PROTOTYPE VIRTUAL DATABASE DEVELOPMENT FOR MANAGEMENT OF FLOODS IN THE RED RIVER BASIN

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ABSTRACT

Technical requirements for the development of the Red River Basin Virtual Database (VDB) are tested through the virtual database prototype project currently under completion at the University of Manitoba. The main objectives of the prototype development are to: (a) test the Inetrnet technology as a support for the development of floodplain management database; (b) develop an appropriate VDB architecture; (c) investigate technical issues involved with the development of VDB; and (d) implement a prototype VDB for the Rural Municipality (RM) of Ritchot in the Red River Basin.

DATA FOR FLOODPLAIN MANAGEMENT

Data for floodplain management in the Red River Basin exist in many forms and are not always widely available (IJC, 1997). One of the main activities in the basin is to ensure that all data (topographic, land use, hydrologic, hydraulic, environmental and economic) are accessible to all users in order to provide support for: (a) planning and design for flood protection; (b) real time flood emergency; and (c) flood recovery. Table 1 includes initial data components as identified by the Red River Basin Task Force of International Joint Commission.

The virtual database (VDB) was described as "fundamental for success" in the IJC Interim Report (IJC, 1997) and is considered one of the three main components of the decision support system being developed for the floodplain management in the Red River basin (Simonovic, 1999; SAIC, 1999). The VDB is an Internet based data catalog that facilitates search by data type, custodian, location, and other attributes from a distributed confederation of data holding organizations within and outside of the Red River Basin. The Red River Basin VDB will have no single data repository thus eliminating the need for regular updates of data to a central data clearinghouse. The data will be managed and maintained current by the existing custodial agencies where the appropriate scientific and engineering capability exists for sustainable and cost-effective data management.

Metadata (text files describing various characteristics of a data set, such as accuracy, format, collection source, heritage, custodians, errors/gaps) is developed for all data that is going to be accessible through the VDB (PhaseFour, 1999). Although the focus of the Metadata project was to identify actual data providers and then to collect metadata for each land related information data set within the Red River Basin, a brief technology assessment was also conducted to indicate the agency's level of Internet usage. Summary of the findings for the Canadian portion of the basin includes: (a) 34 agencies were contacted and surveyed; (b) 121 data sets were catalogued; (c) 26 agencies have an internet presence in the form of a corporate or departmental web site; (d) 5 agencies are actively promoting data services over the Internet; and (e) 3 agencies currently use the Internet by way of email and browse access only. The use of technology within the agencies that were contacted is changing rapidly. As the Internet becomes a stronger vehicle for information sharing and application and services deployment, many of the agencies have indicated plans to move from a passive and static web based environment, to a more interactive and dynamic environment. The next generation of web sites will incorporate facilities in which products and services are offered to business partners, suppliers, contractors and the public at large. Setting the foundation for the Red River Basin Virtual Data Base is the key factor in helping some of these agencies move forward in their plans to capitalize on the benefits of Internet technology.

Data providers within the Canadian portion of the Red River Basin (as identified by PhaseFour, 1999) are listed in Table 2. The key data providers are: Manitoba Emergency Management Organization; Manitoba Natural Resources Water Resources Branch; Manitoba Natural Resources Land Information Centre; Manitoba Natural Resources Remote Sensing Centre; Environment Canada; Manitoba Environment; City of Winnipeg Water and Waste Department; and Manitoba Highways and Transportation.

TABLE 1. Initial database components

INFRASTRUCTURE ***Readily Available*** Roads - elevation and alignment Railroads – elevation and alignment Levees – elevation and alignment Wells – Active and abandoned Bridge and Culvert openings (>5ft) Utilities – Hydro, gas, water, sewage, etc. ***Not Readily Available*** Drains – dimensions and alignment Raised Pads - locations and elevations Impoundments: size, sill elev., construction date Critical Facilities Potential Spill Sources (Hazardous Material) Historic Sites **TERRAIN/ENVIRONMENTAL** ***Readily Available*** Digital Elevation Data Land Use – current and historic National Wetlands Database Soils Water Quality Threatened and Endangered Species (T&E) ***Not Readily Available*** Digital Elevation Data (detailed) Drained Basins Agricultural and other Chemical Use Critical Aquatic & Wildlife Habitat Archeological Sites **MISCELLANEOUS** ***Readily Available*** Census Data ***Not Readily Available*** Emergency plans and Organizational charts	**HYDRO-METEOROLOGICAL DATA** ***Readily Available*** High-water Marks – Flood Extent X-sections (bathymetry) Hydrometric and meteorologic sites/network Gauge locations Precipitation, snow, temperature, dew point, wind, solar radiation, etc. Stage and discharge data Elevation-Discharge Curves Discharge-Frequency curves Stage- Damage Curves ***Not Readily Available*** Head loss – Structures/roads/levee breaches Head loss – Changes since flood Ice data **GEOGRAPHIC DATA** ***Readily Available*** Political Boundaries (State, County, Province) Hydrologic Units River reach Lakes Transportation Network (roads and railway) Geodetic Control ***Not Readily Available*** Floodway/Floodplain Alignment **IMAGERY DATA** ***Readily Available*** Satellite imagery ***Not Readily Available*** Aerial Photographs

