations.

Initial characterization of the Edisto River Basin was based on an initiative entitled the “Natural Resources Decision Support System (NRDSS) Project”, fostered by the South Carolina Water Resources Commission (SCWRC), restructured in 1994 to

become Water Resources Division of the South Carolina Department of Natural Resources (SCDNR). The NRDSS project is a multiyear research and demonstration project begun in 1988 and funded by the NOAA, and the state of South Carolina.

The Basin Task Force first met in November 1993. The project has become a very useful management and planning tool. The GIS data base development has been expanded from the original Edisto River Basin to the entire coastal plain area of South Carolina, and is currently being expanded to include parts of the Piedmont region.

4.10. LAKE MENDOTA

4.10.1. Location. Lake Mendota is a 10,000-acre glacial lake, used extensively for fishing and water sports (Figure 9). It is located in south central Wisconsin adjacent to the city of Madison. About 60% of the 230-square mile (596 km^2) watershed is agricultural.

4.10.2. Study Goals. The primary goal of the project is to reduce non-point source pollution to Lake Mendota by 50%. The lake's water quality problems arise primarily from current and past rural and urban runoff, resulting in excessive phosphorous loading. Dairy farming accounts for most of the farm income in the watershed. Approximately 50% of the original wetlands in the watershed have been drained or filled. Erosion from agricultural land was estimated to contribute 58% of total sediment; however, gully and stream bed erosion were not determined to be significant non-point sources in the Lake Mendota watershed.

4.10.3. Study Methods and Status. River basin planners within Wisconsin Department of Natural Resources (WDNR) collect all available data and rank individual watersheds based on their potential to respond to control measures. Data sources are water quality documents prepared by the WDNR biologists. A Citizens Advisory

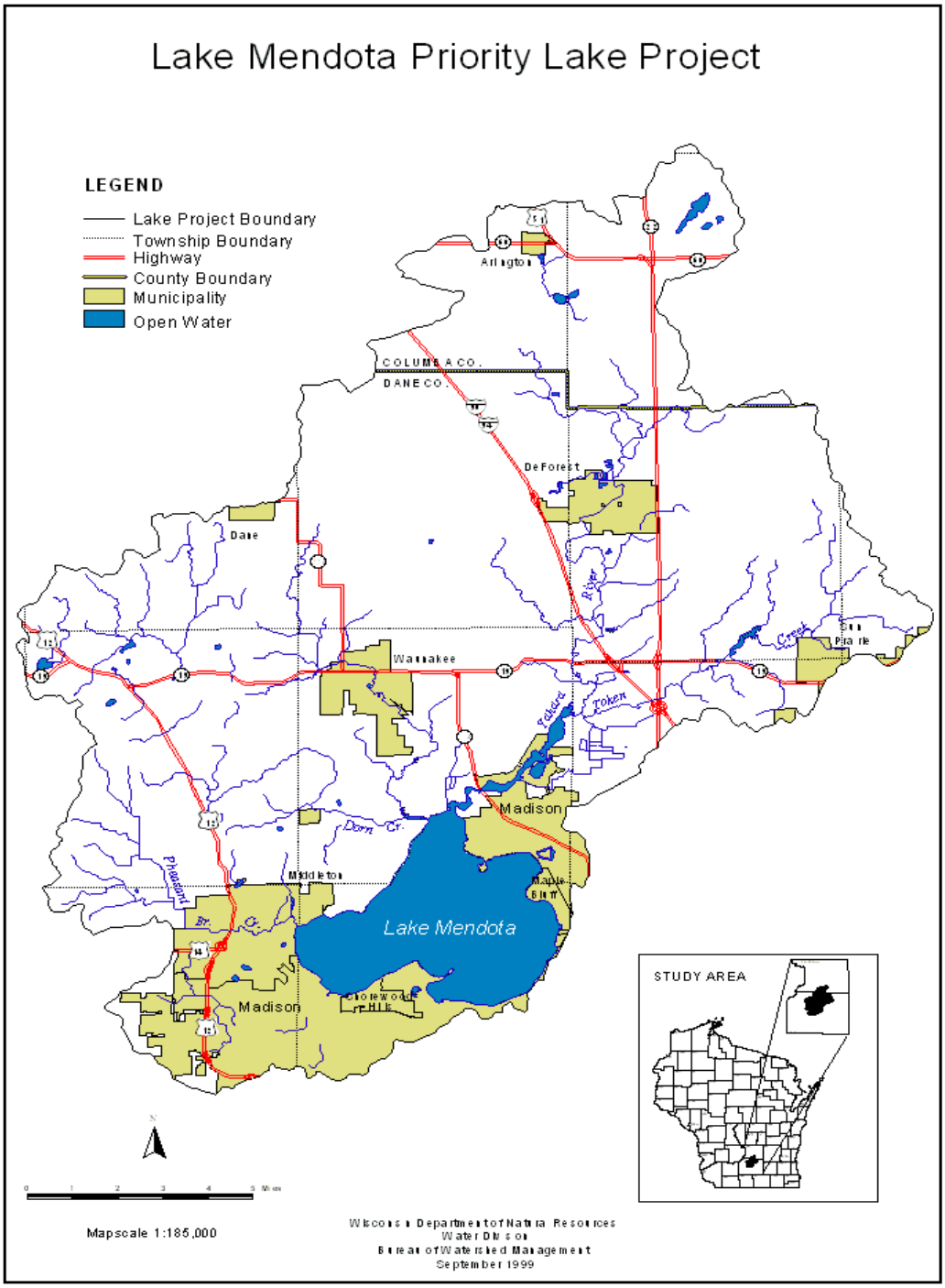

FIGURE 9

Map of the Lake Mendota Study Site (provided by Carolyn Rumery Betz, WIDNR)

Committee is also involved in setting goals as required by state statute. Once a watershed has been selected, an 18-month planning process is initiated. Stream biologists from WNDR spend up to 1 year collecting field data on macroinvertebrates, fish populations, stream width, erosion etc. Data are also collected on barnyards, farm land, wetlands, and urban areas. Models are subsequently developed to estimate loadings from different sources. The assessment endpoints are water quality, turbidity, and fish and wildlife habitat.

The WDNR has delineated 330 watersheds for its statewide non-point source program. Approximately one-fifth of the watersheds have been targeted over the last 20 years for priority status. Each of these projects has included evaluation monitoring to assess water quality improvement. The Wisconsin State Legislature created the Wisconsin State Water Pollution Abatement Program in 1978. The intent of the Program was to improve and protect the water quality of streams, lakes, wetlands, and groundwater by reducing pollutants from urban and non-point sources. There were 86 similar watershed projects statewide in which non-point source control measures were being planned or implemented at the time the Lake Mendota plan was published in May 1997. The Lake Mendota watershed was designated a “priority watershed” in 1993. A recent study of the watershed was completed in 1997 (WDNR, 1997). As an outgrowth of the study, implementation control measures were initiated in the summer of 1997. Funding for implementation is shared between local and state sources. Individuals, municipalities and other governmental units signed cost-share agreements for the first 5 years of the project.

5. SUMMARY OF DATA SOURCES FOR TEN EXAMPLE WATERSHED STUDIES

This section summarizes the approaches used by the 10 watershed studies to address each of the key information categories. The same information, with additional detail, is presented in tabular format in Appendix A.

5.1. WATERSHED/SUBWATERSHED BOUNDARY

Of the 10 studies reviewed, 5 studies (Middle Platte, Middle Snake, Clinch Valley, Indian/Deadwood, and Edisto River) used USGS hydrologic unit maps to delineate watershed and/or subwatershed study boundaries. Lake Mendota and Waquoit Bay delineated watershed boundaries from USGS DLG data. Big Darby Creek achieved finer resolution by using USGS 7.5 minute DEM data. The two studies that did not use a GIS, Lake Chelan and West Fork Clear Creek, relied on USGS 15-minute topographic maps for base mapping. Four studies (Waquoit Bay, Clinch Valley, Indian/Deadwood and Edisto River) delineated subwatershed areas.

5.2. STREAM REACHES

Three studies, Middle Platte, Clinch Valley, and Big Darby Creek, used U.S. EPA's Reach Files to delineate stream reaches; four studies used topographic maps to visually identify homogeneous stream segments (Middle Snake River, West Fork Clear Creek, Indian/Deadwood Watershed and Lake Chelan) and three studies used the hydrography data layer available in the DLG format (Edisto, Lake Mendota, and Waquoit Bay).

5.3. OTHER WATER BODIES

Two of the studies used DLG hydrography data. Edisto River Basin study used DLG hydrography data at 1:250,000 scale and the Middle Platte River study used DLG hydrography data at 1:2,000,000 scale. DEM data with 3-arc resolution was used in the Clinch River Valley study. The Indian/Deadwood study relied on "Cartographic Feature Files" to delineate other water bodies. These digitized maps were constructed from USGS 7.5-minute topographic maps by personnel in USFS. The information they contain is updated by field personnel every 7-10 years.

5.4. MAJOR ROADS, COUNTY AND MUNICIPAL BOUNDARIES

The larger river basin studies (Middle Platte River, Clinch River Valley, and Edisto River) used small scale (coarser resolution) mapping from the National Highway Planning Network (1:2,000,000) and DLGs (1:1,000,000 and 1:250,000) to delineate major roads in the vicinity of the watershed. Big Darby Creek used larger-scale (finer resolution) TIGER data available from the U.S. Census Bureau.

County and municipal boundaries were generally delineated by the case studies from TIGER and DLG data layers, according to the scale appropriate for a particular study. The exception was the Middle-Platte River study, which used USGS Land Use Data (1:250,000) to delineate municipal boundaries.

5.5. BEDROCK/GROUNDWATER HYDROLOGY

The underground flow of water was an important analytical component in several of the watershed studies. On the Middle Snake and Middle Platte Rivers, where much of the river flow is diverted for agricultural use, groundwater recharge accounts for a significant portion of the downstream river flow. In the Waquoit Bay and Lake Chelan watersheds, groundwater discharge into receiving streams and the estuary is a pathway

of concern for nitrates and phosphates associated with on-site wastewater disposal. The Clinch River Valley study is concerned with the extensive karst system, which is inhabited by unique cave fauna.

USGS open-file reports were used as the primary source for baseline information for most of the case studies. However, the Lake Chelan study (Patmont et al., 1989) conducted an extensive hydrogeologic investigation to investigate the suitability of the soils adjacent to the lake for on-site septic systems. The investigation focused on the area where development is occurring. First, existing literature and aerial photographs were reviewed. This information was used by field crews to guide an intensive mapping effort. The result was a terrain unit map. Monitoring wells were also installed.

5.6. PRECIPITATION, EVAPORATION AND WIND SPEED

Precipitation, evaporation and wind speed data were needed by all of the watershed studies because stream flow is a key analytical component. Several study managers said there was limited spatial coverage because of too few meteorology stations in their study area. There are six National Weather Service Stations within the Edisto River Basin. Statistical analysis for consistency in the precipitation data among the stations indicated that data from one station was not predictable by the precipitation at another station. The coefficient of determination (R^2) was about 0.50 (Marshall, 1993).

5.7. NPDES OUTFALLS (EFFLUENT LOCATION AND CONCENTRATION)

NPDES data were available and used to some degree in all of the watershed studies except Indian/Deadwood and West Fork Clear Creek. Most study managers reported problems with the data. Problems commonly mentioned include inaccurate locations (i.e., post office boxes, specific sampling location in the river not indicated),

inaccurate monitoring data, and poor quality control when the data are transferred from permits (paper) to a computerized database. The Big Darby Creek project worked with the NPDES data and corrected outfall locations to within 15 meters. Before the corrections were made, locations were often inaccurate by as much as 100 meters.

