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DEVELOPMENT OF AN INTEGRATED DATA BASE FOR LAND USE AND WATER QUALITY PLANNING

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INTRODUCTION: CREATING UNDERSTANDING

Basic knowledge about the way natural and human systems function and relate to one another is an essential ingredient in charting the best course of action to make choices that affect land and water. The recent Toledo Metropolitan Area Council of Governments (TMACOG) Areawide Water Quality Management Planning Program (PL 92-500, Section 208) has made it possible to gather and analyze information. This, in turn, has led us to a more complete understanding of our local environment than was ever before possible. To help understand the role played by different land resources in water quality management we created a computer based data system. The Land Resource Information System (LRIS) allows data to be readily retrieved or statistically analyzed for a variety of purposes. It is specifically formatted to perform coordination of water quality data with the co-occurrance of land resource factors such as soil characteristics, land use, hydrology, topography, etc.

Our new understanding of the region gained through the use of LRIS has gone well beyond the initial purpose of assessing water quality conditions. The land use and natural features information has provided a well defined starting point for a systematic evaluation of proposed land uses, transportation, housing, and other public investments. It has laid the foundation for a comprehensive and integrated approach to many different planning and investment programs presently underway.

1. LAND RESOURCES INFORMATION SYSTEM SPECIFICATIONS

LRIS has been designed:

1) to take advantage of existing data sources
2) to provide the detail of information necessary to assess the impact of land use on water quality
3) to provide a permanent data base for future comprehensive planning studies.

Size of Study Area: 5200 KM^2 (2006 Mi^2)

Location of Study Area: 6 Counties on the south shore of Lake Erie in Northwest Ohio and Southeast Michigan.

Data Collection System: Grid Cell and point, unaligned random sample

Coordinate System: Universal Transverse Mercator Projection

Cell Size: 4 Hectares (9.88 Acres) (139,538 cells in the study area)

Source Data:

* 1:50,000 Aerial Photography
* USGS 7-1/2 min. Topographic Maps
* County Soil Surveys

Main Data File Content:

* Land Use - 36 categories of land use and up to 12 figures of ancillary data for each cell/point location
* Soils - Mapping unit from detailed soil survey
* Topography - 5' Contour Interval
* Hydrological location - Minor watershed
* Political location - Minor civil division

Socio Economic location - Traffic zones and census tracts

Auxilliary Data Files:

* Soils physical properties
* Water resources data

Output Modes:

* CRT Display (working)
* Ink Jet Printer Maps (working)
* Digital Laser Printer Maps (permanent, printable)
* Calcomp/Symmap Maps

Data Analysis:

* Co-occurrance of natural land resource features
* Land Capability
* Land Use Suitability
* Land Use Policy Impact Analysis

2. APPLICATION OF LRIS

2.1 WATER QUALITY MANAGEMENT PLANNING

The use of LRIS in the assessment of water quality problems and the design of solutions falls into two broad categories. One is Non-Point Source (NPS) oriented and the other focuses on pollution from Point Sources (PS). The NPS problem in the TMACOG region is dominated by agricultural runoff. Fertilizer runoff from agricultural lands contributes nutrients to the water and initiates a sequence of events which degrades water quality. The second category, PS problem, is dominated by Public Sewage Treatment Plants (STP's) and home or on-site sewage systems.

2.1.1 AGRICULTURAL RUNOFF POLLUTION ABATEMENT

Runoff from agricultural land has been identified as a principal source of sediment and nutrient pollution of Lake Erie. Approximately 83% of the total transport of the nutrient phosphorus during 1975 came from some source other than the discharges of municipal sewage treatment plants. Numerous investigations have shown that the sediment and nutrient content of direct runoff from agricultural land is sufficient to account for most of this non point source pollution. Other major categories of non point source pollution include runoff from urban land, atmospheric input (principally related to wind erosion at distant locations) and demineralization of inorganic materials in soil and decomposition of organic detritus.

The most easily identifiable problems include rill and gully erosion, but in Northwest Ohio sheet erosion, the progress of which is nearly invisible to the eye contributes the greatest portion of the sediment transport. Sheet erosion is caused by the impact of falling raindrops on bare soil surfaces. The regions glacial clay soils are highly productive, and nearly 90% of the land area is devoted to the production of row crops, principally corn and soybeans. Fall moldboard plowing is the dominant tillage practice, and leaves the land barren of any protective cover for 8 to 10 months of the year.

