USING A GEOGRAPHIC INFORMATION SYSTEM (GIS) TO INTEGRATE DOC NATURAL RESOURCE DATA

STREAMS DATA COMPONENT

ANNUAL REPORT

July 1, 1991 to April 15, 1992

Illinois Natural History Survey Report to the
Illinois Department of Conservation

Diane L. Szafoni, Lewis L. Osborne,
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INTRODUCTION

The Illinois Department of Conservation (IDOC) currently manages a fish and wildlife database, the Illinois Fish and Wildlife Information System (IFWIS) and a streams database, the Illinois Streams Information System (ISIS). Although both have a narrative component, utilization of the two database management systems and the mechanisms utilized to produce map output are quite different.

Data capture for the **Illinois Streams Information System** (ISIS) was begun in 1981 to meet the policy analysis and management needs of the IDOC Planning Division. It was developed and maintained through a contract with the IDOC and the Departments of Landscape Architecture and Urban and Regional Planning at the University of Illinois. ISIS was created specifically for stream inventory and classification, permit review, and development of stream management policies. It contains a wealth of information on the State's surface water of potential use to managers and researchers alike.

The ISIS database is a relational database organized by river and river mile index (RMI) (Hinrichs, M.A. and L.D. Hopkins, 1991). The streams in ISIS were grouped into ten river basins and all streams were given numerical, 32-digit codes. Data for the streams were then measured to 0.1 mile accuracy, starting from the mouth of each stream. At present ISIS has both a narrative and a graphical component tied to the RMI for each stream reach with a drainage area greater than 10 square miles.

The narrative component of the ISIS data exist in tabular form and represent information for each stream on locational, physical, biological, chemical, cultural, recreational, and developmental characteristics. All of the information for each of these streams are stored in a topologically structured relational database (i.e., upstream/downstream and left bank/right bank relationships are preserved).

An Autocad file (a suite of programs used primarily for computer-aided drafting) of a 1:700,000 scale representation of the streams of the state was used for graphical display. However, this graphic representation was inadequate for GIS work and an alternative was needed. In particular, the graphic capabilities were

too limited and cartographically inaccurate to be complimentary with other state environmental databases that exist or are being developed on the Illinois Geographic Information System (IGIS).

The focus of this project was to use GIS technology to create an accurate hydrologic coverage and 'tie' the tabular data points in ISIS to the coverage. The resulting coverage can then be used to integrate the data contained in both the ISIS and IFWIS databases. Integration, as defined here, is to establish a mechanism by which both databases can be linked via GIS concepts.

Linkage of these databases to a cartographic base will increase the utility of this database and provide a common topographic framework for the integration of additional IDOC data. The conceptual design that establishes this linkage and the resultant geocoded stream network will better meet the management and planning needs of the Illinois Department of Conservation and the State of Illinois.

Task 1. Establish a SUN SPARC station-II workstation with the Center for Aquatic Ecology to more efficiently process GIS data when creating, using and storing the River Mile Index (RMI) coverage.

Progress: A Sun SPARC station II was purchased from Sun Microsystems, Inc. The ARC/INFO software from Environmental Systems Research Institute, Inc. (ESRI) was installed onto the computer.

Task 2. Investigate the applicability of using the new "dynamic segmentation" capabilities of the most recent version of ARC/INFO software to generate a River Mile Index Coverage for the Embarras/Vermilion basin using the 1:100,000 scale DLG Hydrology coverage created in Task 5 and the RMI coding scheme upon which the streams database is based. This is anticipated to be a complex of possibly labor intensive process that will minimally involve:

a. Identification of stream channel intersections and places where Public Land Survey section lines, and other "known geographic coordinate" locations cross the hydrology network as nodes on the 1:100,000 scale DLG hydrology coverage generated in Task 5. These will be used as "tie points" to relate the RMI used in ISIS and its associated data to the hydrology coverage.

b. Coding of all river mile nodes to correspond to streams database river mile coordinate narrative files.

c. Investigate the ability of "dynamic segmentation" to locate specific river mile locations from individual stream data sets on 1:100,000 DLG hydrology coverage in the ARC/INFO environment.