5.8. FLOW GAUGING AND/OR STREAM GRADIENT

Estimates of stream flow were used in all of the watershed studies. There was at least one USGS flow gauge in all of the watersheds except Indian/Deadwood. USFS guidance assumes that there will not be current or historic flow records for streams within Forest Service watersheds (Regional Ecosystem Office, 1995). The guidance recommends use of USGS Surface Water Supply Papers which cover streams nearby. Streamflow data were collected continuously at four stations in the Edisto River Basin from about 1939 to 1990. Statistical analysis showed that streamflows were highly correlated (coefficient of determinations greater than 0.90) among the stations. There was only one gauge in the Lake Chelan basin, but it was on the stream that contributes about 70% of the average annual discharge to the lake.

5.9. STREAM USE, WATER SUPPLY INTAKE, AND REGULATED FLOW STRUCTURES

Stream use, water supply intakes, and regulated flow structures were collected for all the watershed studies.

5.10. STREAM WATER QUALITY

The watershed case studies followed a general pattern of piecing together available data from all available federal (STORET), state, and university sources.

5.11. STREAM SUBSTRATE, STREAM BIOLOGICAL COMMUNITIES

Stream substrate and biological community data are endpoints in most of the watershed studies. A monitoring program was best developed at Big Darby Creek. Researchers used several biological indices to monitor stream quality at 63 sites throughout the watershed.

5.12. FISH HATCHERIES

Information on fish hatcheries was obtained for 5 of the 10 watershed studies, and in one of those, Middle Snake River, hatcheries were evaluated as a stressor. Information source was different for each location.

5.13. ENDANGERED SPECIES

Locations and habitat requirements of threatened and endangered species were explicitly considered in four of the watershed analyses: Middle Snake River, Middle Platte River, Clinch River Valley, and the Indian/Deadwood watershed.

5.14. WETLANDS

Wetland locations were identified in five of the watershed studies: Middle Snake, Middle Platte, Waquoit Bay, Clinch Valley, Indian/Deadwood, Edisto, and Lake Mendota.

5.15. RIPARIAN CHARACTERISTICS

Five of the watershed studies explicitly considered the riparian zone in their analyses.

5.16. SOIL CHARACTERISTICS

Sediment load was identified as a stressor in most of the studies. The Edisto River Basin project used soils data remapped by SCDNR to 1:24,000 scale using zoom

transfer scope methods. Attributes in the data layer include slope, hydric class, site index, and crop productivity (SCDNR).

5.17. LAND USE/LAND COVER

Regional Land use/land cover data was an essential component in the watershed analysis for Waquoit Bay and Edisto River Basin. For the Edisto study, SCDNR derived land use from photography (scale = 1:40,000 and mapped at 1:24,000 scale, 10 acre resolution). Classification was based on Anderson Level II (Anderson et al., 1976); classes include urban or built-up, agriculture, rangeland, forest lands, and water.

5.18. SUPERFUND SITES/LANDFILLS

There was only one Superfund Site in the watershed studies, the Massachusetts Military Reservation located just north of Waquoit Bay watershed. Although watershed ecological risk assessment can be used in conjunction with Superfund Site assessments, each of the watersheds reviewed in this report was analyzed for other concerns and Superfund Sites were not important.

5.19. LOCAL POPULATION ESTIMATES

Population estimates were mostly used for background information; however, the Waquoit Bay analysis correlated population growth with nutrient enrichment in the estuary.

6. REFERENCES

Ahlstedt, S.A. 1984a. Twentieth century changes in the freshwater mussel fauna of the Clinch River (Tennessee and Virginia). Walkerana. 5: 73-122.

Ahlstedt, S.A. 1984b. Cumberlandian mollusk conservation program: Mussel surveys in six Tennessee Valley streams. Walkerana. 5: 123-160.

Anderson, J.A., E.E. Hardy, J.T. Roach and R.T. Witmer. 1976. A land use and land cover classification system for use with remote sensor data. United States Geological Survey. Professional Paper 964.

Beck, R.W. and Associates. 1991. Lake Chelan water quality plan. Report to the Lake Chelan Water Quality Committee, Wenatchee, Washington.

Bricker S.B., et al. 1999. National eutrophication assessment: Effects of nutrient enrichment in the nations's estuaries. NOAA National Ocean Service, Silver Spring, MD.

Cadmus, Inc. 1995. Nitrogen loading to Waquoit Bay: Existing models and recommended modeling approach. Prepared for U.S. EPA Health and Ecological Criteria Division, U.S. EPA Office of Water.

Cormier, S.M., M. Smith, S. Norton and T. Neiheisel. 2000. Assessing ecological risk in watersheds: a case study of problem formulation in the Big Darby Creek watershed, Ohio, USA. Environ. Toxicol. Chem. 19(4):1082-1096.

Cowardin, L., V. Carter, F. Golet and E. LaRoe. 1979. Classification of wetlands and deep water habitats of the United States. U.S. Fish and Wildlife Service, Washington D.C., FWS/OBS-79/31.

Gordon, S.I. and S. Majumder. 2000. Empirical stressor-response relationships for prospective risk analysis. Environ. Toxicol. Chem. 19(4:2) 1106-1112.

Idaho Department of Health and Welfare, Division of Environmental Quality. 1996. Middle Snake River watershed management plan, Phase 1 TMDL total phosphorus.

Jones, A.L. and S.I. Gordon. 2000. From plan to pracxtice: Implementing watershed-based strategies into local, state and federal policy. Environ. Toxicol. Chem. 19(4:2) 1136-1142.

Jones, J., M. Patterson, C. Good, A. DiVittorio and R. Neves. 2000. Survey to evaluate the status of freshwater musel populations in the upper Clinch River, VA. Final Report. U.S. Fish and Wildlife Service, Abingdon, VA.

Marshall, W.D. 1993. Assessing Change in the Edisto River Basin. South Carolina Water Resources Commission, Report No. 177. South Carolina Water Resources Commission, Columbia, SC.

Neves, R.J. 1991. Mollusks, *In* Terwilliger, K. (ed.), Virginia's endangered species. The McDonald and Woodward Publishing Company, Blacksburg, Virginia, pp. 251-320

Norton, S.B., S.M. Cormier, M. Smith and R.C. Jones. 2000. Can biological assessments discriminate among types of stress? A case study from the eastern cornbelt plains ecoregion. Environ. Toxicol. Chem. 19(4:2) 1113-1119.

O'Bara, C.J., M.A. Eggleton, L.M. McAdoo et al. 1994. Clinch River biotic assessment part 1: macrobenthic and fish communities. Tennessee Wildlife Resources Agency, Nashville, TN. p. 75.

Patmont, C.R., G.J. Pelletier, E.B. Welch and C.C. Ebbesmeyer. 1989. Lake Chelan water quality assessment. Prepared by Harper Owes, Inc. for Washington State Department of Ecology, Olympia, Washington.

Pelletier, G. 1991. Lake Chelan TMDL for total phosphorus. Memorandum of April 5 to B. Hashim and J. Milton. Washington State Department of Ecology, Olympia, Washington.

Regional Ecosystem Office. 1995. Ecosystem analysis at the watershed scale: Federal guide for watershed analysis, Rev. August 1995, Ver 2.2, Portland, OR.

Schubauer-Berigan, M.K., M. Smith, J. Hopkins and S.M. Cormier. 2000. Using historical data to evaluate status and trends in the Big Darby Creek watershed (Ohio, USA). Environ. Toxicol. Chem. 19(4):1097-1105.

Seaber, P.R., F.P. Kapinos and G.L. Knapp. 1987. Hydrologic Unit Maps: U.S.G.S. Water-Supply Paper 2294. p. 63.

Serveiss, V.B., D. Norton and S.B. Norton. 2000. Watershed Ecological Risk Assessment; The Watershed Academy, US EPA; on-line training module at http://www.epa.gov/owow/watershed/wacademy/acad2000/ecorisk

Sham, C.H., J. Brawley and M.A. Moritz. 1995. Quantifying nitrogen loading from residential septic sources to a shallow coastal embayment. Int. J. Geog. Infor. Sys. 9(4):463-473.

Slack, J.R. and J.M. Landwehr. 1998. Hydro-climatic data network (HCDN): A U.S. Geological Survey streamflow data set for the United States for the study fo climate variations, 1874-1988. U.S. Geological Survey Open-File Report 92-129.

South Carolina Department of Natural Resources (SCDNR). 1996. Managing Resources for a Sustainable Future: The Edisto River Project Report. South Carolina Department of Natural Resources, Water Resources Division.

USDA Forest Service, USDI Bureau of Land Management. 1994. Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl. Portland, OR.

USDA Forest Service. 1996. Indian/Deadwood Watershed Analysis. Unpublished Report. Siuslaw National Forest, p. 106.

U.S. EPA. 1988. Final guidance for implementation of requirements under section 304(l) of the Clean Water Act as Amended. U.S. Environmental Protection Agency, Office of Water Regulations and Standards and Office of Water Enforcement and Policy, Washington, DC.

U.S. EPA. 1991. Guidance for water quality-based decisions: The TMDL process. Environmental Protection Agency, Office of Water, Washington DC.

U.S. EPA. 1992. Framework for Ecological Risk Assessment. Risk Assessment Forum, Washington, DC. EPA/630/R-92/001.

U.S. EPA. 1994. TMDL Case Study, Lake Chelan, Washington. EPA841-F-94-001.

U.S. EPA. 1996a. Proposed Guidelines for Ecological Risk Assessment. Federal Register. 61(175):47552-47631, Sept. 9, 1996.

U.S. EPA. 1996b. Middle Snake River Watershed. Ecological Risk Assessment, draft Planning and Problem Formulation. EPA 630/r-96/008A.

U.S. EPA. 1996c. Middle Platte River Floodplain Ecological Risk Assessment. Planning and Problem Formulation.

U.S. EPA. 1996d. Waquoit Bay Watershed, Ecological Risk Assessment. Planning and Problem Formulation. EPA/630/R-96/004A.

U.S. EPA. 1996e. Clinch Valley Watershed, Ecological Risk Assessment. Planning and Problem Formulation. EPA/630/R-96/005A.

U.S. EPA. 1996f. Big Darby Creek Watershed Ecological Risk Assessment. Planning and Problem Formulation. EPA/630/R-96/006A.

U.S. EPA. 1996g. Watershed Approach Framework. Office of Water, Washington DC 20460. EPA-840-S-96-001.

U.S. EPA. 1997a. People, Places and Partnerships: A progress report on community-Based Environmental Protection. Office of the Administrator. Washington, DC 20460. EPA 100-R-97-003.

U.S. EPA. 1997b. Designing an information management system for watersheds. EPA841-R-97-005.

U.S. EPA. 1998. Guidelines for Ecological Risk Assessment. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC. EPA/630/R-95/002F.

U.S. EPA. 2000a. Deposition of air pollutants to the Great Waters: Third report to Congress. EPA/453/R-00-005.

U.S. EPA. 2000b. The quality of our nations waters. A summary of the National Water Quality Inventory: 1998 report to Congress.

Valiela, I., G. Collins, J. Kremer et al. 1997. Nitrogen loading from coastal watersheds to receiving estuaries: New method and application. Ecolog. Appl. 7(2):358-380.

Valiela, I., M. Geist, J. McClelland and G. Tomasky. 2000. Nitrogen loading from watersheds to esturines: Verification of the Waquoit Bay loading model. Biogeochemistry. 49(3):277-293.

Wisconsin Department of Natural Resources. 1997. Nonpoint Source Control Plan for the Lake Mendota Priority Watershed Project. Department of Natural Resources, Bureau of Watershed Management, Madison, WI.

Yearsley, J.R. 1991. A Dynamic River Basin Water Quality Model. EPA/910/9-91-019. U.S. EPA, Region 10, Seattle, WA.

Yearsley, J., P. Cirone, G. Filbin and D. Karna. 1998. Middle Snake River Risk Analysis. Draft. U.S. Environmental Protection Agency.