Recent studies have shown that sheet erosion can be reduced to nearly zero by the use of a cropping practice called No-till, which can leave the land with almost complete ground cover between harvesting and planting. Other systems of reduced tillage produce less dramatic reductions in sheet erosion, proportionate to the amount of surface coverage.

Research studies which have been done at the Ohio Agricultural Research and Development Center have proven the utility of no-tillage and reduced tillage as economically feasible crop production systems. This work has also identified the soils of Ohio on which these new techniques will be practical, since not all soils are suitable for reduced tillage practices without significant reduction in yield.

If an agricultural pollution abatement is to be built around around a reduced tillage program it is necessary that suitable soils be identified. A general classification of soils groups them into the following categories: 1) suitable for no-tillage, possible increased yields; 2) suitable for no-tillage with improved subsurface drainage; 3) unsuitable for no-tillage; 4) suitable for no-tillage under certain circumstances; and 5) undetermined suitability. Further work with these classifications has been done to define the economics of the systems and the suitability of other forms of reduced tillage. This analysis places groups 1 and 2 into a suitable for no-tillage class, group 4 is suitable for minimum tillage, and groups 3 and 5 are not considered for any form of reduced tillage.

The LRIS was used to identify, map, and summarize the areas which were suitable for reduced tillage systems. Overall, about 60% of the total TMACOG area was found to be in categories 1, 2 and 4. A Calcomp plotter was used to draw a map of the entire 5200 square kilometer area showing areas of cropland in each of the 5 categories. This map will be used in a technical assistance program to help farmers decide whether or not a reduced tillage practice would be suitable for their cropping system.

In order to determine the effectiveness of widespread adoption of reduced tillage systems in reducing sediment and phosphorus loading to Lake Erie, the LRIS was again used to develop the soils data into a format that could be used with the Universal Soil Loss Equation. Estimates of existing gross erosion and total phosphorus transport were calculated for comparison with total transport which would result when appropriate no-or-minimum tillage systems were in operation on 100% of all cropland where those systems could be applied with no seriously adverse economic effect. The analysis indicated that sediment delivery could be reduced by 41% and total phosphorus by 26%.

2.1.2 POINT SOURCE POLLUTION ABATEMENT PROGRAM

There are a number of intervention points in the planning, design, and operation of treatment facilities to affect their impact on water quality. By far, the most cost effective is at the planning stage. At this stage, the size and location of treatment plants and the collection system are determined as a function of population growth and those factors which affect its spatial allocation. Historically such decisions are determined through a mix of perceived trends, local politics and real estate developers. LRIS introduced a new dimension, the environment. Physiographic features and regions are mapped for the facility planning area using LRIS. Each feature is characterized in terms of development attributes such as: excavation, drainage, grading, etc. Specific capability functions have been coded into the LRIS. Hence, it is possible to map an area's capability for residential, commercial/industrial development or for underground facilities.

The LRIS environmental capability maps can be overlayed with local land use maps, trend growth maps and existing land use maps to form a readily understood graphic evaluation procedure. Proposed facility plans can then be evaluated according to their compatibility with the soils and geology of the area, minimizing the pollution potential from a facility.

2.1.3 HOME SEWAGE SYSTEMS

The combination in the TMACOG area of extensive rural development, the predominance of soils unsuitable for septic systems, and a network of drainage ditches, makes for a condition called "Black Water". Poorly functioning on-site disposal systems drain into local ditches causing poor water quality and a potential health hazard. LRIS was used to map a septic tank capability for the region based upon basic soils data. Local health officers and sanitary engineers can now use the map to guide rural development, avoiding unsuitable areas.

2.2 COMPREHENSIVE LAND DEVELOPMENT PLANNING

LRIS can also assist in the integration of the many categorical planning programs, water quality, housing, transportation, etc. into a comprehensive region-wide planning program. One way it can do this is by the Urban Service Area concept. Highway congestion, the availability of nearby parks and recreation facilities, a wide choice in housing, convenient shopping, commercial, cultural, and entertainment centers, and a viable local economic base -- these are all very strongly affected by public investment decisions. The Urban Service Area concept is a means for managing public resources so as to maximize the use of existing infrastructure, and insure a coordinated public investment strategy consistent with environmental, economic and land use policy objectives. LRIS provides the ability to delineate and evaluate these service areas.

