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CR - 146379

LAND USE CHANGE DETECTION WITH LANDSAT-2 DATA FOR MONITORING AND
PREDICTING REGIONAL WATER QUALITY DEGRADATION

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February 1976
Quarterly Progress Report 28 October 1975 – 27 January 1976

23710

Prepared for

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle LAND USE CHANGE DETECTION WITH LANDSAT-2 DATA FOR MONITORING AND PREDICTING REGIONAL WATER QUALITY DEGRADATION		5. Report Date February 1976
		6. Performing Organization Code
7. Author(s) H. C. MacDonald and K. F. Steele		8. Performing Organization Report No.
9. Performing Organization Name and Address Geology Department University of Arkansas Fayetteville, Arkansas 72701		10. Work Unit No.
		11. Contract or Grant No. NAS 5-20810
12. Sponsoring Agency Name and Address Edmund Szajna, Tech. Officer Goddard Space Flight Center Greenbelt, Maryland 20771		13. Type of Report and Period Covered Quarterly Progress Report 28 October 1975– 27 January 1976
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

The overall objective of this research investigation is to compare LANDSAT 1 and 2 imagery for land use change detection which may be correlative with variations in water quality.

Analysis of historical water quality has revealed that while point-source pollution can be generally detected using the water quality sampling data collected by both State and Federal Agencies, non-point source contamination attributable to changing land use is usually completely masked. During the past quarterly period, data analysis would suggest that storm event water quality sampling is far more indicative of the actual influence of land use than information collected during scheduled periods. Specific sites with diverse land use have been selected for the collection of storm event data. In addition we are developing a computer program to analyze, model, and predict water quality under varying conditions, including land use and storm event data.

17. Key Words (Selected by Author(s)) Arkansas, Change Detection, Land Use, Pollution Monitoring, Water Quality		18. Distribution Statement		
19. Security Classif. (of this report) U	20. Security Classif. (of this page) U		21. No. of Pages 9.	22. Price

*For sale by the National Technical Information Service, Springfield, Virginia 22151.

ABSTRACT

The quality of surface waters can be influenced by many factors;

however, land usage now appears to be the dominating factor causing

the change in water quality of most streams and rivers in the United

States. The extent to which land use change detection with LANDSAT

1 and 2 data can be used for monitoring and predicting regional water

quality degradation is the fundamental question to be answered by

this investigation. There are two obvious approaches that can be

used in evaluating LANDSAT applicability; first, LANDSAT 1 and 2

imagery could be compared for change detection, then areas of change

examined for water quality trends; and second, one might observe

changes in historical water quality records and then determine if

any land use changes have occurred. During the initial phases of

this research investigation we have used both approaches.

LANDSAT 1 and 2 imagery analyses have revealed significant

changes in land use in the forested areas of Arkansas (as reported in

our last quarterly report); however, historical water quality data

coincident with these same areas are not available. Based on water

quality data analysis for the entire State of Arkansas, it has become

apparent that most samples contained in historical records do not re-

veal the influence of changing land use because they are normally

collected at times of low flow. Based on this LANDSAT investigation,

we now believe that water quality collected during storm events would

be more indicative of changing land use.

We are now monitoring and sampling several control and test

streams during times of low flow, and during times of very high flow

(storm events). The sites reflect variations in land use. In addition, we are continuing the development of a computer program which will analyze varying water quality parameters as well as land use, precipitation and stream flow.

Introduction

In our attempt to determine the feasibility of using LANDSAT
land use change detection data for predicting and monitoring regional
water quality, it was necessary to analyze historical water quality re-
cords for significant changes. Arkansas water quality data which
had been collected by various State and Federal agencies for over 40
years, have been compiled, published, and stored in a data retrieval
system by the Arkansas Department of Pollution Control and Ecology,
and by the USGS (in cooperation with the Arkansas Geological Commission).
Similar to many   states, Arkansas water quality data are stored on
magnetic disk in the IBM 370 computer system of Optimum Systems Incor-
porated of Bethesda, Maryland. Prior to our LANDSAT investigation,
minimal effort had been expended to analyze these data in an attempt
to define long term trends, seasonal variation, or water quality
characteristics of data collection points. In our last quarterly re-
port we indicated that although water grab samples are taken on a regular
basis at over 200 sites in the State, the great majority of samples are
taken biweekly, or at best, every two or three months. While it has
been possible to detect obvious stream pollution using these data,
inconsistency in sampling and data availability have caused data analysis
problems.

Areas of obvious land use change (mostly forest clearcutting) de-
tected by comparing LANDSAT 1 and 2 imagery often do not coincide with
any of the sampling stations within the State's network, and consequently
historical data are lacking. Even where adequate water quality data are
available, it is becoming obvious that samples have been collected during
the time period which does not reflect the true relationship between

water quality and land use. For example, when flow information is analyzed with water quality records, much of the collecting is accomplished during low flow or base flow conditions. While point-source pollution (sewage effluent, etc.) may be obvious during low flow, most non-point-source contamination (mostly from surface runoff), attributable to changing land use, will not be reflected in the water quality. More specifically, during base flow conditions, we are seeing mostly groundwater in the streams, the quality of which is controlled primarily by the kind of rocks and soil through which the water moves. The water quality of surface runoff (which will be influenced by landuse) then, will have maximum influence on a stream's water quality during storm events, and not during times of base flow.

