# WEB-BASED INFORMATION SYSTEM FOR ABORIGINAL LAND MANAGEMENT

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## ABSTRACT

With increased land development on aboriginal lands in Canada, there is a need for a web-enabled spatial information system to allow improved access and analysis of land management information. In this paper, a web-based database for sharing information on aboriginal territories has been developed and updated. It allows First Nations, interested individuals, and businesses to interactively access, browse, analyze and share information pertaining to the land use activities in Aboriginal communities. This paper presents the procedures for the development of a prototype of a web-based Information system for aboriginal land management. In this user-friendly prototype system, ArcIMS is used as the spatial server. Due to the limitation of the existing commercial software, such as ArcIMS, Web GIS customization of Internet mapping applications has also been discussed. Implementation of basic spatial queries and advanced spatial queries through ArcXML coding has been presented as well.

## INTRODUCTION

Since 1973, when Aboriginal rights were first recognized legally in Canada, various land management initiatives to reform the land management systems in Indian reserves have been introduced by the federal government. With self-government agreement, many First Nations have the freedom to design the policies to manage their land resources (Rakai & Nichols, 1998). There are different groups and individuals (such as First Nation Communities, governmental, academic and private organizations working with First Nations) interested in obtaining information and services regarding land use activities in First Nation communities in Canada (Fiscal Realities, 1999). For each interested group, there is a problem of identifying where to obtain and analyze information on land use activities in Aboriginal communities (Rakai & Nichols, 2002).

Currently, data and information on Aboriginal Peoples' land use activities are scattered. Some of the aboriginal and government organization websites provide huge amount of information using HTML, which is unstructured and thus very time-consuming for the end-users to extract information about specific aspects of land use. It is important to mention that land use activities that are of interest have spatial and non-spatial context. The problem arises when users want to gather information from text, static maps (such as sketch maps and images) that are stored at different websites in a scattered way. There is no centrally maintained website that provides integrated data/information retrieve services. The first problem is that the spatial data of First Nation communities are not always complete and well maintained. In most cases, metadata is not available. Secondly, different static maps sometimes are not geo-referenced to a common coordinate system, and it is difficult to compare the locations and conduct spatial measurements. Another issue is that these static maps cannot be changed to suit the users' needs. For example, user cannot change the scale of a map, cannot select an area of interest, or perform any spatial analysis. The textual information that is available is not linked with the spatial location (e.g. Campsite, hunting area, traditional territories). In most cases, just by looking at the maps, the user doesn't have the full understanding of the land use activities. This is mainly because the information regarding land use also needs to be conveyed through textual description, or even pictures and videos. For the reasons mentioned above, it is very difficult for the user to obtain integrated land use information regarding specific area in the current situation.

An important functionality of Geographic Information System (GIS) is to link, relate, and analyze spatial and attribute data. As a spatial information manipulation tool, GIS allows for the integration of different data sources, thus, input data may be gathered from a variety of sources: maps, aerial photos, satellite images, etc. As an analytical tool, GIS can be used to perform spatial queries, develop dynamic models, to analyze trends over time, simulate scenarios, and predict possible events (Maguire & Dangermond, 1991). The achievement of Internet technology has allowed some GIS data and functionality to be accessed remotely by the users. Web GIS has become the popular way to process and disseminate geographical data thus providing users with greater and more-timely access of data. Therefore, Web GIS is an efficient tool for sharing land use information for remote Aboriginal communities (Duerden & Kuhn, 1996; Mohamed & Ventura, 2000). It may also facilitate the interaction of Aboriginal communities and other agencies involved in their land development to achieve integrated land use planning.

## REQUIREMENTS FOR WEB-BASED INFORMATION SYSTEM

In this research project we have chosen Yukon as the study area, mainly because of the availability of data. Determining user requirements is one of the basic and fundamental components of GIS design and implementation as each project is unique. The potential users of our web-based GIS system include remote First Nation communities, land managers, land developers and various academic and governmental agencies. The purpose of this Web GIS prototype is to provide the basic spatial information, including land tenure information on Aboriginal land, together with other planning and policy information. The required functions will be browsing, and interactively retrieving spatial information, conducting spatial analysis as well as generating "what if" scenarios to assist the decision-making process.

The basic procedures of system implementation includes: user requirements analysis, data collection, data processing, database design and updating, system architecture design, users' interface design, map hyperlinks and query implementation.