In the preliminary contacts, most agencies were supportive, but required follow-up dialog. The outstanding issues associated with providing online data access to the public are: network and data security for each agency, cost recovery programs operated by some agencies (like Environment Canada) when providing data, and some concerns over inappropriate use of some data by the public.

TABLE 2. Initial list of data providers

– Canadian National Railways – Cantel AT&T – City of Winnipeg – Conservation Data Centre – Ducks Unlimited – Emergency Preparedness Canada – Environment Canada – Fisheries and Oceans Canada	– Linnet Geomatics International – Manitoba Crop Insurance Corporation – Manitoba Agriculture – Manitoba Culture, Heritage and Citizenship – Manitoba Emergency Management Organization – Manitoba Environment	– Manitoba Highways and Transportation – Manitoba Hydro – Manitoba Natural Resources – MTS Mobility – Prairie Farm Rehabilitation – Ruraland Consulting Ltd. – Statistics Canada

PROTOTYPE VIRTUAL DATABASE DEVELOPMENT

Evaluation of user data needs

At the beginning of VDB prototype development a series of communications have been conducted with the representatives of the RM of Ritchot. Results of the IJC data needs workshops were also utilized (Science Applications International Corporation, 1999). The intent of these communications was to help capture the data needs, critical communication links, and processing requirements necessary to perform emergency and floodplain management functions within the RM of Ritchot. A secondary goal was to find out which data and/or information "data providers" might be able to share with the RM of Ritchot. Three types of information were identified as necessary by the users: numerical and descriptive information; spatial information and modeling tools for data analyses.

System architecture

Simple four-component architecture has been selected for the prototype development including: (i) user interface; (ii) data query; (iii) map query; and (iv) model library. *User interface* of the prototype VBD is developed in the form of a web page written in HTML and Java. It is designed to provide assistance to the user in accessing data, maps, and different modeling tools. *Data query* allows access to: (a) four water level data stations (Winnipeg floodway, upstream and downstream, St. Adolphe, and Ste. Agathe); (b) weather data (daily high and low temperature, and daily precipitation at Winnipeg airport and Glenlea); (c) information on available volunteers; (d) information on available material for emergency temporary flood protection; (d) information on available construction equipment; and (e) some information on the 1997 Red River flood. *Map query* allows user to access the following spatial data: (a) topography; (b) roads; (c) flooded area; (d) power lines; (e) communication network; (f) infrastructure; (g) buildings; and (h) land use. *Model library* contains programs for analysis of basic data. Prototype VDB for the RM of Ritchot includes four types of models for: (a) hydrologic forecasting; (b) hydraulic forecasting; (c) economic analyses; and (d) emergency assistance. Examples of user interface for accessing data, maps and models are shown in Figures 1a, 1b, and 1c, respectively.

System technical requirements

Implementation of four-component system architecture requires complex technical solutions (hardware and software). Prototype development was implemented within the research *Facility for Intelligent Decision Support* at the University of Manitoba using three servers to simulate different data providers connected by the Internet. One computer was used as the HTTP (web) server containing number of user interface web pages written in HTML and Java and supported by Java applets.

The same computer is serving as the database access server which provides for the connection to the relational database and transfer of the data from this database to the user. Technical solutions for this server may differ based on the type of database being accessed and the type of user. For example, a public HTTP server can provide the same function if a metadata is not used. In the prototype VDB for the RM of Ritchot access to one database is provided through the HTTP server, and access to other databases is provided through the database access server. The data query programs in the prototype VDB are written using Java servlets (a standard extension to the Java language) and therefore a Java servlet engine is also needed as a part of the public HTTP server.