In delineating the service area, the first step is to measure the carrying capability of the area presently served by sewer and water. LRIS can be used to identify urban open space and evaluate it for its development capability. As a guide to expansion, areas of potential conflict between development and agriculture are identified on an LRIS generated map. This, along with the other land use and environmental capability functions, is used as a part of a methodology to identify areas suitable for expansion.

3.0 IMPLICATIONS FOR RESOURCE MANAGEMENT SYSTEMS

The fundamental task of any public agency is the effective management of public resources. A pre-requisite for sound public investment decision-making is local capability to solve problems and inplement solutions. This requires the existence of a comprehensive management structure as well as the necessary data, tools and analytical procedures.

3.1 NATURAL REGIONS AND FEATURES

The use of LRIS in the delineation and functional characterization of natural areas will have long term implications for the management and institutional frameworks governing sub-state units of government.

City and county lines have a long tradition, are firmly implanted in the legal/institutional structure of local government, and are part of each resident's sense of place. Metropolitan regions, based largely on trip patterns, also enjoy an identity in the minds of their inhabitants which may or may not be reflected in the local governmental structure.

The least identifiable areas are those which are based on common natural features. River basins and unique or sensitive environmental areas are usually distributed among many political jurisdictions. Sometimes citizen/environmental groups who may share a common concern for such an area may form a link among the many local governments and agencies. But such links often breakdown, lack of interest, membership continuity, and their weight and standing with local officials can change with the next election.

The challenge, then, is to integrate natural areas as management areas into the local institutional structure. Here is where LRIS has proven invaluable. It has allowed us to identify such areas, and through various graphic output devices has provided us with the means to communicate the concept of natural areas in a meaningful way.

TMACOG's Water Quality Management Plan has integrated natural areas into its proposed management structure. Specific programs regarding home sewage systems, agricultural runoff abatement, sewer service facility evaluation, comprehensive land use planning, all embody the concept of natural areas as management areas.

TMACOG has identified physiographic regions and features based on LRIS analysis of soils and geologic data. These are basic land resource units, each characterized by a unique set of opportunities and constraints on their use.

These areas provide the basis, not only of water quality planning, but provide input to local land use decisions. It is the aim of ecological planning to successfully integrate human activities with the natural system. To accomplish this we have described the region according to the characteristics that influence human activities and, in turn, how those activities would have to be modified in order to successfully adapt to those same natural characteristics. The activities investigated include: residential development, intensive development such as industry and agriculture and open space.

Each physiographic unit is analyzed for activities relevant to development such as clearing, excavation, soil stability, on-site sewage disposal, etc. The result is a guide which identifies those areas propitious for development, and also outlines the necessary adaptation if development takes place. For example, detailed knowledge of the specific limitations of a particular natural unit (e.g., Sand Hollows) can be translated into performance zoning available to local government to guarantee the successful adaptation of any development. The advantage is that unlike conventional zoning which is usually expressed in terms of a single type of use, performance zoning is expressed in terms of the natural characteristics of the site and allows a variety of uses as long as it conforms with the required adaptations.

3.2 SURFACING ISSUES AND ARTICULATING THE LOCAL VIEW

One consequence of analyses such as those described above is that issues, problems and potential conflicts surface early. The purpose of planning is not necessarily to resolve conflict, rather its function is to spotlight potential problems and test alternative solutions. The assumption is that it is less expensive to do so in the abstract, before the concrete has a chance to set.

Another major benefit of the LRIS based analytical process is its use as a communications device. This is where the alternative graphic output modes of LRIS are very useful. It has been our experience that the immediacy of a color land use map or a residential capability map increases the impact of the information on elected officials and other public policy decision makers.

LRIS makes it possible to express the community and regional viewpoint in a organized and well structured context. This greatly enhances its chance of being heard and influencing federal decisions. In the long-term the cumulative effect could be to incorporate the common concern of the region into federal policy formulation, possibly reversing the trend of federal encroachment on local government decision-making.