7. GLOSSARY

Aerial photography	Photographs taken of the Earth's surface features from an airplane. Usually differentiated from remote sensing date due to the difference in media.
ARC/INFO	A high-end GIS software by ESRI, it is used to create spatial databases and perform spatial analysis. Add-ins provide spatial modeling, 3-D visualization, and surface analysis. ARC/INFO runs on Unix and Windows NT operating platforms.
ArcView GIS	A data integrating and viewing software by ESRI, this software allows the user to view, query, and create full color maps of existing spatial data. ArcView GIS runs on Windows and Unix platforms.
AVHRR	Advanced Very High Resolution Radiometer is the broad-band, multi-channel scanner carried on NOAA's POES. This scanner senses visible, near-infrared and thermal infrared wavelength bands of the electromagnetic spectrum.
Bedrock geology	The geology of the solid rock foundation usually overlain by unconsolidated soil and vegetation.
CFF	Cartographic Feature Files (USFS) are edgematched digitized vector files of USFS-administered lands produced by (Geometronics Service Center) GSC. GSC digitizes USGS topographic quadrangles to 0.005" accuracy and adds USFS information to produce CFFs.
Color infrared	Used especially to detect change in vegetation.
DEM	Digital Elevation Model contains elevation (X,Y,Z) data in a continuous or gridded surface.
DLG	Digital Line Graphs (USGS) are vector representations of map features digitized using USGS topographic quadrangles and aerial photographs. It is also a data format to which ARC/INFO reads and writes.
EROS	USGS Earth Resources Observation Systems Data Center is an archive for remotely sensed data such as aerial photographs and satellite land remote sensing data. The Center is located near Sioux Falls, South Dakota.

GLOSSARY cont.

ESRI	Environmental Systems Research Institute, Inc., a producer of commercial GIS software, including ARC/INFO and ArcView.
National Geospatial Data Clearinghouse	The USGS node of the Geospatial Data Clearinghouse contains metadata on geospatial data available from USGS. The Clearinghouse is part of NSDI.
GIS	Geographic Information Systems integrate database operations with the visualization capabilities of maps. Images are stored as spatial data and can be linked to data in relational databases. In a GIS, the results of a database query is displayed on a map.
GIS layer	A coverage representing a single theme. Types or themes of spatial data are usually stored separately, such as roads, buildings, streams, trees, land use, land cover, etc.
Glacial lake	A lake formed in the trough created by the migration of a glacier.
GPS	Global positioning system. A system using satellites to determine coordinates on the Earth's surface. Base station and hand-held receivers receive positional information from the satellites. Coordinates can be obtained in real-time or by computing differential conversion.
Hydrologic unit	A component of a four level system of division which organizes the hydrology of the United States into regions, sub-regions, accounting, and cataloging units.
Land cover	Mapped using aerial photography or satellite imagery, land cover types identify the natural features on the Earth's surface.
Landsat	An Earth resources satellite, Landsat 1, formerly Earth Resources Technology Satellite-A (ERTS-A), was launched by NASA in 1973. Landsat 2 (ERTS-B) launched in 1975. Subsequent launches were Landsat 3 (1978), Landsat 4 (1982) and Landsat 5(1984). Landsat 7 is expected to launch in February 1999.

GLOSSARY cont.

Land use	The classification of human use of land cover features on the Earth's surface.
Metadata	Data about data. Metadata provides information on the statistics and characteristics of datasets.
MSS	References Landsat multispectral scanner land surface information data from the early 1970's to 1992. The MSS sensor recorded the reflected radiation from the Earth's surface in the visible and mid-infrared wavelength bands of the electromagnetic spectrum.
Reach Files	Hydrologic databases created by USGS and U.S. EPA that identify and connect the stream segments of the US surface water drainage system. These databases support mapping and spatial analysis applications. Three versions, RF1, RF2, and RF3, are currently available.
Remote sensing	Information about the Earth's surface features collected by sensing the electromagnetic energy they disseminate.
Resolution	The measurement of the ability of a remote sensing system to distinguish between close or similar objects in a remotely sensed image.
Spatial data	The topology and coordinates of geographic features.
STATSGO	The State Soil Geographic Data Base, a soil survey product developed by the USDA NRCS, is for state and regional use as a reference tool. It contains vectorized map data and associated relational tables of soil and vegetation information.
STORET	Storage and Retrieval of U.S. Waterways Parametric Data. STORET is EPA's national water quality data system.
TIGER	The Topologically Integrated Geographic Encoding and Referencing system and database of geographic information developed by the Census Bureau. The geographical data contained in the TIGER database is available to the public for use with mapping and GIS softwares. TIGER is a registered trademark.

TM	References Landsat thematic mapper land surface information data from the early 1980's to the present. The TM sensor records images spanning the visible, mid-infrared, and into the thermal-infrared wavelength bands of the electromagnetic spectrum. Landsat data is archived by the USGS EROS Data Center.
Topology	The relationships between adjacent or coincident spatial features. Topology eliminates duplication of coordinate information to describe coincident features. For example, for two adjacent polygons that share a common boundary, topology requires only one set of coordinate and vector information for that boundary to successfully recognize either or both polygons.
Topographic maps	Maps that show a horizontal or plan view of features on and elevation contours of the Earth's surface.
U.S. EPA data	The President's Executive Order 12906 (Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure (NSDI) mandated each Federal Agency or Department to establish a Geospatial Data Clearinghouse. U.S. EPA is developing its own node on the National Geospatial Data Clearinghouse. The Spatial Data Library System (ESDLS) is a major component on the node. It provides a consistent Agency-wide spatial data management infrastructure. ESDLS contains the following coverages: TIGER 92; coverages of EPA regulated entities; GNIS2; TIGER 90 Block and Block Group boundaries and point centriods; 1:2M DLG for roads, hydrography, and state and county boundaries; U.S. EPA Reach File Version 1.0 (RF1);1:250K land use/landrover GIRAS spatial data; and Fish and Wildlife Refuge and National Park Service boundaries. The EPA point coverages will be generated from the Agency's ENVIROFACTS database which contains information on EPA's regulated facilities. ESDLS also contains statistics from the Bureau of the Census STF-3A and PL/94-171 files in the Oracle data base. U.S. EPA has assembled its regulatory data in Envirofacts, provides access to the Census Bureau's demographic data in Oracle through mapping applications developed by the

	Agency. The Envirofacts database consolidates regulatory data from six EPA national data systems: the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS), the Permit Compliance System (PCS), the Resource Conservation and Recovery Information System (RCRIS), the Toxic Release Inventory System (TRIS), the Grants Information and Control System (GICS), and the Envirofacts Aerometric Information Retrieval System/AIRS Facility Subsystem (AFS). The Safe Drinking Water Information System may be added by now.
WBLMER	Waquiot Bay Land Margin Ecological Research project sponsored by the National Science Foundation.
WBNERR	Waquiot Bay National Estuarine Research Reserve

APPENDIX A

SUMMARY OF INFORMATION USED IN THE WATERSHED STUDIES

TABLE A-1

Information Used in the Watershed Studies

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
WATERSHED BOUNDARY OR STUDY AREA						
Mid-Snake	Yes	USGS	Paper/HUC map		1:500,000	
Mid-Platte	Yes	USGS	GIS/HUC map		1:250,000	
Waquoit Bay	Yes	CCC, WBLMER	GIS/DLG		1:250,000	
Clinch	Yes	USGS	GIS/HUC (fourth field)		1:250,000	
Big Darby	Yes	USGS	GIS/DEM		30 m	
Lake Chelan	Yes	USGS	Topographic map		15 minute	
W Fk Cl Crk	Yes	USGS	Topographic map		100 ft contours	
Ind-Dedwd	Yes	USGS	GIS/HUC (fourth field)		1:250,000	Limited resolution
Edisto	Yes	USGS	GIS/HUC		1:24,000	Some maps outdated
L. Mendota	Yes	USGS	GIS/DLG		1:24,000	
SUBWATERSHED BOUNDARY						
Mid-Snake	Not needed					
Mid-Platte	Not needed					
Waquoit Bay	Yes	WBLMER, Univ	GIS		1:100,000	
Clinch	Yes	USGS	GIS/DLG		1:1,000,000	
Big Darby	Not needed					
Lake Chelan	Not needed					
W Fk Cl Crk	Not needed					
Ind-Dedwd	Yes	USGS	GIS/HUC (sixth field), topographic map, aerial photos		1:250,000	
Edisto	Yes	USGS	GIS/HUC		1:24,000	

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
L. Mendota	Not needed					
MAP OF STREAM REACHES						
Mid-Snake	Yes	USGS	Topographic map		1:24,000	
Mid-Platte	Yes	USEPA	RF1 (inside basin)		1:500,000	
Waquoit Bay	Yes	USGS	GIS/DLG		1:250,000	
Clinch	Yes	USEPA	RF3		1:100,000	
Big Darby	Yes	USEPA	RF3		1:100,000	
Lake Chelan	Yes	USGS	Topographic map		15 min	
W Fk Cl Crk	Yes	USGS	Topographic map		1:24,000	
Ind-Dedwd	Yes	USGS	GIS/Topographic map, aerial photos		1:12,000	Several intermittent streams missing from topographic map
Edisto	Yes	USGS	GIS/DLG		1:24,000	
L. Mendota	Yes	USGS	GIS/DLG		1:250,000	
OTHER WATER BODIES						
Mid-Snake	Not needed					
Mid-Platte	Yes	USGS	GIS/DLG hydrography (for outside the basin)		1:2,000,000	
Waquoit Bay	Yes	USGS	Maps, GIS		NA	
Clinch	Yes	USGS	DEM		3 arc resolution	
Big Darby	Not needed					
Lake Chelan	Yes	USGS	Topographic map		15 min	
W Fk Cl Crk	Yes	USGS	Topographic map		1:24,000	

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
Ind-Dedwd	Yes	USDA	GIS/Cartographic Feature Files (CFF)		1:24,000	
Edisto	Yes	USGS	GIS/DLG		1:24,000	
L. Mendota	Not needed					
MAJOR ROADS						
Mid-Snake	Not needed					
Mid-Platte	Yes	US Federal Highway Adm	National Highway Planning Network		1:2,000,000	
Waquoit Bay	Not needed					
Clinch	Yes	USGS	GIS/DLG		1:1,000,000	
Big Darby	Yes	US Census Bureau	GIS/TIGER			Obtained commercial version from ESRI
Lake Chelan	Yes	USGS	Topographic map		15 min	
W Fk Cl Crk	Not needed					
Ind-Dedwd	Yes	USGS	GIS/CFF, topographic map, aerial photos		1:24,000	
Edisto	Yes	USGS	GIS/DLG		1:24,000	
L. Mendota	Yes	USGS	GIS/DLG		1:250,000	
COUNTY BOUNDARIES						
Mid-Snake	Yes	USGS	Paper/DLG		1:2,000,000	
Mid-Platte	Yes	US Census Bureau	GIS/ TIGER files		1:100,000	
Waquoit Bay	Not needed					
Clinch	Yes	USGS	GIS/DLG		1:250,000	
Big Darby	Yes	USGS	GIS/TIGER files		1:24,000	
Lake Chelan	Not needed					

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
W Fk Cl Crk	Yes	USGS	Topographic map		1:24,000	
Ind-Dedwd	Yes	State	GIS/CFF		1:24,000	
Edisto	Yes	USGS	GIS/DLG		1:24,000	
L. Mendota	Yes	WDNR	GIS/DLG		1:24,000	
MUNICIPAL BOUNDARIES						
Mid-Snake	Not needed					
Mid-Platte	Yes	USGS	GIS/Land use data		1:250,000	
Waquoit Bay	Not needed					
Clinch	Yes	USGS	GIS/TIGER files		1:100,00	
Big Darby	Yes	USGS	GIS/DLG		1:24,000	
Lake Chelan	Yes	USGS	Topographic map		15 min	
W Fk Cl Crk	Not needed					
Ind-Dedwd	Not needed					
Edisto	Yes	USGS	GIS/DLG		1:24,000	
L. Mendota	Yes	USGS	GIS/DLG		1:24,000	
BEDROCK GEOLOGY/GROUND WATER						
Mid-Snake	Yes	USGS	Open file report	1902-1992	Many points	
Mid-Platte	Yes	USGS, Nebraska DEQ, DOH	Literature files, field data			Need study
Waquoit Bay	Yes	USGS, CCC, WBLMER, Univ	Literature files, field data	Days	m	
Clinch	Yes	Va Cave Bd	Significant karst areas			
Big Darby	Not needed					