The second computer provides support for the VDB map query. Three main tools used to support map query include an HTTP server, a GIS computer program and an Internet map server. Prototype development included VDBR HTTP server (known as MS Personal Server), ArcView GIS program, and ArcView Internet Map Server. Link between HTTP server and ArcView GIS program is provided through a Java applet.

The third computer is serving as the support for model library. Models in the prototype VDB for the RM of Ritchot are written using Java applets and Java servlets and are installed on the public HTTP server. More complex modelling efforts will require further investigation in the appropriate technical support for efficient execution of models, submission of input data and access to modeling results.

CONCLUSIONS

The distributed nature of four-component prototype VDB provides flexibility in selecting the location for and type of hardware platform containing data necessary for floodplain management. VDB prototype for the RM of Ritchot demonstrated that the Internet technology is mature enough to support the development of virtual database for a complex domain such as floodplain management. It is also quite clear that this mode of support has many advantages when compared to more traditional centralized database model.

It is important to point out that there are still some very important outstanding issues associated with providing online data access to the public. They are: network and data security for each data provider, cost recovery programs operated by some data collection and distribution agencies, and some concerns over inappropriate use of some data by the public.

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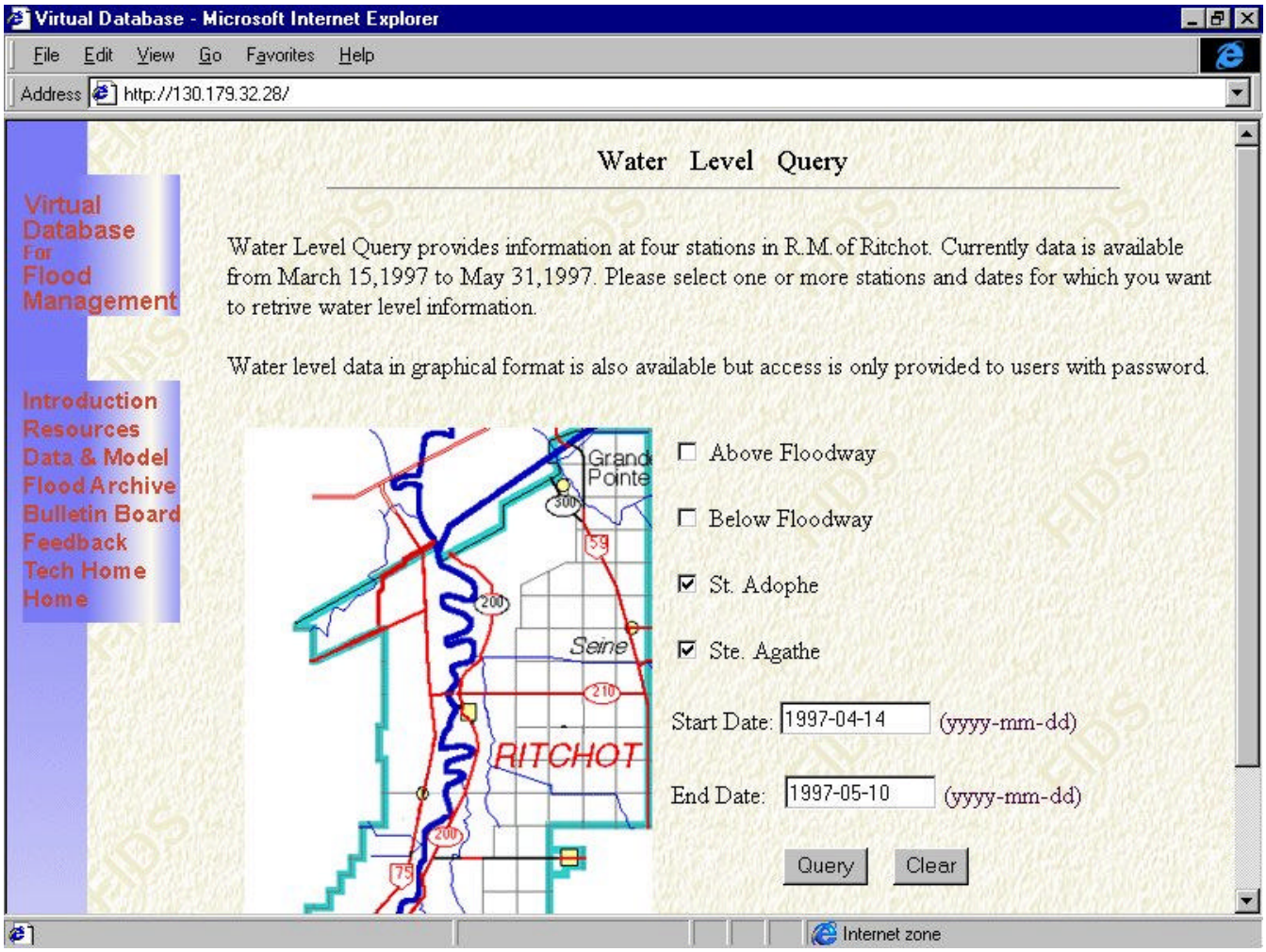