Progress:

The USGS Digital Line Graph (DLG), 1:100,000 scale statewide coverage was chosen as the best source of hydrologic data for this study. The hydrographic layer of the DLG files for Illinois already resides on the Illinois Geographic Information System (IGIS) at the Survey and comprises the most detailed representation of the streams and lakes available for the whole State. The U.S. Geological Survey (USGS) produced these data by digitizing a 1:100,000 scale photographically reduced composite of the hydrography layer from the 1:24,000 USGS base map series. DLG hydrographic files are

stored in the IGIS in a tile structure based on the 1:24,000 scale of the base map series.

The data pertinent to the Embarras and Vermilion River Basin study area were extracted from the statewide DLG files and modified for use in this project (Figure 1). This modification involved selecting and joining the appropriate DLG tiles together and correcting for any edge distortion where tiles abut. The resulting line coverage was 'clipped' with the outline of the river basin to produce a map of the Embarras/Vermilion river basin as recognized by the ISIS database (Figure 2).

The lines or 'arcs' in this coverage were checked for extraneous breaks or 'nodes'. These were deleted, leaving nodes only at stream intersections. This step was necessary so that all nodes in the coverage would have a known RMI in the ISIS database. Because this step simplified the original DLG data, the obsolete items in the associated INFO file (INFO files contain the tabular or descriptive data for the coverage) were deleted. Only the lakes and reservoirs on ISIS streams were retained; non-connected ponds and lakes were deleted. Because ARC/INFO treats the open spaces in the lakes differently, it was necessary to add a center line to these lakes to accommodate the ISIS RMI data.

The location of the headwaters of ISIS streams were checked and modified as necessary to match the headwaters as described in the ISIS database and as represented on the 7.5 minute topographic map sources. All of the arcs in the coverage were oriented such that they all pointed upstream. All arcs must point in the same direction for the dynamic segmentation process (described below) to properly account for the proportional distances along the line segment. The items necessary for the dynamic segmentation process were added to the INFO file. These include the stream code and the upstream and downstream RMI for each arcs.

ISIS includes only channels with at least 10 square miles of drainage area, so far fewer streams exist in ISIS then were present in the DLG dataset (Figure 2). These additional streams create extraneous nodes where they merge with ISIS streams. The extra nodes have no RMIs in the ISIS database and would cause problems during the dynamic segmentation processes. Therefore, a separate coverage of only the ISIS streams without these nodes was created for use during the remainder of the study.

Dynamic segmentation

A new module of the ARC/INFO software supports linear modeling through a process called dynamic segmentation. This approach 'ties' ISIS tabular data to the corresponding geographic representation of the stream network in ARC/INFO. Once tied, any point or stream segment identified in ISIS can be mapped and manipulated relative to other information contained in the IGIS.

Dynamic segmentation works by imposing a linear referencing system onto existing arc coverages. The beginning and end of each arc is coded according to a linear scale. For ISIS data, this measurement scheme is the River Mile Index (RMI). The dynamic segmentation software then supports interpolation along the arcs based on the to-from (or up-down stream) measures carried with the ISIS descriptive data.

To increase locational accuracy, more RMI locations were needed than just the ISIS stream headwaters and mouths locations. The number of 'tie' points were increased by intersecting the DLG generated hydrology with the Public Land Survey (PLS) section lines coverage that reside in the IGIS. This step subdivided each individual ISIS stream into many, shorter arcs, each beginning and ending at a section line. The RMI values of each of these locations, present in ISIS, were transferred to the corresponding INFO file of the coverage. The use of PLS section lines imposed a 1 square mile grid into the stream network. All data in ISIS are reported to the tenth of a mile, including the RMI where streams cross section lines. While this greatly improves the level of accuracy, it is still a fairly coarse resolution and limits how accurately data can be expected to be positionally located.

To use the dynamic segmentation feature of ARC/INFO, the ISIS streams were assigned to 'routes' by running the 'arcsection' command; specifying the stream identification number as the delimiter for each route and the 'up' and 'down' RMI as the unit of measure. The RMI for each mile was calculated for ISIS streams to test the ability of dynamic segmentation to locate specific locations (Figure 3). This final coverage will now provide the roadmap for locating the rest of the ISIS data in a graphics environment.

Task 3. Train and familiarize Streams Project Manager with operation of the stream database on the PC. Adequate training to generate stream retrievals is expected to take a minimum of two months following the acquisition of the computerized database. Following initial training, the project manager will provide outputs of information requested from the streams database that have been authorized by the IDOC Project Administrator. A record of all requests will be maintained during the first year of operation.