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
Lake Chelan	Yes	USGS, Washington DOE	High altitude photos (NHAP), field survey	1967, 1971, 1987	1:25,000 (color); 1:60,000 (U-2 false color infrared)	
W Fk Cl Crk	Yes	WQCD	Expert knowledge			
Ind-Dedwd	Yes	USGS	Geologic quadrangle map		1:250,000	Limited resolution
Edisto	Yes	USGS	Literature files			
L. Mendota	Yes	USGS, Geol. and Nat. His. Sur.	Literature files			
PRECIPITATION						
Mid-Snake	Yes	National Weather Service	Monitoring data	1951-1973, monthly mean		
Mid-Platte	Yes	National Weather Service	Monitoring data	Variable	Point data	Scattered data points
Waquoit Bay	Yes	CCC, USGS, WBLMER, Univ	Literature files, field data			
Clinch	Not needed					
Big Darby	Not needed					
Lake Chelan	Yes	NWS	Monitoring data (totalizing anemometer)	Continuous	3 sites	
W Fk Cl Crk	Yes	USGS	Database	Monthly	Not needed	
Ind-Dedwd	Yes	State climatologist	GIS	20 years/ monthly		
Edisto	Yes	Federal	Database	Annual	6 stations	Limited coverage
L. Mendota	Yes	State climatologist	GIS	Monthly		

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
EVAPORATION/WIND SPEED						
Mid-Snake	Yes	National Weather Service/ Pacific NW Riv Bas Comm	Monitoring data	1928-1994, daily min-max/ monthly average	2 points	
Mid-Platte	Not needed					
Waquoit Bay	Yes	WBLMER, Univ	Literature files, field data			
Clinch	Not needed					
Big Darby	Not needed					
Lake Chelan	Not needed					
W Fk Cl Crk	Not needed					
Ind-Dedwd	Not needed					
Edisto	Yes	USGS	Literature files			Data from different watershed
L. Mendota	No					
NPDES OUTFALLS (location and effluent concentration)						
Mid-Snake	Yes	USEPA	Permits	Monthly	Point data	
Mid-Platte	Yes	Nebraska DEQ, DOH	Monitoring data	Monthly	Point data	
Waquoit Bay	Not needed					
Clinch	Yes	USEPA	Monitoring data	Variable	Point data	Poor quality control in data transfer
Big Darby	Yes	Ohio EPA	Monitoring data		Point data	Locations were not accurate, corrected to within 15 m
Lake Chelan	No					

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
W Fk Cl Crk	Not needed					
Ind-Dedwd	Not needed					
Edisto	Yes	SCDHEC	Permits		1:24,000	Original location data often inaccurate
L. Mendota	Yes	State	Database			
FLOW GAUGING/STREAM GRADIENT						
Mid-Snake	Yes (stressor)	USGS, Idaho DWR, Idaho DEQ, consultants	Open file report (USGS), field data	1928-1994	4 points	Used model to estimate current daily flows
Mid-Platte	Yes	USGS, Nebraska Conservation and Surveys Division	Monitoring data	Variable	Stream reaches	
Waquoit Bay	Yes	USGS, WBLMER, Univ	Literature files, field data			
Clinch	Yes (stressor)	USGS, TVA	Monitoring data, calc. from DEM		Point data	Not enough data points
Big Darby	Yes	Ohio EPA	Computer database		0.1 river mile	
Lake Chelan	Yes	USGS	Open file report	1902-1985	Point data	
W Fk Cl Crk	Yes	USGS and permit holder	Database	Not needed		
Ind-Dedwd	Not needed					
Edisto	Yes	USGS	Monitoring data	Monthly	4 stations	
L. Mendota	Yes	USGS	Literature files	Daily		

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
STREAM USE						
Mid-Snake	Yes	Idaho Dept. Water Res.	Field data	1990-1994	Point data	
Mid-Platte	Yes	Nebraska DEQ	Monitoring data		River mile	
Waquoit Bay	Not needed					
Clinch	Not available					
Big Darby	Yes	Ohio EPA	Field observation	~5 year	River segment	
Lake Chelan	Yes	WDOE	Research data	Seasonal		
W Fk Cl Crk	Yes	WQCD	Database			
Ind-Dedwd	Yes	Forest Service and State Permits	Database and files			Incomplete
Edisto	Yes	Task Force	Research	One-time		Limited time frame
L. Mendota	Yes	WDNR	GIS/River Basin Reports		1:24,000	
WATER SUPPLY INTAKES (location and description)						
Mid-Snake	Yes	Idaho Dept. Water Res.	Field data	1990-1994	Point data	
Mid-Platte	Yes	Nebraska DEQ, DOH	Monitoring data		Point data	
Waquoit Bay	Not needed					
Clinch	Yes	EPA, VADEQ	Permits		Point data	
Big Darby	Yes	Ohio EPA	Field observation	~5 year	River segment	
Lake Chelan	Yes	WDOE	Research data	Seasonal	Point data	
W Fk Cl Crk	Yes	WQCD	Database			
Ind-Dedwd	Yes	Forest Service and State Permits	Database and files			Incomplete

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
Edisto	Yes	SCDOC	GIS		1:100,000	
L. Mendota	Yes	Drinking Water Bureau WDNR	Files			
REGULATED FLOW STRUCTURES						
Mid-Snake	Yes (stressor)	Idaho Power	Historical	1902-present		
Mid-Platte	Yes (stressor)	Nebraska DEQ, DOH	Historical		Point data	
Waquoit Bay	Not needed					
Clinch	Yes	TVA	Topographic map		Point data	
Big Darby	Yes	Ohio EPA	Field observation	~5 year	River segment	
Lake Chelan	Yes	WDOE	Historic		Point data	
W Fk Cl Crk	Yes	Permit holder	Not needed			
Ind-Dedwd	Yes		Interviews and historical maps			
Edisto	Yes	USFWS	GIS/National Wetlands Inventory (NWI)		1:24,000	
L. Mendota	Yes	Water Regulation and Zoning Section	Files			
STREAM WATER QUALITY						
Mid-Snake	Yes (stressor)	Idaho DEQ, Idaho St Univ, ARS, Idaho Power	Monitoring data	1990-1995	River Mile	Interpolation was necessary for the daily time step
Mid-Platte	Yes (stressor)	USGS, NDEQ, NDOH, NRD	Monitoring data	Variable	Point data	Not enough sampling points on tributaries
Waquoit Bay	Yes (stressor)	USGS, WBLMER, Univ	Research data, monitoring data			

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
Clinch	Yes (stressor)	TVA, VA, FWS, Univ	STORET			STORET data is being modified for inclusion as a GIS layer
Big Darby	Yes (stressor)	Ohio EPA	STORET, field observation		River segment	
Lake Chelan	Yes (stressor)	Canada Centre for Remote Sensing, WDOE	Landsat, field sampling	1985	30 m	
W Fk Cl Crk	Yes	Permit holder, USFS, USGS, CDH, CDNR	Database			
Ind-Dedwd	Yes	USFS	Stream survey field data	91-95/0.5 hr	20% coverage	
Edisto	Yes	SCDHEC	monitoring data	Monthly	11 stations	Limited historical data
L. Mendota	Yes	WDNR	River Basin Reports and Literature			
STREAMBED SUBSTRATE						
Mid-Snake	Yes (endpoint)	USFWS, Idaho Power	Habitat Suitability Curves	1990-1995		
Mid-Platte	Yes	Nebraska Games and Parks, USFWS, Nebraska Power	Monitoring data	Variable	River Mile	
Waquoit Bay	Yes	Trout Unlimited, WBLMER, Univ	Research data			
Clinch	Yes	TVA, VA, FWS, Univ	Monitoring data	Variable	Point data	Yes
Big Darby	Yes	Ohio EPA	Monitoring data	1992-1993	63 sampling points	
Lake Chelan	Yes	Washington DOE	Monitoring data	1987	~20 sites	

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
W Fk Cl Crk	Not needed					
Ind-Dedwd	Yes	USFS	Stream survey field data		20% coverage	Incomplete data
Edisto	Not needed					
L. Mendota	Yes	WDNR	Field analyses			
STREAM BIOLOGICAL COMMUNITIES						
Mid-Snake	Yes (endpoint)	Univ of Idaho, FERC, USFWS	Field data, literature review	1990-1995	River mile	
Mid-Platte	Yes (endpoint)	USFWS, DEQ, private	Monitoring data	Variable	Point data	
Waquoit Bay	Yes (endpoint)	USGS, WBLMER, Univ	Research data, monitoring data		Point data	
Clinch	Yes	TVA, VA, FWS, Univ	Field data, literature review	1989-93 (TVA)	River mile	
Big Darby	Yes	Ohio EPA, Ohio St. Univ	Field data	1992-1993	63 sampling points	
Lake Chelan	Yes (endpoint)	Washington DOE	Field data	1982-84, 1986, 1987		
W Fk Cl Crk	Yes	WQCD, Dept of Wildlife (DOW), Permit holder	Field measurements			
Ind-Dedwd	Not available					
Edisto	Yes	SCDNR	Stream survey field data			Limited data
L. Mendota	Yes	WDNR	Field analyses			
FISH HATCHERIES						
Mid-Snake	Yes (stressor)	Univ Idaho/ARS	Field data	1990-1991	144 points	
Mid-Platte	Not needed					
Waquoit Bay	Not needed					

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
Clinch	Not needed					
Big Darby	Not needed					
Lake Chelan	Yes	Consulting/ Local	Monitoring data	1987	Point data	
W Fk Cl Crk	Not needed					
Ind-Dedwd	Yes	USFS	Stream survey field data		20% coverage	Incomplete data
Edisto	Yes	USFWS	Literature files	Variable	Unknown	
L. Mendota	Yes	WDNR	Field analyses			
ENDANGERED SPECIES						
Mid-Snake	Yes	USFWS	Snake River Aquatic Recovery Plan	1995	Point data	
Mid-Platte	Yes (endpoint)	USFWS, DEQ, private	Historical	Variable	Point data	
Waquoit Bay	Yes	MA Natural Heritage, WBNERR, WBLMER, Univ	Research data, monitoring data			
Clinch	Yes (endpoint)	TVA, FWS, TNC	Field data, literature files	Variable	Point data	
Big Darby	Not needed					
Lake Chelan	Not needed					
W Fk Cl Crk	Yes	USFWS, DOW	Database			
Ind-Dedwd	Yes	USFS, State	Database		1:24,000	
Edisto	Yes	SCDNR	GIS/Field surveys			Limited surveys, No data for many areas
L. Mendota	Yes	WDNR & USFWS	Database			

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
WETLANDS						
Mid-Snake	Yes	IDEQ	Literature files, field data	1994	River mile	
Mid-Platte	Yes	USFWS	GIS/NWI		1:24,000	
Waquoit Bay	Yes (endpoint)	MA DEP	Aerial photos	Scattered	Variable	
Clinch	Yes	USFWS	GIS/NWI		1:24,000	
Big Darby	Not needed					
Lake Chelan	Not needed					
W Fk Cl Crk	Not needed					
Ind-Dedwd	Yes	USFWS	GIS/NWI		1:24,000	
Edisto	Yes	SCDNR/USFWS	GIS/NWI		1:24,000	
L. Mendota	Yes	WDNR and NRCS	Digitized maps		1:24,000	
RIPARIAN CHARACTERISTICS						
Mid-Snake	Yes	IDEQ	Literature files, field data	1994	River mile	
Mid-Platte	Yes (endpoint)	TNC, Nebraska Games and Parks	Research data	Variable	River mile	
Waquoit Bay	Yes	USGS, WBLMER, Univ	Research data			
Clinch	Yes	NASA	Landsat		30 m	
Big Darby	Yes	USEPA, Ohio EPA	EMAP/REMAP			
Lake Chelan	Not needed					
W Fk Cl Crk	Not needed					
Ind-Dedwd	Yes	Project	Aerial photos, remote sensing		1:12,000	See discussion