## SPATIAL DATA COLLECTION AND DATA PROCESSING

The digital spatial data are collected from different sources. These include the Yukon Government Geomatics Department Website (www.geomaticsyukon.ca), GeoConnections (www.geoconnections.org), Geogratis (www.geogratis.cgdi.gc.ca).

Data includes base mapping data, such as administrative boundary, cities and towns, roads, rivers and lakes. Aboriginal related data includes: traditional territories, land settlement data, protected areas including national parks, and game management area. Traditional territories data shows the boundary of each First Nation community. Land settlement gives the details of the ownership of the land parcel within the First Nation territories, such as lands belonging to the crown, and the lands to which First Nations own both surface and mineral rights. Game management area shows the area for hunting different animals by the First Nations. In addition, the mining data is included, which shows the areas where mining claim placers occurred. Mining is now one of the major land development activities in Yukon, so this information together with various geographic data will be very valuable for the new developers. Table 1 shows the various datasets used in this project:

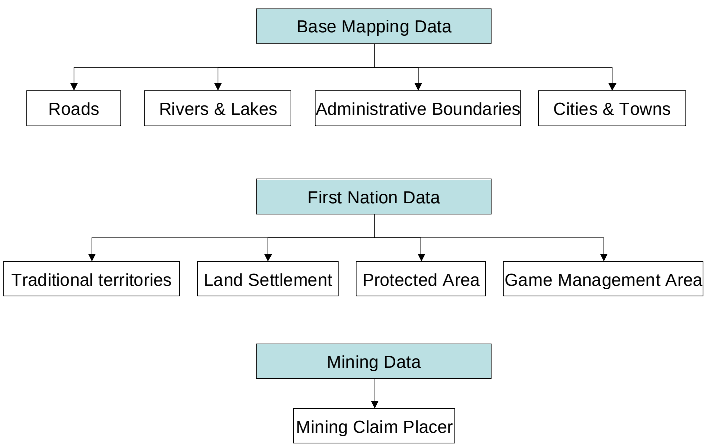


Figure 1: Spatial Datasets used in Research for Yukon Territory

Since the collected spatial datasets were produced by different data providers, they came in different formats, different map projections, and different coordinate systems. Data processing was therefore a necessary step needed to ensure data consistency.

### Regulatory Information:

Another important part of the data is the land use procedure and regulations. The land development activities that are affecting the Yukon Territory the most are mining activities and now we will present the procedures related to placer mining application. In the Table 1 the general information about the various approval processes regarding placer mining in Yukon is presented.

| **Class** | **Type of Approval** | **Fees + (YPMLUR Schedule 2)** | **Approval Time** | **Approval Expiry** |
|---|---|---|---|---|
| I | Follow Operating Conditions | no fee required | - | one year |
| II | Notification and Mining Land Use Approval | $100 | 25 days | one year |
| III | Operating Plan and Mining Land Use Approval | under five years $250<br>over five years $500 | 25 days | up to ten years |
| IV | Operating Plan<br>Type B Water License | under five years $250<br>over five years $500 | up to and exceeding ten months | up to ten years |

Table 1: General Approval Information for Different Types of Placer Mining

The information regarding mining application have been included in the prototype website. This is just one of the examples where legal information can be incorporated to enrich the spatial database. Integrating such kind of information is useful for the land developer in order to minimize time to get the information to support the application, and also for aboriginal land managers and the general public as a whole (Campbell & Sindlinger, 2001; Sharvit et al, 1999).

## GEODATABASE IMPLEMENTATION

One of the challenges of this project was to link many different types of spatial and non-spatial data that may also be unstructured and available from different web sites in various data formats. During the database design process, some of the information extracted from the data, when incorporated into the database, become the structured data. Some of the information are rich in semantics aspects, but were not easily incorporated into the relational database. Therefore they were maintained through hyperlinks incorporated into the database system. This is important to ensure the images and hypermedia data can be integrated into the system.

After geo-processing the data and storing them as ESRI shapefiles, attribute tables were redesigned as shown below:

| | | | | |
|---|---|---|---|---|
| Roads | Road_ID | Geometry[1] | Name | Type |
| Places | Place_ID | Geometry | Name | Population |
| First Nation Territories | Territory_ID | Geometry | Name | Hyperlinks |
| Games | Game_ID | Geometry | Name | |
| Settlements | Settlement_ID | Geometry | Name | Category |
| Mining | Mining_ID | Geometry | Claim_Type | |
| Mining license renewal | Mining_ID | Renewal_Number | Start_date | End_date |

Table 2: Attribute Tables of Web-GIS Prototype System

[1] Geometry includes shape, coordinates in addition to length (for line features) and perimeter and area (for polygon features).