Progress:

The ISIS project manager is sufficiently familiar with the Rbase database on the PC to provide outputs of information. To date, the following people have requested information from ISIS:

Shaheen Khan - University of Illinois, Dept of Biology - graduate student. He works with Dr. Shaffer, a toxicologist in the Dept of Veterinarian Medicine. He wanted IBI, PIBI, or MBI statewide for all kinds of aquatic systems to develop threshold cutoff indices. Such data are not available in ISIS. He later called back for size of the drainage area in the LaMoine, Machinaw, Vermilion and Embarras river basins for all IEPA macroinvertebrate sampling stations. Because only the Sangamon Basin has drainage areas in the database, he was referred to Healy (1979a, 1979b).

Lewis Osborne, Steve Kohler and Peter Bayley (Illinois Natural History Survey); David Day, Bill Bertrand, Randy Sauer (IDOC streams group); and Mike Wiley (University of Michigan). They requested stream lengths and stream orders for the LaMoine, Machinaw and Vermilion river basins for all IEPA sampling stations. A list was prepared for them.

Helen Tyson - Dept of Landscape Architecture graduate student. She works with Dr Kovacic. She requested stream orders and stream lengths for the Embarras River and its tributaries above Carmargo, Il. A list was prepared for her.

Task 4. Respond in a very timely and priority manner to all requests for information by the Governor's Land and Water Use Task Force.

Progress:

No requests for information were made to date.

Task 5. Addition tasks in priority order which shall proceed only after permission granted by DOC Database Manager and tasks 1-4 satisfied.

*Obtain a copy of the Streams database and the River Mile Indices (Healy number book) used in developing the original stream database files.

Progress:

A copy of the corrected Healy book (1979a. 1979b) was obtained from the Dept. of Landscape Architecture and now resides in the Center for Aquatic Ecology GIS office.

*Obtain PC from IDOC Project Administrator. This PC will house a copy of the ISIS database at INHS in Champaign and will be used to achieve Task 3.

Progress:

A Compac 386/20 computer was obtained from the Dept. of Landscape Architecture.

*Generate an ARC/INFO coverage of hydrology which mimics the hydrologic network outlined in the streams database from USGS 1:100,000 DLG data for the Embarras/Vermilion Basin (one of 10 major drainage basins in the streams database).

Progress:

A coverage of the Embarras/Vermilion Basin was created from the statewide DLG data. This coverage was used to complete task 2.

*Outline a strategy for utilizing the newly created RMI Coverage in the determination of Karr's Index of Biological Integrity (IBI) and its interface with other datasets.

Progress:

Preliminary discussions with the IDOC streams group were held regarding the feasibility and wisdom of this task in light of other database developments. Discussions will continue.

*A long-term management strategy for the River Mile Index coverage and its relation to the streams database will be devised to be used in future GIS activities.

Progress:

Once the RMI coverage has been developed for an ISIS river basin, data from ISIS or any ARC/INFO compatible database can be incorporated into the RMI coverage as 'events'. By utilizing the Public Land Survey (PLS) section lines and the dynamic segmentation process, any data identified should be graphically locatable in a timely fashion. Because the Paradox database is being used in the development of a new streams fisheries database (under an ongoing D-J project), and is compatible with ARC/INFO, the data it contains should be readily displayed on the ISIS coverage.

The new streams fisheries database being developed by INHS staff will contain data from IDOC fisheries sampling stations. Because the IEPA station coding system was used to identify these sites, many of the station locations already exist in the ISIS database. Any new stations should be easily located. This will provide the means of linking the ISIS database to the IDOC streams fisheries database and IEPA databases.

*Complete documentation of all aspects of the GIS project will be assembled and include an implementation strategy, datafile definition, program designed, application development based on user needs, and interfaces with other datasets both now and in the future.

Progress:

The long range strategy for implementing the RMI coverages includes moving the rest of the ISIS data into the ARC/INFO environment as 'events'. An event is located in a table associated with the RMI coverage. It may be in an INFO data file or a table in an ARC/INFO supported relational database management system (RDBMS), such as Paradox.