In an attempt to accomplish the objectives of our LANDSAT investigation, we have reoriented our objectives to include two additional approach phases. First, we have selected several test sites to obtain storm event data during the approaching winter months of 1975, and spring and early summer months of 1976. These sampling sites include areas of contrasting land use, but having similar geologic and geomorphic characteristics. The second phase meshes nicely with the first just mentioned, i.e. in an attempt to make use of the historical water quality data, we are attempting to develop a computer program to analyze, model, and predict water quality under varying conditions, including land use. In contrast to our previous data analyses, event data will be an integral part of this computer model.

Problems

The reorientation of our investigation procedures (described in

the objectives) may necessitate requesting a one month, no-cost exten-

sion of our program. The additional one-month period would allow us

to collect and analyze storm event data during the early summer months

of 1976. We plan to review our proposed sampling schedule after we

have collected several sets of storm event data this spring.

Accomplishments

Storm Event Data Collection. Collection sites were selected for

diversity in land use. Two generalized areas were defined on LANDSAT

imagery and topographic maps; 1) an area dominated by urbanization, and

2) an area characterized by agricultural land use. Within each area a

control stream was selected where minimal land use was in evidence.

The control streams will provide "background" water quality data, which

can be compared with the "test" stream where land use changes are

obvious. During at least one of the storm event collection periods

and at one of our control and test sites, the Arkansas Department of

Pollution Control and Ecology will collect and analyze water quality

data.

In Northwest Arkansas, most streams with even limited access and

extreme slope have been developed to some extent, however, the control

stream for the agricultural land use test stream is located in the Ozark

National Forest and represents a near pristine stream having only limited

access. The probability of locating a comparable stream on private land

would be extremely slight.

The control and test streams need to be relatively close to enable

simultaneous sampling during periods of high flow. Thus, one problem

resulted in locating a test stream close to the control that could be

detected on LANDSAT imagery; however once selected, flow characteristics

were monitored to assure adequate flow during periods of low flow.

Criteria for Selecting Sampling Sites

1. The control and test watersheds must be detectable on LANDSAT
    imagery.

2. The control stream must be as near pristine conditions as
    possible.

3. The control and test watersheds must be reasonably close to
    allow simultaneous sampling.

4. Both control and test streams must be easily accessible.

5. The test stream was restricted in size allowing a water quality
    change to be related to land use instead of a direct pollution
    source.

6. The control and test streams must have sustained flow to allow
    for low flow sampling.

7. Both control and test watersheds must be similar in geology,
    size and relief.

All streams will be sampled at least three times during normal
flow and twice during high flow conditions. Samples will be collected
simultaneously on all three streams during both high and low flow
sampling periods. To obtain results for a valid comparison, at least
two high flow samples will be collected. The frequency in sampling
high flow conditions will depend on the occurrence and extent of
precipitation.

One sample per stream will be collected during low flow conditions.
Due to the flushing effect, at least three different samples will be
collected during a particular storm event. The amount of samples needed
during high flow conditions will depend upon the length and severity of
the storm.

Water Quality Parameters to be Measured

Dissolved Oxygen	ppm
Temperature	^{o}C
Turbidity	(FTU)
pH	
Conductivity	(u mhos)
Alkalinity	mg/1
Dissolved Solids	mg/1
Suspended Solids	mg/1
Settable Solids	mg/1
Sulfate	mg/1
Chlorides	mg/1

Nitrogen:

Ammonia Nitrogen	mg/1
Nitrate Nitrogen	mg/1
Nitrite Nitrogen	mg/1

Phosphate:

Ortho Phosphate	mg/1
Total, Inorganic & Meta Phosphate	mg/1
Organic & Total Phosphate	mg/1

Fecal Coliform Bacteria   #/100ml

(parameters determined by AA)

Calcium	ppm	Potassium	ppm
Magnesium	"	Arsenic	"
Sodium	"		
Iron	"		
Manganese	"		

Computer Modeling

With all factors being considered, every water quality station, and more specifically, every point on the stream, should have a set of characteristic curves that must be constant for that point.

Water quality data from the following stations have been analyzed:
Lock & Dam # 1 on the White River, Corning, St. Francis, McDougal,
Pocahontas, Dalton, Mammoth Spring, Salem, Eureka Springs, Berryville,
Glenwood, and Doddridge in Arkansas; and Thayer in Missouri. These
particular water quality stations appear to have the most complete
history of sampling, as well as stream flow data that may be reflective
of storm events. Water quality parameters showing the most consistent
and definitive curves are turbidity, total hardness, BOD, total residue,
total coliform, and some trace metals. Several parameters have shown
no correlation with variations in streamflow, temperature, or rainfall,
with correlations of less than 10 percent. However, data reduction
has resulted in up to 98 percent correlation in other parameters.

Quantitive differences in definitive curves with the same
general shape have been found between several stations. For example,
the parameter total hardness has the same characteristic curve at
both Corning and St. Francis, Arkansas, but the quantitive values are
quite different; with the values at Corning running about 50 percent
above those at St. Francis. We would eventually hope to demonstrate
that these types of variations are due to varying streamflow mass values
from station to station. Areas where definitive curves are found for
particular parameters resulting in a high degree of correlation will be
contrasted with those areas where curves are not in agreement. These
differences are most certainly leading to indications of differing
geology from station to station or area to area, and more importantly
to differing land use. With our intended data analysis program, when
precise determinations are made as to the causes of varying parameter
value curves, the computer will be programmed to accept this material

objectively and be ready to predict water quality changes under

varying conditions with emphasis on varying land use.

Significant Results   None

Publications   None

Recommendations   None

Funds Expended   Latest computer print-out from University dated

12/30/75 - $24,883.00

Data Use

Value of Data Allowed	Value of Data Ordered	Value of Data Received
$1,400.00	$1,076.00	$1,076.00

Aircraft Data   None