In the database design process, some of the fields have been added to enrich the semantics of the information system prototype. For example, in the Mining license renewal, Start_date and End_date are added as extra fields to include temporal aspects of the mining placer claims. Start_date represents the time of establishment of mining placer, while End_date represents the time when mining placer claim is expired.

## PROTOTYPE SYSTEM ARCHITECTURE AND IMPLEMENTATION

In this project, the architecture of the system is determined largely by the commercial Web-GIS software ArcIMS. But the developer still has the flexibility to decide how to divide the function modules at the client and server side as ArcIMS provides different types of client viewers: Java Standard, HTML Standard, Java Custom, HTML Custom. Each of them provides different functionalities at the client side. HTML viewer is a relatively thin client, and Java viewer is a relatively thick client. For customized types of viewers, ArcIMS provides many different ways to do it, such as using Javascript, java beans, ActiveX control, Coldfusion. Choosing the appropriate programming language is based on the type of connector used to connect the web server and application server, and the developers preference.

Figure 2 shows the system architecture of the Web-GIS system prototype for Aboriginal communities. In the prototype implementation, Apache 2.0.42 is installed as the Web Server, while Tomcat 4.0.5 is installed as the Servlet Engine. ArcIMS connector is used for this project.

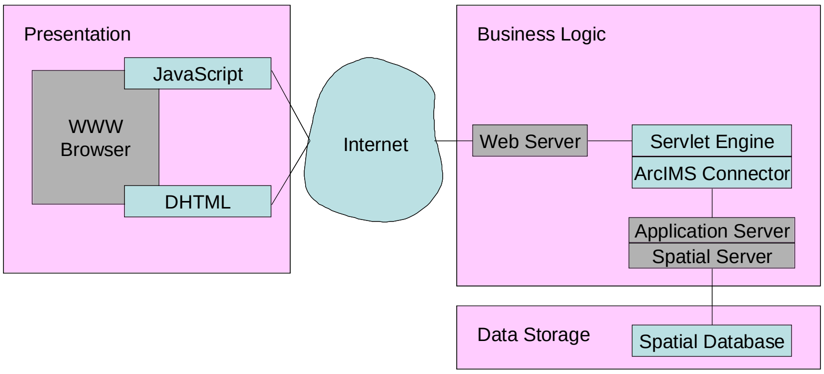


Figure 2: Prototype System Architecture

As alternatives, Java Connector, Coldfusion, and ActiveX connectors can be installed. Javascript and DHTML are used to customize the client viewer in this prototype development. In the Figure 3 the interactive users' interface of the system is shown.

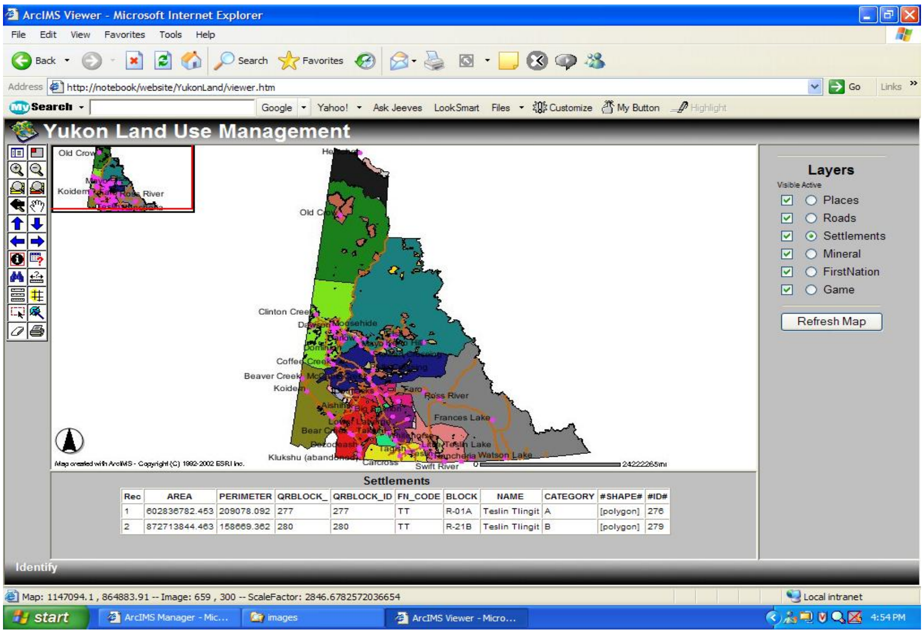


Figure 3: Users' Interface

## Hyperlinks

Within a specific land information system, land management and land activities always have their legal and institutional aspects. Some of the information is in rich semantics, but is not easily incorporated into relational database. As mentioned in the database design, we can keep it via hyperlinks incorporated into the database system. In order to incorporate these aspects for the users' access, the spatial feature on the map should have more flexibility to link to other type of information other than the attribute table. For example, it is very useful to link each First Nation Territories with the band council webpage, allowing users to get the contact information via hyperlinks.