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
Edisto	Yes	SCDNR	Aerial photos/Landuse inventory		1:24,000	
L. Mendota	Yes	County Land Conservation Depts. (LCD)	County aerial photos		1:24,000	
SOIL CHARACTERISTICS						
Mid-Snake	Yes (endpoint-sediment)	ARS, IDEQ, Univ Idaho	County Soil Surveys, River Basin Reports	1976-1981		
Mid-Platte	Yes	SCS	County Soil Surveys			
Waquoit Bay	Yes	USGS, WBLMER	County Soil Surveys, research data			
Clinch	Yes (stressor-sediment)	NRCS	County Soil Surveys			
Big Darby	Yes (stressor-sediment)	Ohio DNR	STATSGO		1:250,000	
Lake Chelan	Yes	Washington DOE	Field data	1987		
W Fk Cl Crk	Yes	Permit holder	County Soil Surveys			
Ind-Dedwd	Yes	USDA-NRCS	County Soil Surveys		1:20,000	Biased to agricultural use
Edisto	Yes	USDA-NRCS	County Soil Surveys		1:20,000	
L. Mendota	Yes	USDA-NRCS	Soil Survey Map		1:20,000	
LAND USE/LANDCOVER						
Mid-Snake	Yes	NASA	Landsat		30 m	
Mid-Platte	Yes	USGS	GIS/GIRAS		1:250,000	
Waquoit Bay	Yes	USGS, Municipalities	Landsat, parcel data into ARC/INFO		30 m	
Clinch	Yes	NASA	Landsat		30 m	
Big Darby	Yes	NASA	Landsat		30 m	
Lake Chelan	Yes	USGS	Literature file	1976		

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
W Fk Cl Crk	Yes	Permit holder	Research data			
Ind-Dedwd	Yes	USFS, State, County	USFS permits, county tax files, state land ownership		1:12,000	
Edisto	Yes	SCDNR/USFWS	Aerial photos		1:24,000	
L. Mendota	Yes	WDNR, County Land Conservation Depts., NRCS	Computer database		1:24,000	
HISTORIC LAND USE						
Mid-Snake	Yes	Idaho DEQ	Literature files	1907-		
Mid-Platte	Yes (stressor)	Federal	Historical		1:900,000	
Waquoit Bay	Yes	State, Municipalities	Aerial photos, parcel data into ARC/INFO/VIEW		3 m	Skewed to present
Clinch	Yes	TVA	Aerial photo			
Big Darby	Not needed					
Lake Chelan	Not needed					
W Fk Cl Crk	Yes					
Ind-Dedwd	Yes	USFS	Logging history data base, history of human settlement	1950-present	1:12,000	Does not include private land
Edisto	Yes	USDA and Forest Service	Literature files, Ag census, Forest survey	10 year	County	
L. Mendota	Yes	WDNR & Country LCD	River Basin Reports			
SUPERFUND SITES/LANDFILLS						
Mid-Snake	Not needed					
Mid-Platte	Not needed					

TABLE A-1 cont.

Watershed	Obtained?	Source	Format	Temporal Range and Coverage	Spatial Scale or Resolution	Limitations or Problems
Waquoit Bay	Yes	HAZRAP, AFCEE	Research data, monitoring data			
Clinch	Not needed					
Big Darby	Yes	USEPA, Ohio EPA				
Lake Chelan	Not needed					
W Fk Cl Crk	Not needed					
Ind-Dedwd	Not needed					
Edisto	Yes	SCDHEC	Database			
L. Mendota	Yes	WDNR	Files			
LOCAL POPULATION ESTIMATES						
Mid-Snake	Yes	US Census Bureau	Database	1920-1990		
Mid-Platte	Yes	Nebraska DEQ	Database	10 year		
Waquoit Bay	Yes	Municipalities US Census Bureau	Database	10 year		
Clinch	Yes	US Census Bureau	GIS/TIGER	10 year		
Big Darby	Yes	US Census Bureau	GIS/TIGER	1990-1996		Obtained commercial version from ESRI
Lake Chelan	Yes	US Census Bureau	Database	1902-1990		
W Fk Cl Crk	No					
Ind-Dedwd	Yes	US Census Bureau	Database	10 year		
Edisto	Yes	US Census Bureau	Database	10 year	16 sq. miles	
L. Mendota	Yes	Regional Planning Commission	Database	10 year		

APPENDIX B

INFORMATION SUMMARY BY WATERSHED

TABLE B-1

Information Summary for the Middle Snake River

CATEGORY	INFORMATION SUMMARY
Base Mapping	
Geographic Management Unit	
Study area base map	The study area extends about 100 km from Milner Dam to King Hill.
Subwatershed boundary	Subwatersheds were not delineated.
Major Hydrology	
Map of stream reaches	Homogeneous reaches of the river were identified on topographic maps from existing data for the analysis.
Other water bodies	A schematic shows locations of dams, tributaries, inflows, water withdrawals, and River Mile.
Major Roads	Roads were not included in the study.
Political Boundaries	
County	A map of Idaho with county boundaries delineated was included in the site characterization.
Municipal	Municipal boundaries were not delineated for the study.
Analytical Data	
Bedrock/Groundwater	The study area lies within the eastern unit of the Snake River Plain. Four major waterfalls occur over basalt ledges. The site is underlain by the largest and most productive aquifer in the northwest, the aquifer contributes to flow in the river through springs. Monitoring data is available from USGS reports.
Meteorology	
Precipitation	Precipitation averages 27 cm/year. It is evenly distributed except for the summer months.
Evaporation rates	Wind speed and relative humidity were needed for the risk analysis. There were only two available data points, widely spaced. Mean air temperatures for the period 1951-1973 for Twin Falls were -1.4°C for January and 22.6°C for July.
Stream Environment	
NPDES outfalls	USEPA is responsible for the NPDES program. The point sources of greatest concern are municipal facilities, fish hatcheries, and confined animal feeding operations.

TABLE B-1 cont.

CATEGORY	INFORMATION SUMMARY
Flow gauging, stream gradient	USGS maintains gauging stations at several locations, including both the uppermost and lower most stream segments. USGS also maintains gauges at important inflow points. Until 1992, the entire river was diverted for agriculture. The current FERC license requires a target flow of 6cm^3/second, if available. These changes in the system were considered in the hydrological component of the model. Gradient was calculated from existing cross-sectional studies for the analytical report.
Stream use information	Stream use is mostly for irrigation, municipal withdrawals, trout hatcheries, and recreation.
Water supply intake locations	Until recently, the entire river was diverted from April to October for irrigation. In 1992, FERC required a target flow be maintained.
Regulated flow structures	There are five impoundments on the mainstem. There are many structures on tributaries.
Streambed substrate	A roughness coefficient was calculated using methodology developed by USACE. Sediment deposition smothers macroinvertebrates and promotes macrophyte growth. More field work is required.
Stream water quality	Field data collected by the state and universities from 1990-1995 was combined to provide good coverage for the study area, particularly from Milner Dam to Lower Salmon Falls. Suspended sediment and nutrient enrichment were identified as primary stressors.
Aquatic Biological Resources	
Fish hatcheries	140 privately owned commercial trout farms and 4 state or federal farms are located in the study area.
Stream biological communities	Historical description of vertebrate and invertebrate species diversity and decline from hydropower development. Fish monitoring was conducted by the state. Vascular macrophytes and algae--species associated with nutrient-rich water--cover up to 40% of the benthic habitat. Results of the effects analysis are presented graphically by River Mile and show probability of life stage impairment (i.e., spawn, incubation, fry, adult) for the coldwater species of concern.
Endangered species	The USFWS draft Recovery Plan describes remedial action to protect threatened and endangered fish and snails, including runs of Chinook salmon.
Terrestrial Biological Resources	
Wetlands	Wetlands provide critical habitat for waterfowl breeding, nesting, and migration; however, wetlands were not addressed in this phase of the assessment.
Riparian corridor characteristics	The remaining riparian corridor is a narrow band of vegetation adjacent to the river; however, it was not addressed in this phase of the assessment.
Soil characteristics	Erosion from poor agricultural practices contributes to the sediment load. The ARS, Idaho DEQ, and the University of Idaho designed a comprehensive study in consideration of the watershed risk assessment. This study was not directly used in this analysis.
Land Use/Land Cover	Land use is part of the ARS study. Agriculture and grazing account for 93% of the land use; urban areas and forests make up the remaining 7% of the land use in the study area.

TABLE B-1 cont.

CATEGORY	INFORMATION SUMMARY
Historic Land Use	Farmers have diverted water from Snake River tributaries since 1907.
Superfund Sites/Landfills	Not discussed.
Local Population Estimates	58% of the population of Idaho's South Central Region lives in five municipalities along the study area.

TABLE B-2

Information Summary for the Middle Platte River Floodplain

CATEGORY	INFORMATION SUMMARY
Base Mapping	
Geographic Management Unit	
Study area base map	The study area extends 200 km from North Platte to Grand Island and encompasses 2,000 km^2.
Subwatershed boundary	Subwatersheds were not delineated.
Major Hydrology	
Map of stream reaches	A schematic shows locations of dams, tributaries, inflows, water withdrawals, and River Mile.
Other water bodies	DLG data was used for water bodies outside the watershed study area.
Major Roads	The resolution of the regional transportation network was coarse in relation to the base map.
Political Boundaries	
County	TIGER files were used to delineate county boundaries.
Municipal	Land use data was used to delineate urbanized areas.
Analytical Data	
Bedrock/Groundwater	The Middle Platte river valley is underlain by a porous formation and low permeable chalk and limestone shales, forming the "high plains aquifer system." Groundwater hydrology is an ecosystem assessment endpoint that needs more study.
Meteorology	
Precipitation	Annual precipitation averages 57 cm.
Evaporation rates	The study area is considered semihumid.
Stream Environment	The analytical portion of the study will use an IHA model to provide quantitative measures of variation. This model considers the following variables: 1) magnitude of water condition, 2) timing of occurrence of a specific water condition, 3) frequency of occurrence of a specific water condition, 4) duration of time over which a specific water condition occurs, and 5) rate of change of the water condition over a specified time interval.
NPDES outfalls	NPDES data is available from the Nebraska DEQ and DOH.

TABLE B-2 cont.

CATEGORY	INFORMATION SUMMARY
Flow gauging/stream gradient	Data include longitudinal river stage (schematic) and mean annual stream flow; some data was measured, some calculated. Stream gradient information has been developed for irrigation canal development.
Stream use information	Stream segments have been assessed for recreation, aquatic life, agriculture, and industry by the Nebraska DEQ.
Water supply intake locations	Nebraska DWR is responsible for instream flow. There is no surface water supply for communities; wells supply the water.
Regulated flow structures	Low head dams are used for irrigation.
Stream bed substrate	
Stream water quality	There are some concerns about the distance between water quality monitoring stations.
Aquatic Biological Resources	
Primary shellfish waters	Research data related to food source for sandhill cranes and other waterfowl.
Fish hatcheries	There are no hatcheries in the study reach.
Stream biological communities	
Endangered species	Sightings and migration corridors for the whooping crane occur in the study area. Least tern and piping plover also occur within the study area.
Terrestrial Biological Resources	
Wetlands	Wetlands have been characterized according to the habitat they provide for breeding core-grassland birds.
Riparian corridor characteristics	The analytical phase will address landscape scale, influences on riparian habitat use by breeding neotropical migrant birds, and species and habitat survey information to study of biodiversity.
Soil characteristics	The soil is primarily alluvial.
Land Use/Land Cover	Land use land cover data is available from Nebraska's GAP analysis. Eighty percent of the watershed is in private ownership and used for agriculture.
Historic Land Use	
Superfund Sites/Landfills	
Local Population Estimates	Grand Island, the largest city in the study, has a population of about 40,000.