One important application is the develop of a demonstration, in the ARCVIEW software, of the interactions between the RMI coverages and the various other datasets in ISIS. This would facilitate the use by IDOC resource managers. However, this would involve moving the data from Rbase into either INFO files or Paradox database software. An assessment of this transfer of the data should be made early in the next contract year.

Data from other databases, such as the IFWIS database, should also be linked to the ISIS RMI coverage as event tables. The IFWIS database has its own coding system for streams in Illinois. A conversion table for IFWIS/ISIS streams codes could easily be created to facilitate the use of the data in IFWIS. However, IDOC database design and implementation would be better served if stream and station location coding were standardized among the IFWIS, ISIS and the streams databases.

References

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Hinrichs, M.A. and L.D. Hopkins, 1991. Illinois Streams Information System: ISIS data descriptions manual. Illinois Dept. of Conservation, Springfield, University of Illinois at Urbana-Champaign, Dept. of Landscape Architecture and Dept. of Urban and Regional Planning. 135pp.

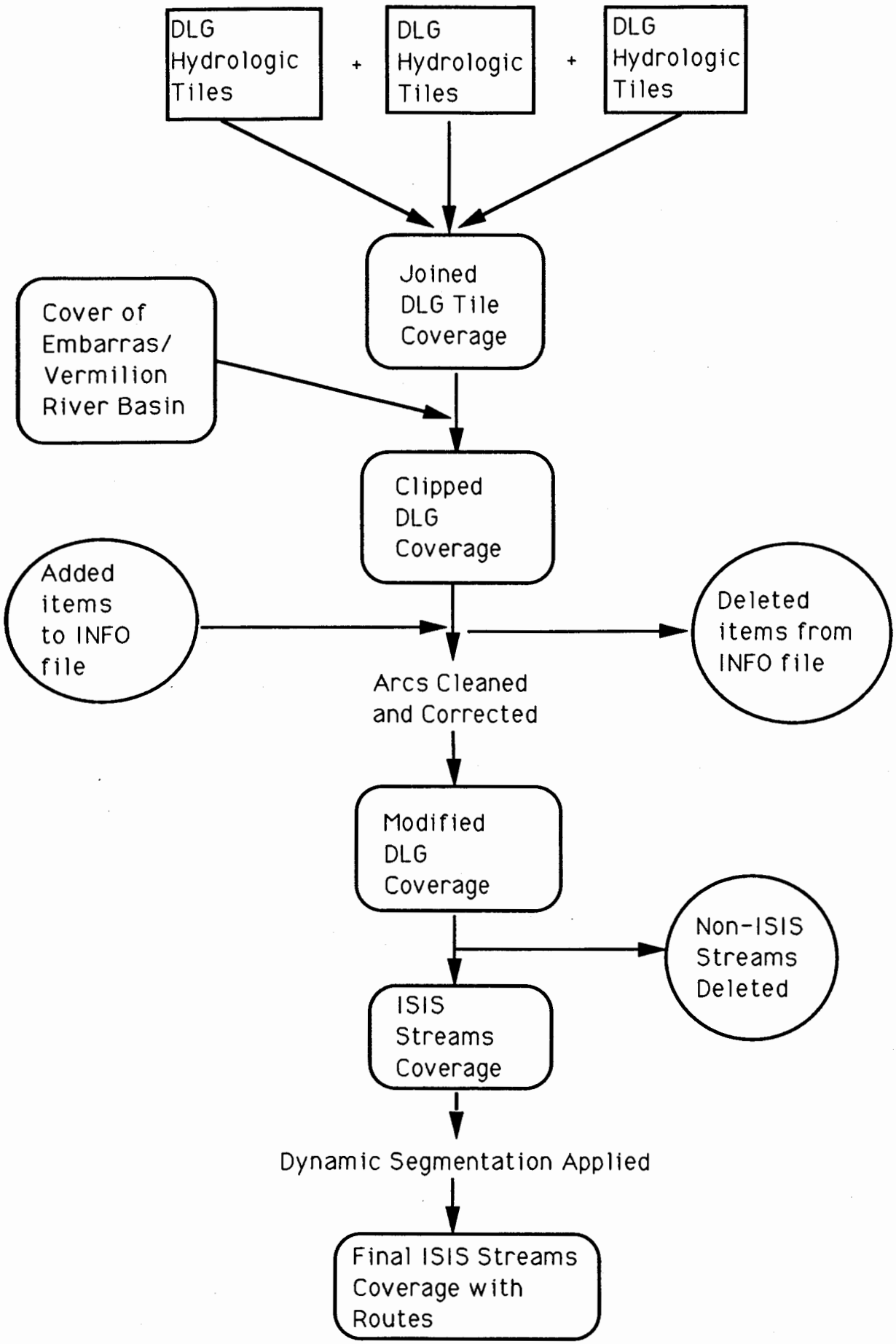
DLG Hydrologic Tiles
+
DLG Hydrologic Tiles
+
DLG Hydrologic Tiles
Joined DLG Tile Coverage
Cover of Embarras/ Vermilion River Basin
Clipped DLG Coverage
Added items to INFO file
Deleted items from INFO file
Arcs Cleaned and Corrected
Modified DLG Coverage
Non-ISIS Streams Deleted
ISIS Streams Coverage
Dynamic Segmentation Applied
Final ISIS Streams Coverage with Routes