The database you want to link with hyperlinks must contain a field with valid URLs. Combining hypertext information with spatial data in this project is important, for example the linkage to each first nation council webpage, allows users to get quick contact with specific First Nation. We show in the attribute table how we created a field for Hyperlink in the First Nation Territories database to link the spatial layer features with the band council website:

| AREA | PERIMETER | FN ID | First Nation | CODE | Hyperlink |
|---|---|---|---|---|---|
| 11.96110 | 13.38296 | 1 | Trondek Hwech'in First Nation | TH | www.trondek.com |
| 4.48377 | 9.78834 | 2 | Teslin Tlingit Council | TT | www.yesnet.yk.ca |

As shown in the Figure 4, when the user chooses the hyperlink tool from the toolbox, and clicks on the specific First Nation on the map, the link to the band council's websites appears.

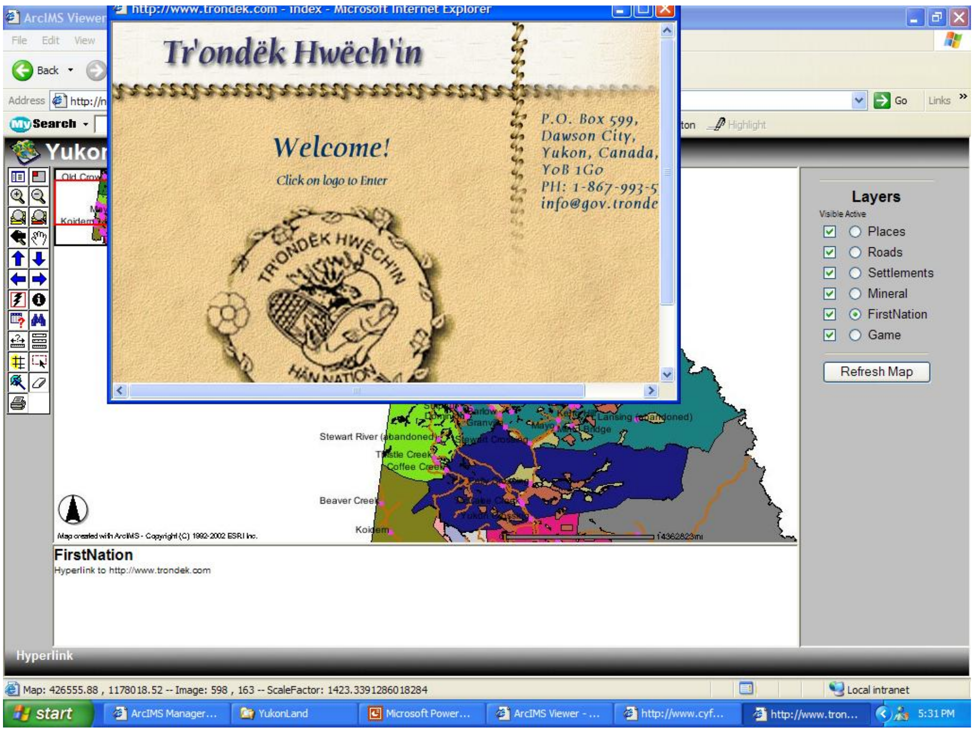


Figure 4: Hyperlinks to the First Nation Band Council Website

It is important to note that more than one layer can be set active with the hyperlink. For example, the legal information mentioned earlier can also be incorporated into the layer "placer mining" in the same way.

## SPATIAL QUERY IMPLEMENTATIONS

The developed prototype provides a seamless integrated spatial and non-spatial information environment. The basic spatial analysis functionalities associated with a web-based GIS (ArcIMS) system is included.
For example:

- Vector data manipulation (pan, scroll, zoom, locate, window queries, etc.);
- Attribute data query;

- Spatial data query (buffering, intersection);

In the following section we will present some of the basic query examples using the functions mentioned above.

Figure 5 shows the query result for the query "Find the settlement in the Yukon where the population is more than 5000".