TABLE B-3

Information Summary for Waquoit Bay

CATEGORY	INFORMATION SUMMARY
Base Mapping	
Geographic Management Unit	
Watershed boundary	The watershed covers about 53 km^2 (21 $miles^2$). It extends 8 km (5 miles) from the head of the bay to the regional groundwater divide.
Subwatershed boundary	There are seven subwatersheds in the study area.
Major Hydrology	
Map of stream reaches	Not applicable.
Other water bodies	There are four large ponds in the study area.
Major Roads	
Political Boundaries	
County	County boundaries are not included in the study.
Municipal	Municipal boundaries are not included in the study.
Analytical Data	
Bedrock, Groundwater	The watershed is composed of glacial materials deposited on top of bedrock. The aquifer, and sole source of drinking water, is under pressure from urban development and contaminated by plumes from a Superfund site.
Meteorology	
Precipitation	One hundred percent of the freshwater entering the estuary is from precipitation (113 cm/yr./46% recharge).
Evaporation rates	Evaporation rates are considered in the analysis.
Stream Environment	
NPDES outfalls	NPDES data was not used in the analysis.
Flow gauging, stream gradient	Flow estimates are available from research data.
Bay use information	Aquatic activities include recreational boating, shellfishing, and swimming.
Water supply intake locations	Intake locations were not considered in the analysis.
Regulated flow structures	There is a gate-controlled spillway at John's Pond, the largest source of freshwater flow to the estuary.

TABLE B-3 cont.

CATEGORY	INFORMATION SUMMARY
Bedrock, groundwater hydrology	The aquifer, and sole source of drinking water, is under pressure from urban development and contaminated by plumes from a Superfund site.
Bed substrate, habitat	The estuarine substrate is composed of loose glacial sand and gravel.
Stream water quality	Eutrophication causes water quality problems in the Bay.
Aquatic Biological Resources	
Fish hatcheries	The eelgrass beds provide habitat for fish nurseries.
Stream biological communities	Eelgrass is being replaced by thick mats of macroalgae. Fifty-two species of finfish were collected in the Bay.
Endangered species	Endangered birds (piping plover, least tern, roseat tern) and an endangered plant (sandplain gerardia).
Terrestrial Biological Resources	Terrestrial resources are not included in the analysis at this time.
Wetlands	Freshwater wetlands occur along pond and river shores.
Riparian corridor characteristics	
Soil characteristics	Soil characteristics are explicitly considered in the model.
Land Use/Land Cover	The watershed contains freshwater streams and ponds, salt ponds and marshes, pine and oak forest, barrier beaches, and open estuarine waters. The primary development pressures are from residential and business development (marine-dependent industry)
Historic Land Use	Land use/landrover maps were generated for 1951, 1971, 1980, 1985, and 1990. Change hectare over time for 24 land use classes was generated.
Superfund Sites/Landfills	The Massachusetts Military Reservation, a Superfund site, is located in the study area.
Local Population Estimates	Population data for the last 5 years, for the previous 5-10 years, and for more than 10 years ago was correlated with groundwater travel time to tidal area to estimate the impact of population growth on nitrogen loading in the estuary.

TABLE B-4

Information Summary for the Clinch Valley

CATEGORY	INFORMATION SUMMARY
Base Mapping	
Geographic Management Unit	
Watershed boundary	The Clinch River Basin covers an area of about 1131 km^2.
Subwatershed boundary	Three subwatersheds were selected for analysis: Cooper Creek, Upper Clinch River, and Upper Powell River.
Major Hydrology	
Map of stream reaches	Stream reaches were considered in the GIS base map.
Other water bodies	Other water bodies were included in the GIS base map.
Major Roads	Major roads were included in the GIS base map.
Political Boundaries	
County	County boundaries were included in the GIS base map.
Municipal	Municipal boundaries were considered in the GIS base map.
Analytical Data	
Bedrock/Groundwater	Groundwater and surface water interact extensively. The basin contains extensive karst formations in the Ridge and Valley province.
Meteorology	
Precipitation	Researchers are considering obtaining historical precipitation records.
Evaporation rates	Evaporation is not included in the analysis.
Stream Environment	
NPDES outfalls	Permit compliance data from USEPA is incorporated as a GIS data layer.
Flow gauging, stream gradient	Gradient was calculated from DEM data. Streamflow ranges from 1593 ft^3/second to 190 ft^3/second
Stream use information	Rivers and springs provide drinking water for households, municipalities, and livestock and recreational opportunities for the local population.
Water supply intake locations	Water intake locations from permits were incorporated in the GIS and used in the analysis.

Regulated flow structures	There are no regulated flow structures in the study area; although, Norris Dam (TVA) receives the flow from both the Clinch and Powell Rivers.

TABLE B-4 cont.

CATEGORY	INFORMATION SUMMARY
Streambed substrate, quality of habitat	Field data is available from Virginia and TVA.
Stream water quality	Stream water quality data is available from TVA monitoring stations, STORET, and from monitoring following a coal slurry spill. A Water Quality 305(b) Assessment Report identified violations of fecal coliform standards. STORET data is being incorporated as a GIS layer.
Aquatic Biological Resources	
Fish hatcheries	There are no fish hatcheries in the study area.
Stream biological communities	The assemblage of fish and freshwater mussels is among the most diverse in North America. TVA monitored stream biology during the 1970's - 1990's. Historic information is available back to the late 1800's.
Endangered species	The Clinch River Basin supports more imperiled mussel and fish species than any other basin in Virginia. Recovery plans have been developed for most of the federally protected species.
Terrestrial Biological Resources	
Wetlands	Wetlands are not being considered in the assessment.
Riparian corridor characteristics	Riparian corridor integrity is an assessment endpoint because of its role in reducing soil and nutrient loss from runoff and bank erosion.
Soil characteristics	Soil loss estimates were developed from Best Management Practices.
Land Use/Land Cover	Land use/land cover coverages were developed from LANDSAT data, and correlated with stream water quality in the analysis.
Historic Land Use	Aerial photographys are available from TVA, and may be scanned and digitized to include a historical re-creation of stressors.
Superfund Sites/Landfills	There are no Superfund sites in the study area.
Local Population Estimates	Population estimates from TIGER files were incorporated as a data layer in the GIS.

TABLE B-5

Information Summary for Big Darby Creek

CATEGORY	INFORMATION SUMMARY
Base Mapping	
Geographic Management Unit	
Watershed boundary	Mapped from DEM data.
Subwatershed boundary	Subwatersheds were not delineated for the WERA study. They are being delineated by OEPA.
Major Hydrology	
Map of stream reaches	Stream reaches were mapped from Reach File 3a.
Water bodies	Not applicable.
Major Roads	TIGER data files were obtained from ESRI with purchase of ARCINFO. These files were prepared for immediate compatibility with the GIS software. DLG data was too coarse for the watershed study.
Political Boundaries	
County	County boundary delineations provided by ESRI.
Municipal	Municipal boundary delineations provided by ESRI.
Analytical Data	
Bedrock/Groundwater	Geology was not included in the study.
Meteorology	
Precipitation	Precipitation was not included in the study.
Evaporation rates	Evaporation rates were not included in the study.
Stream Environment	
NPDES outfalls	The NPDES data was converted for use as a data layer in the GIS.
Flow gauging/stream gradient	There is one station in study area. Staff are looking for flow data. Stream gradient was calculated (feet/mile) by OEPA.
Stream use information	Field data was collected for Big Darby Creek and its tributaries by OEPA for the non-point source assessment.
Water supply intake locations	Field data was collected for Big Darby Creek and its tributaries by OEPA for the non-point source assessment.

TABLE B-5 cont.

CATEGORY	INFORMATION SUMMARY
Regulated flow structures	Low head dams are located in the study area.
Streambed substrate	Habitat degradation is incorporated into the IBI.
Stream water quality	Water quality was estimated from the three biological indices. Staff are reviewing STORET data for inclusion in the study.
Aquatic Biological Resources	
Primary shellfish waters	Data has been collected on mussel diversity in Big Darby Creek by River Mile.
Fish hatcheries	There are no fish hatcheries in the study area.
Stream biological communities	Biological indices were calculated over time by River Mile.
Endangered species	A species list was included in the P&PF Report, but endangered species were not included in the analysis.
Terrestrial Biological Resources	
Wetlands	Wetlands are not being considered in the study.
Riparian corridor characteristics	The riparian corridor was not discussed in the P&PF Report, but work is ongoing by Dale White (OEPA).
Soil characteristics	The STATSGO data for Ohio is being incorporated into the GIS. There are about 20 map units for the state.
Land Use/Land Cover	Steve Gordon, Ohio State University, is developing this coverage from LANDSAT data.
Historic Land Use	Historic land use is not being considered in the analysis.
Superfund Sites/Landfills	Harshburger Landfill occurs in the watershed.
Local Population Estimates	Population estimates were included from a commercial software (ESRI).

TABLE B-6

Information Summary for Lake Chelan

CATEGORY	INFORMATION SUMMARY
Base Mapping	
Geographic Management Unit	
Watershed boundary	The watershed encompasses 2393 km^2 (924$miles^{2)}$.
Subwatershed boundary	Subwatersheds were not explicitly considered in the analysis.
Major Hydrology	
Map of stream reaches	The lake is divided into two distinct morphometric basins; the lower basin is relatively shallow (43 m, 140 ft deep), while the upper basin has steep walls and a mean depth of 180 m (590 ft).
Other water bodies	Chelan River empties into the Columbia River
Major Roads	Roads were not discussed in the study.
Political Boundaries	
County	County boundaries are not applicable to the study.
Municipal	The City of Chelan is the major population center; a smaller population center exists at Manson.
Analytical Data	
Bedrock Geology/Groundwater	Surficial soil and rock outcrops were mapped to evaluate the suitability of the soil for on-site wastewater disposal. Fifteen monitoring wells were installed downgradient of septic systems, and an additional eight were also installed upgradient and in agricultural areas. The objective was to evaluate wastewater transport and attenuation within the basin. Groundwater contributions to the water balance were assumed to be negligible.
Meteorology	
Precipitation	There are three rain gauges in the study area. Atmospheric deposition was estimated for phosphorus.
Evaporation rates	A totalizing anemometer was used to measure daily total wind movement. A relative humidity gauge also provided continuous data.
Stream Environment	
NPDES outfalls	Wastewater treatment is provided by the City of Chelan; the effluent is discharged into the Columbia River.
Flow gauging stations	Average annual discharge since 1904 is 56 m^3/second (2,050 ft^3/second). Total water residence time is 10.6 years; water residence time in the lower basin is 0.84 years.
Stream use information	Recreation and withdrawal is the primary use of the lake.

TABLE B-6 cont.

CATEGORY	INFORMATION SUMMARY
Water supply intake locations	Municipal intakes are located under the lake.
Regulated flow structures	A hydroelectric dam was built in 1927 within the City of Chelan.
Streambed substrate, habitat	Sediment in the lake was sampled to evaluate toxic accumulation versus land use and to estimate sedimentation rates.
Stream water quality	Analysis of LANDSAT data was used to evaluate spatial variation in temperature and chlorophyll a across the surface of the lake. This information was used to select 10 stations for routine water quality monitoring. About half of the residents use on-site septic systems.
Aquatic Biological Resources	
Fish hatcheries	Salmon net pens located on the lake are point sources of phosphorus.
Stream biological communities	Fish were collected and analyzed for pesticides, PCBs, and metal contaminants.
Endangered species	Endangered species are not addressed in this study.
Terrestrial Biological Resources	
Wetlands	Wetlands are not addressed in this study.
Riparian corridor characteristics	A riparian corridor is not applicable to this study.
Soil characteristics	Surficial soil and rock outcrops were mapped to evaluate the suitability of the soil for on-site wastewater disposal.
Land Use/Land Cover	The dominant land use is undeveloped forest managed by USFS for recreation. Four percent of the watershed is developed, primarily for apple orchards.
Historic	Historic land use is not applicable to the study.
Superfund Sites	There are no Superfund sites in the watershed.
Landfills	Landfills are not addressed in the study.
Small Area Population/Household Estimates and Projections	Total resident population within the basin in 1987 was 6,600. This does not include the large seasonal fluctuations. Population growth increased 12.5% from 1970-1980; this rate of increase is expected to continue.