Figure 1a. Examples of prototype VDB interface - Data query

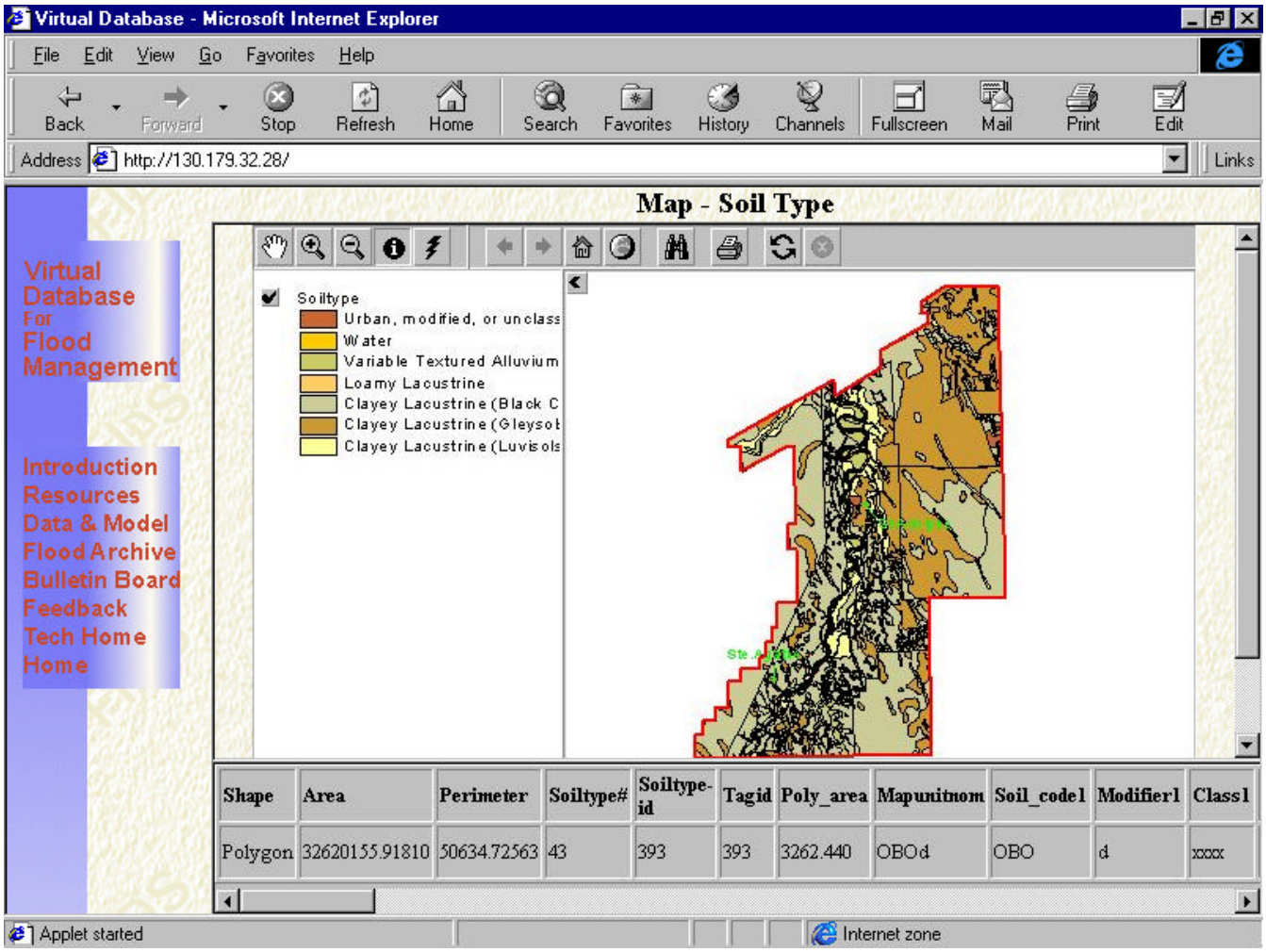

Figure 1b. Examples of prototype