Figure 1.

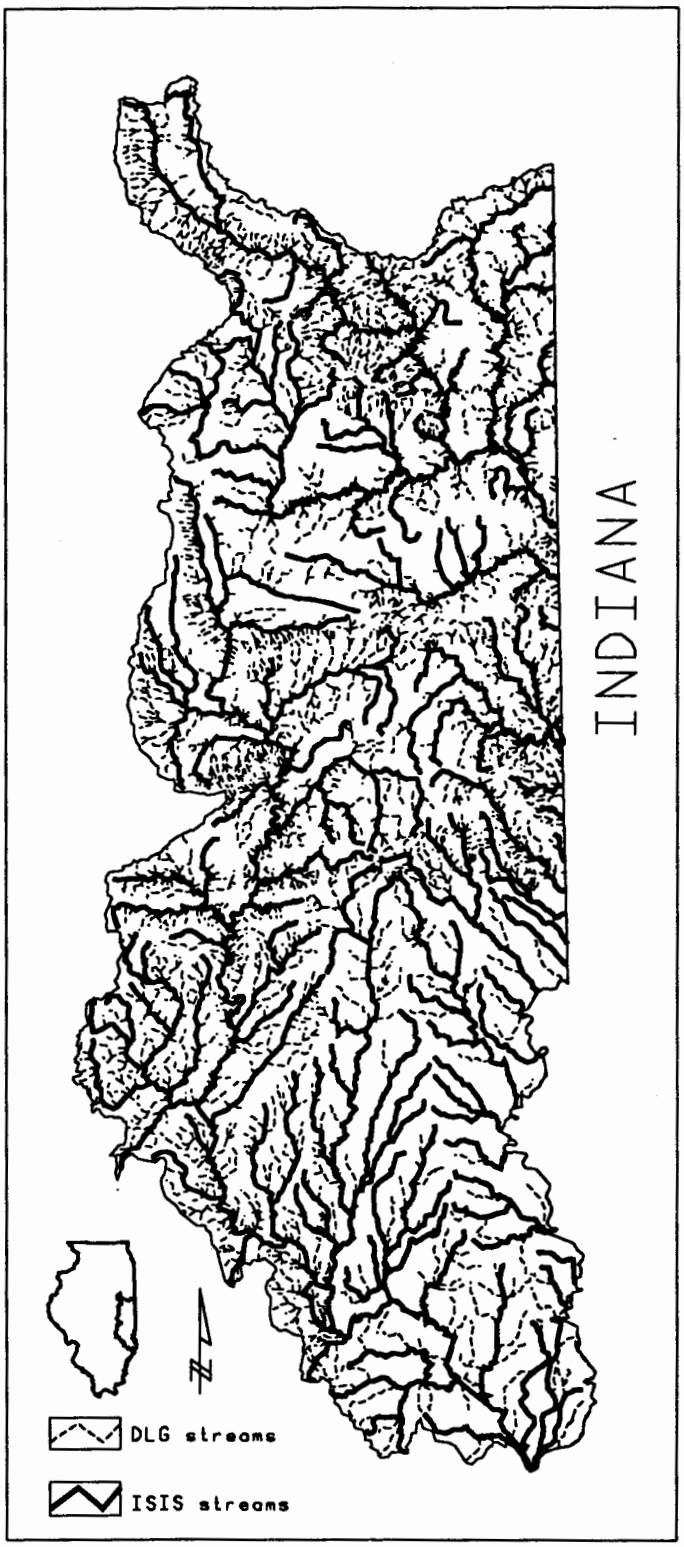

Figure 2 The Embarras and Vermilion River Basins

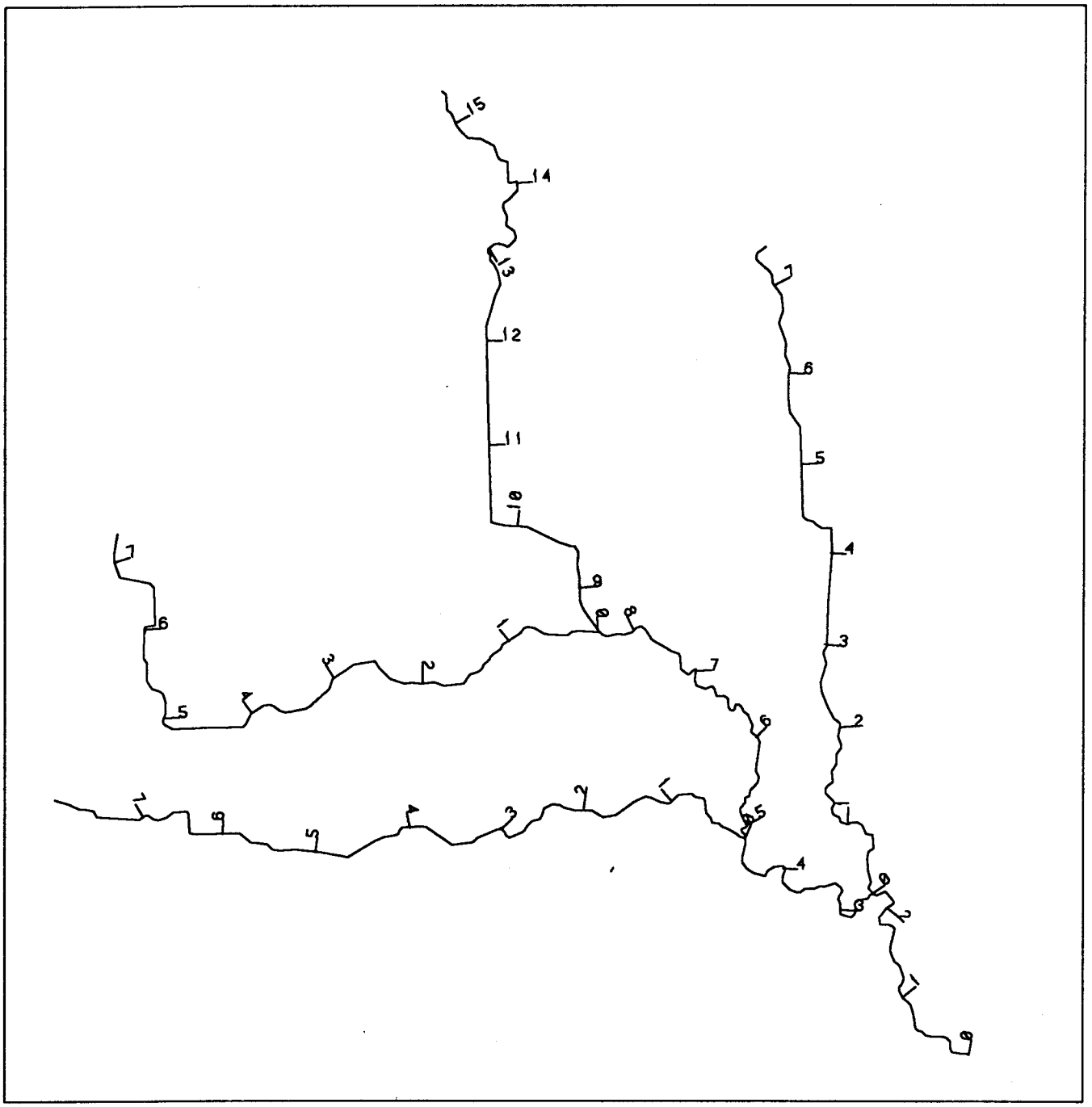

Figure 3 Example of Dynamic Segmentation on Stoney Cr in the Vermilion River Basin (Numbers in Figure = RMI)