TABLE B-7

Information Summary for West Fork Clear Creek

CATEGORY	INFORMATION SUMMARY
BASE MAPPING	
Geographic Management Unit	
River basin	USGS 1:24,000 scale topographic quadrangle maps were used to delineate the river basin. Information was supplemented by site visits.
Watershed boundary	USGS 1:24,000 scale topographic quadrangle maps were used to delineate the boundaries. Information was supplemented by site visits.
Subwatershed boundary	USGS 1:24,000 scale topographic quadrangle maps were used to delineate the boundaries. Information was supplemented by site visits.
Major Hydrology	
Map of stream reaches	USGS 1:24,000 scale topographic quadrangle maps were used to delineate the stream reaches. Information was supplemented by site visits.
Water bodies	USGS 1:24,000 scale topographic quadrangle maps were used to delineate the water bodies. Information was supplemented by site visits.
Major Roads	Roads were not relevant for this TMDL study.
Political Boundaries	
County	USGS 1:24,000 scale topographic quadrangle maps were used to delineate the boundaries. The watershed is all in one county.
Municipal	There are no municipalities within the immediate watershed.
ANALYTICAL DATA	
Subbasin Units	Two subbasins, Woods Creek and West Fork Clear Creek, were delineated based on USGS topographic maps.
Bedrock Geology	Basic understanding of the Geology was provided by the staff of the Colorado WQCD. Local mining industries also have information on the geology.
Imperviousness of subarea	The formation underlying Woods Creek comes to the surface near where Woods Creek and West Fork Clear Creek come together, based on field observations of the Colorado WQCD staff.
Fraction impervious/stream	Information on this topic was not needed for this TMDL study.
Meteorology	
Precipitation	USGS. 1985. National Water Summary for 1985. Water-Supply Paper 2300.

Evaporation rates (temperature and wind)	Information on this topic was not needed for this TMDL study.

TABLE B-7 cont.

CATEGORY	INFORMATION SUMMARY
Stream Environment	
NPDES outfalls	Information on NPDES outfalls is maintained by the Colorado WQCD. Two mines (one active, one inactive; owned and run by the same company) are covered by one NPDES outfall permit. There are no other industries or municipalities in the immediate watershed.
Flow gauging	Flow gauging information was obtained from USGS and the permit holder.
Stream use information	The Colorado WQCD has determined the primary designated uses of the affected reaches as cold water aquatic habitat, and recreation. West Fork Clear Creek, however, is classified as a higher quality fishery and, based on Colorado Water Quality Standards, a different set of water quality criteria apply to this stream.
Water supply intake locations	Information on water intakes was obtained from the Colorado WQCD.
Regulated flow structures	Two dams are present on Woods Creek forming reservoirs to collect mine effluent. Information on the dams was obtained from the permit holder.
Stream gradient, slope	Gradient information was not used, but could be obtained from USGS topographic maps.
Groundwater hydrology	Observational information on the groundwater hydrology was provided by Colorado WQCD staff.
Streambed substrate, habitat	Substrate was not specifically considered in the West Fork Clear Creek TMDL study. However, information on stream bed substrate, stream flow, and many other parameters is contained in two documents that every state is required to maintain under the Clean Water Act: the Section 303D "Waterbody List", and Section 305B "Report of Health of Water Resources in the State." In Colorado, these documents are maintained by the Colorado WQCD.
Stream water quality, physical, chemical	A number of organizations conduct monitoring on the creeks. Both the Urad and Henderson mines monitor water quality as required by the NPDES permits. Water quality along the affected reaches is also monitored by USFS, USGS, and the Colorado DOW and DNR.
Aquatic biological resources	Three sources of information were used: Colorado WQCD; Colorado DOW; and the permit holder.
Primary shellfish waters	Not applicable.
Fish nurseries	Not considered specifically in this TMDL study. Information could be obtained from the Colorado DOW and the USFWS.
Stream biological communities	Three sources of information were used: Colorado WQCD; Colorado DOW; and the permit holder.
Endangered species	No endangered species were present at the site. Information was obtained from USFWS and the Colorado DOW.
Terrestrial Biological Resources	
Wetlands	Wetlands are not considered in the study.
Riparian characteristics	Riparian characteristics are not considered in the study.

TABLE B-7 cont.

CATEGORY	INFORMATION SUMMARY
Vegetation coverages	The permit holder has conducted a large amount of work on revegetation for restoration, and has collected information on the local vegetation coverage.
Soil characteristics	The permit holder has extensive information on the soil characteristics as part of its revegetation and restoration program.
Endangered species	No endangered species were present at the site. Information was obtained from USFWS and the Colorado DOW.
Land Uses	
Historic	Historic land use was not considered in this TMDL study. There has been little human activity in the watershed area other than the two mines.
Present	Present land use was not considered in this TMDL study. There is little human activity in the watershed area other than the two mines. Most of the land is national forest land, although there is some grazing.
Superfund sites	No Superfund sites (SFS) are present in immediate watershed. There are SFS throughout the larger Clear Cr. watershed. There is little human activity in the watershed except for the two mines. Information on SFS is maintained by the USEPA Regional office in Denver.
Landfills	There are no landfills present in the watershed.
Small Area Population/Household Estimates and Projections	Information on local population is not considered in this TMDL study. The closest population center is the town of Empire, 8 miles away; there are only a few homes closer to the site.

TABLE B-8

Information Summary for the Indian/Deadwood Watershed

CATEGORY	INFORMATION SUMMARY
Base Mapping	
Geographic Management Unit	
River basin	The information on the spatial boundaries was obtained from HUC maps. River basin information was found in the fourth fields of the HUC maps. This is a national database, and copies for this analysis were obtained from the USFS West Region Office in Portland. The HUC map data, however, had limited resolution that had to be supplemented by a hydrologist using 7.5- minute topographic maps. This was done as an interagency effort with the BLM.
Watershed boundary	See above.
Subwatershed boundary	Information for subwatershed boundaries was taken from the sixth field of the HUC maps and supplemented locally using topographic maps and aerial photographs.
Major Hydrology	
Map of stream reaches	The effort started with 10-meter digital elevation maps; however, many streams, especially intermittent streams, were missing from these maps. Data for the missing streams was taken from aerial photographs. Work was done under contract by the Geometrics Service Center in the Salt Lake City USFS office. Information was digitized on-screen on digital ortho photographs using a digital stereoscope.
Water bodies	A GIS layer of lakes and other water bodies was obtained from the CFF; available in GIS format from USGS. Other small water bodies (livestock ponds) were added manually from local observations. Water bodies were added at the wildlife biologists discretion.
Major Roads	Some roads were taken from the CFF, others were added from aerial photographs, and others were mapped by driving the roads with a GPS receiver.
Political Boundaries	
County	Information was obtained as a GIS file from the State of Oregon.
Municipal	There were no municipalities within the watershed. Information on municipalities is available as a GIS ARCINFO file from the State of Oregon.
Analytical Data	
Subbasin Units	Information for subbasin boundaries was taken from the sixth field of the HUC maps and supplemented locally using topographic maps and aerial photographs.

TABLE B-8 cont.

CATEGORY	INFORMATION SUMMARY
Bedrock Geology	USGS quadrangle maps were used to identify rock types. These were hard copy maps that were digitized by the staff for the project. The data was limited in resolution and several areas within the watershed were found that did not correspond to information in the USGS maps. The scale was 1:250,000. The information was good but limited in resolution.
Imperviousness of subarea	This information was not needed for this analysis.
Fraction impervious/ stream	This information was not needed for this analysis.
Meteorology	
Precipitation	The State Climatologist at Oregon State University monthly averages on a 20-year sliding average. The data is available as a GIS raster layer. The scale is very large but was adequate for their purposes.
Evaporation rates	No other climatology information was used.
Stream Environment	
NPDES outfalls	There are no industries or municipalities in the Siuslaw National Forest.
Flow gauging stations	No flow gauging stations are in the watershed, and streamflow information was not collected for the analysis.
Stream use information	The Siuslaw National Forest issues permits for stream use within the forest. This permit system is separate from the state permitting system on private land. A permits database is being developed. Conditions for fish habitat were determined using existing Level II stream habitat surveys conducted by USFS and other existing survey information. The information was incomplete and covered approximately 20% of the watershed, as only 74 of 360 miles of streams have been surveyed.
Water supply intake locations	Information on permitted outtakes in the watershed was obtained from Siuslaw National Forest permit files and State of Oregon permit files; however, not all actual outtakes have been reported.
Regulated flow structures	All regulated flow structures have been removed from the streams. Information on the location of old structures was obtained from interviews of area residents and from historic maps.
Stream gradient, slope	The streams were classified by confinement and gradient class following the Montgomery and Buffington methodology described in the Washington Site Watershed Analysis Manual (Washington DNR, 1993) using information from topographic quadrangle maps.
Groundwater hydrology	Information on groundwater hydrology was not needed. The area is characterized by steep dissected slopes, and groundwater is not a concern.
Stream bed substrate	Some information on streambed substrates has been collected during USFS stream surveys, but the information is anecdotal and not systematic. The information is not fixed to a specific set of map points and cannot be mapped for GIS storage. The information only covered approximately 20% of the watershed as only 74 of 360 miles of stream have been surveyed.

TABLE B-8 cont.

CATEGORY	INFORMATION SUMMARY
Stream water quality	The analysis used data on a set of streams in the Siuslaw National Forest that were monitored for stream temperature in the summer every year since 1991-1995. Temperature was recorded every half hour. Information on stream water chemical characteristics has not been collected.
Aquatic Biological Resources	
Primary shellfish waters	A survey of the streams for mussels, snails, and other fauna recently began. Thus, information on shellfish was not available.
Fish nurseries	Some areas that would be suitable for fish nurseries have been identified from topographic maps and the GIS database. Suitable areas are unconfined areas with low gradient. The information was incomplete and covered approximately 20% of the watershed, as only 74 of 360 miles of streams have been surveyed.
Stream biological communities	No information on fish populations in the watershed was available. During stream surveys, presence or absence of fish species was noted but not systematically collected. No information on other aquatic fauna was collected.
Endangered species	Information was compiled from the Regional Forester's List, USFWS, and the Oregon Natural Heritage Program.
Terrestrial Biological Resources	
Wetlands	Wetlands information was obtained from the National Wetland Inventory. This information is available from the USFWS as an ARCINFO GIS layer. The information is good, but not available for all quadrangles.
Riparian corridor characteristics	Information on riparian vegetation was digitized from aerial photographs for the watershed analysis. The usefulness of the information was limited because tree species could not be identified from the photographs. This is important for evaluating presence of species that could contribute to recruitment of coarse woody debris (important for fish habitat).
Vegetation coverages	Information on vegetation coverage was also obtained from aerial photographs. Accuracy of the vegetation coverage GIS layer was checked by examining selected stands for size and species composition.
Maximum surface storage	No specific information on storage of moisture in surface soils was available. The information could be useful as inputs from groundwater, and important in helping to moderate stream temperatures.
Soil characteristics	Soil surveys for some counties were out of date. The USDA-NRCS surveys tend to be biased toward agricultural land uses and did not contain detailed information on forest soils. The delineations of the survey were also too large for the purposes of the watershed analysis.
Endangered species	Information was compiled from Regional Forester's List, USFWS, and the Oregon Natural Heritage Program.. Two bald eagle nest sites are located in the southern portion of the watershed, in proximity to Lake Creek.
Land Uses	
Historic	Information on historic land use was obtained from the Siuslaw National Forest's logging history database and from histories of human settlement. Information on historic vegetation coverage was also available from the Oregon State Forestry Department for 1914 (Scale 1:380,000), and on a county basis from the USFS Regional Office for 1950.