VDB interface - Map query

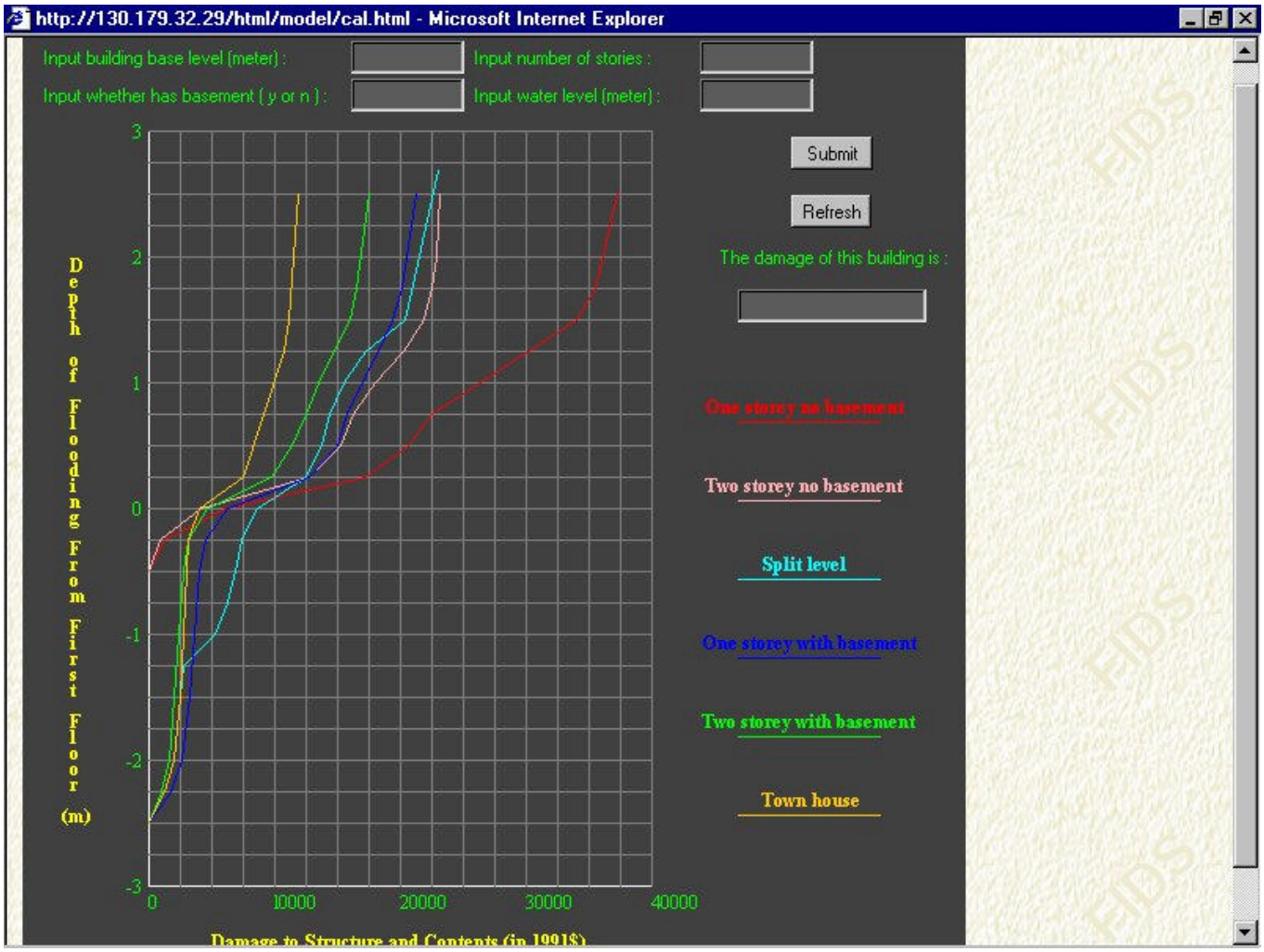

Figure 1c. Examples of prototype VDB interface - Model base