TABLE B-8 cont.	
CATEGORY	INFORMATION SUMMARY
Present	Information on land ownership was obtained in two GIS layers from the State of Oregon. These layers were created by consultants and edited by the university. There were mistakes in the information which had to be corrected. There was also a layer developed by the Siuslaw National Forest's own survey department. Information on land use for grazing and agriculture was obtained from Lane County. Information is derived from tax records.
Superfund sites	None present.
Landfills	No landfills are known to exist in the watershed.
Small Area Population/Household Estimates and Projections	Demographic characteristics were derived from census reports (U.S. Department of Commerce, 1993). Data from the Federal Census.

TABLE B-9

Information Summary for Edisto River Basin

CATEGORY	INFORMATION SUMMARY
Base Mapping	
Geographic Management Unit	
River basin	USGS 1:24000 scale topographic quadrangle maps were used to create the GIS layer with hydrography information, however, some of the USGS topography maps were out of date (20 years old). Information was also obtained from the NWI Database.
Watershed boundary	See above.
Subwatershed boundary	See above.
Major Hydrology	
Map of stream reaches	See above.
Water bodies	See above.
Major Roads	USGS 1:24000 scale topographic quadrangle maps were used to create the GIS layer with transportation network information. Four-lane divided highways were the only type of road considered to be a barrier to the travel of most species. Again, some of these maps were out of date.
Political Boundaries	
County	USGS 1:24000 scale topographic quadrangle maps were used to create the GIS layer with political boundary information.
Municipal	See above.
Analytical Data	
Sub-basin Units	Four subbasins of the Edisto River Basin were defined from USGS topographic maps.
Bedrock Geology	Information was obtained from USGS and the South Carolina State Geologist in the SCDNR.
Imperviousness of subarea	Not needed.
Fraction impervious/stream	Not needed.
Meteorology	
Precipitation	Data on precipitation from 1935-1990 was obtained from six NWS rainfall stations located in the Edisto River Basin.
Evaporation rates	Evaporation rates (61% of rainfall) were estimated from the water budget study of Winner and Simmons (1977) for a small North Carolina Coastal Plain blackwater stream.

TABLE B-9 cont.

CATEGORY	INFORMATION SUMMARY
Stream Environment	
NPDES outfalls	Information on pipe location, facility information, and permitted effluent limits was obtained from SCDHEC. Early information on the actual location of the outfall pipes in the SCDHEC database, however, was often inaccurate. In several cases, the location of the company's main office was listed in the database, and not the permitted outfall. The data has been improved by taking GPS readings from the actual pipe locations.
Flow gauging stations	Streamflow data has been collected continuously at four USGS stations from 1939-1990. Annual peak flow and 7-day average annual minimum discharges were obtained from the USGS WATSTORE database. The WATSTORE data was reliable; however, additional streamflow gauging stations would have been desirable for more detailed analysis of loading in the subwatersheds.
Stream use information	Information on recreational boating and fishing was collected for the assessment by the task force committees.
Water supply intake locations	Data on permitted surface water withdrawals and permitted wells was included in a GIS layer provided by the South Carolina DOC. Scale: 1;100,000. The information was current and reliable.
Regulated flow structures	There are no dams on the major river system; however most tributaries have damswith impoundments. Information was taken from the NWI database. This information was available from SCDNR.
Stream gradient, slope	Stream gradient and slope information was not collected because the topography in the region is flat, and the data was expensive to produce. However, several of the task force committees requested gradient information, which would have been useful.
Groundwater hydrology	Information was obtained from USGS.
Streambed substrate	Information on streambed substrate was not needed because there is little variation within the watershed; the substrate all tends to be either sandy or silty, with little gravel or limestone (marl). Some general information is available in the NWI database.
Stream water quality	Monthly data from 11 monitoring stations in the basin covering the period 1975-1991 was obtained from SCDHEC. More historical data from earlier time periods would have been useful.
Aquatic Biological Resources	
Primary shellfish waters	Data on shellfish harvest permits, culture, and polluted waters designations was obtained from SCDNR. Data was adequate.
Fish nurseries	Data was obtained from the scientific literature, SCDNR fisheries biologist, and the USFWS National Marine Fisheries Office in Charleston.
Stream biological communities	Little information was available on stream biological communities, and information was mostly limited to fish. Information was obtained from the SCDNR fisheries biologist, and from the National Marine Fisheries office of the USFWS in Charleston. Some information on macroinvertebrates was available from the Marine Resources Division of SCDNR.
Endangered species	Information was obtained from SCDNR. Information was not adequate for the watershed analysis because the exact locations of endangered species sightings are not readily available, and no systematic survey data exists.

TABLE B-9 cont.

CATEGORY	INFORMATION SUMMARY
Terrestrial Biological Resources	
Wetlands	Wetlands data were derived by SCDNR through the U.S. Fish and Wildlife Service (USFWS). NAPP color infrared photography (1:40,000 scale) used to map wetlands at 1:24,000 based on NWI classification. Wetlands were ranked by functional value classes 1, 2, and by a committee of the Edisto River Basin Task Force.
Riparian corridor characteristics	Information was derived from the NAPP color infrared photography. Interpretation of the photographs was also contracted through USFWS, similar to the NWI.
Vegetation coverages	Information was obtained from the USFS, which conducts the Forest Survey, a detailed survey of randomly distributed areas across the state on an 8-10 year rotation.
Soil characteristics	Soils data was derived from the 1:20,000 scale NRCS county soil survey maps. Publication dates of the soil surveys for the 12 counties in the Edisto River Basin ranged from 1963 to 1984. The older soil surveys were less detailed.
Endangered species	Information was obtained from the SCDNR. Information was not adequate for the watershed analysis because the exact locations of endangered species sightings are not readily available, and no systematic survey data exists.
Land Uses	
Historic	Forest survey data was also used for determining historical land uses. Census of Agriculture information has been collected every 5 years since 1925 by the Census Bureau.
Present	Data on land use were derived from 1989 NAPP photography and mapped at 1:24,0000. Source SCDNR. Classification: Anderson level II
Superfund sites	Data on locations of hazardous waste sites and leaking underground storage tanks was included in a GIS layer obtained from SCDHEC. The information was adequate, but was not used extensively in the watershed analysis.
Landfills	Data on locations of industrial and domestic waste landfills was included in a GIS layer obtained from SCDHEC. The information was adequate.
Small Area Population/Household Estimates and Projections	Detailed evaluation of population estimates and trends was presented in a separate document: "Socioeconomic Conditions in the Edisto River Basin." The basic data was taken from the Census Bureau.

TABLE B-10

Information Summary for Lake Mendota

CATEGORY	INFORMATION SUMMARY
Base Mapping	
Geographic Management Unit	
River basin	Five major tributaries drain directly into Lake Mendota: Pheasant Branch Creek, Dorn Creek, Sixmile Creek, the Yahara River, and Token Creek. Data are from river basin plan WDNR.
Watershed boundary	The watershed drains 230 square miles. Information on watershed boundaries was available as a GIS layer from the WNDR. The WNDR is organized according to 22 major river basins in the state. A river basin plan has been developed for each of the 22 basins.
Subwatershed boundary	The Land Conservation Departments (LCDs) of Dane and Columbia Counties used topographic maps to delineate 12 subwatersheds.
Major Hydrology	
Map of stream reaches	Five major tributaries drain directly into Lake Mendota: Pheasant Branch Creek, Dorn Creek, Sixmile Creek, the Yahara River, and Token Creek.
Water bodies	Lake Mendota has a total area of 10,000 acres.
Major Roads	Roads were included as part of the baseline map.
Political Boundaries	
County	The watershed is located in Dane and Columbia Counties.
Municipal	The study area includes most of the city of Madison, part of Sun Prairie, and all of the city of Middleton, and several villages.
Analytical Data	
Bedrock Geology	Imperviousness was not a concern in the Lake Mendota watershed. Data on basic geology were obtained from USGS.
Meteorology	Data on atmospheric fallout were obtained from a Ph.D. thesis from the University of Wisconsin. This factor is not controllable and is not usually considered in the Wisconsin Priority Watershed Program.
Precipitation	Data were obtained from the state climatologist.
Evaporation rates	Evaporation rates were not considered in the analysis.
Stream Environment	
NPDES outfalls	Municipalities of greater than 100,000 are required to report all outfalls to the state.

TABLE B-10 cont.	
CATEGORY	INFORMATION SUMMARY
Flow gauging stations	USGS flow gauging data are available from the USGS. A two volume report on results of daily stream flow measurement is published annually for Wisconsin.
Stream use information	Uses of the streams include warm water fishery and recreation. Streams were classified using the state's stream classification system.
Water supply intake locations	Information was available from the Drinking Water Bureau of the WDNR. These are paper files and include well drilling records.
Regulated flow structures	Information was obtained from Water Regulation and Zoning.
Stream channel conditions, obstructions, barriers	Information obtained from Water Regulation and Zoning.
Stream gradient, slope	Gradient is not a major concern in an area of relatively flat topography. The WINHUSLE model was used to calculate water hydrology parameters using information from the NRCS soil map.
Groundwater hydrology	A county by county description of groundwater hydrology is available for Wisconsin, probably from the USGS or Wisconsin Geological and Natural History Survey.
Streambed substrate	Information on the streambed substrate is collected on a project specific basis by a WDNR stream biologist during the planning phase of each Priority Watershed Project.
Stream water quality	Monitoring stations have been in the Lake Mendota Watershed for 20 years for phosphorus loading. Historical information is available in an older publication, "Surface Water Resources of Dane County." This is a part of a 72 volume series, one for each county of Wisconsin. The volumes in this set range from 15-40 years old, and are not being updated systematically.
Aquatic Biological Resources	The Surface Water Resources for Dane and Columbia counties provides information on fish, miles of stream, size of lakes, and uses.
Primary shellfish waters	NA
Fish nurseries	Lake Mendota has one northern pike spawning area identified in the stream biologist's survey conducted in the planning phase of the priority watershed program.
Stream biological communities	The Surface Water Resources for Dane and Columbia counties provides information on fish, miles of stream, size of lakes and uses. Additional information available in the River Basin Plans.
Endangered species	The Wisconsin Natural Heritage Program of the WDNR and the USFWS were the sources of information. The WDNR database is a computer database. The information is good but confidential.
Terrestrial Biological Resources	
Wetlands	Information was obtained from WDNR digitized wetlands map and USDA Natural Resources Conservation Services (NRCS) wetland maps. The NRCS maps were more detailed and also provided information on previously existing wetlands now being farmed.

TABLE B-10 cont.	
CATEGORY	INFORMATION SUMMARY
Riparian corridor characteristics	Counties are responsible for maintaining aerial photographs for land conservation purposes. Also a recent Ph.D. thesis from University of Wisconsin had studies on riparian areas in the Lake Mendota watershed, and prepared a GIS layer for this.
Vegetation coverages	Information from county Land Conservation Department located in computerized database.
Soil characteristics	NRCS Soil Survey for Dane and Columbia counties. Information was good for this purpose.
Endangered species	The Wisconsin Natural Heritage Program of the WDNR and the US FWS were the sources of information.
Land Uses	
Historic	Not Available at time of report.
Present	Information from county Land Conservation Department located in computerized database.
Superfund sites	Information on Superfund sites is maintained as paper files in WDNR.
Landfills	Information is on file with WDNR.
Small Area Population/Household Estimates and Projections	Information was obtained from Dane County Regional Planning Commission.