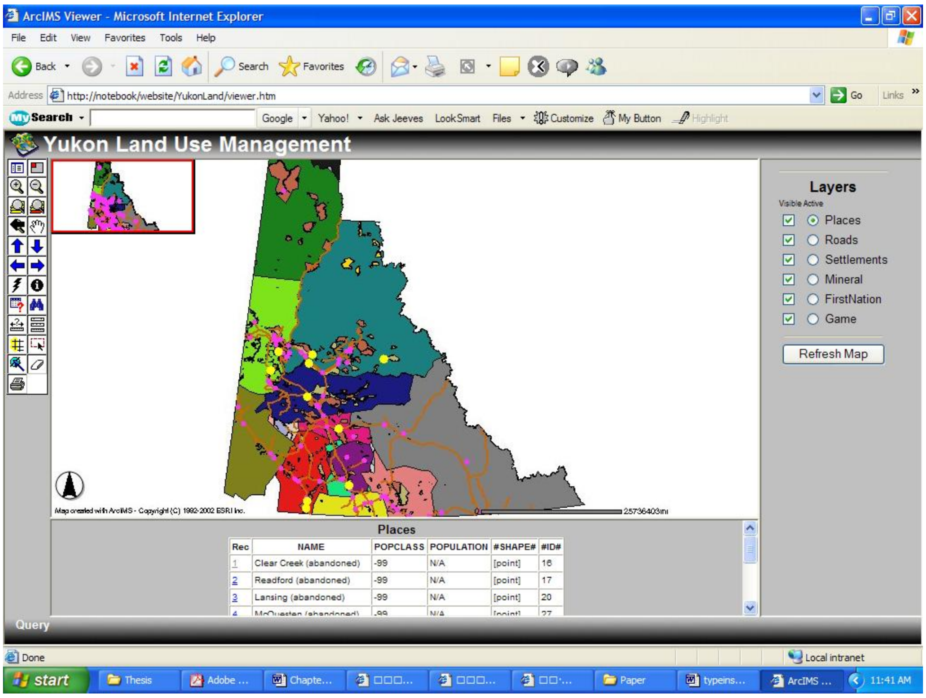


Figure 5: Settlement in Yukon where the population is more than 5000

Figure 6 below shows the query result for the query "Find the area where I can hunt deer".

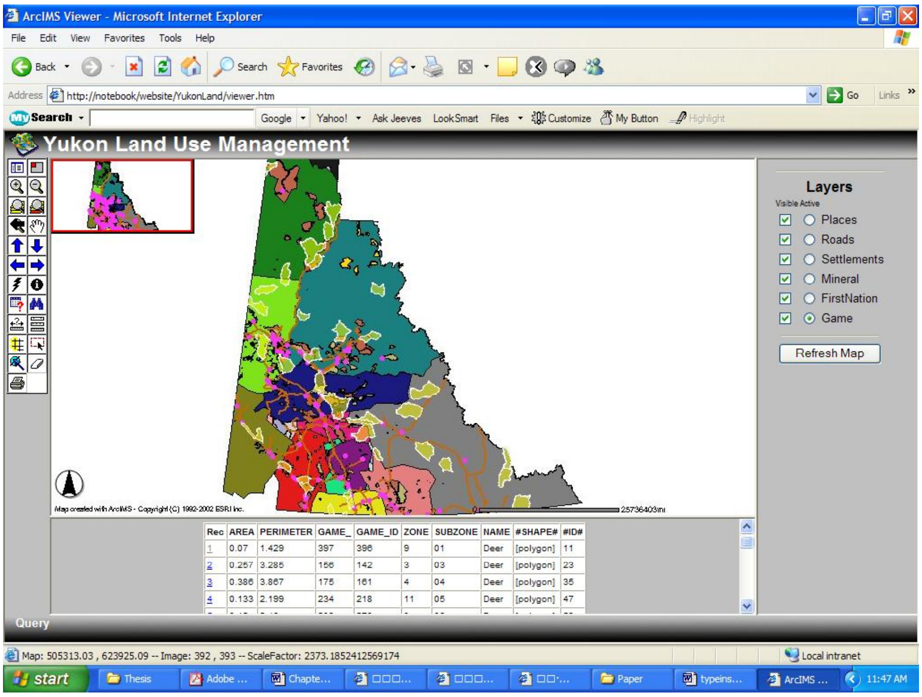


Figure 6: Areas where deer can be hunted

For the query “Identify the type of settlement land within selected area”, window selection and identification is shown in Figure 7, and the query results are shown in Figure 8.

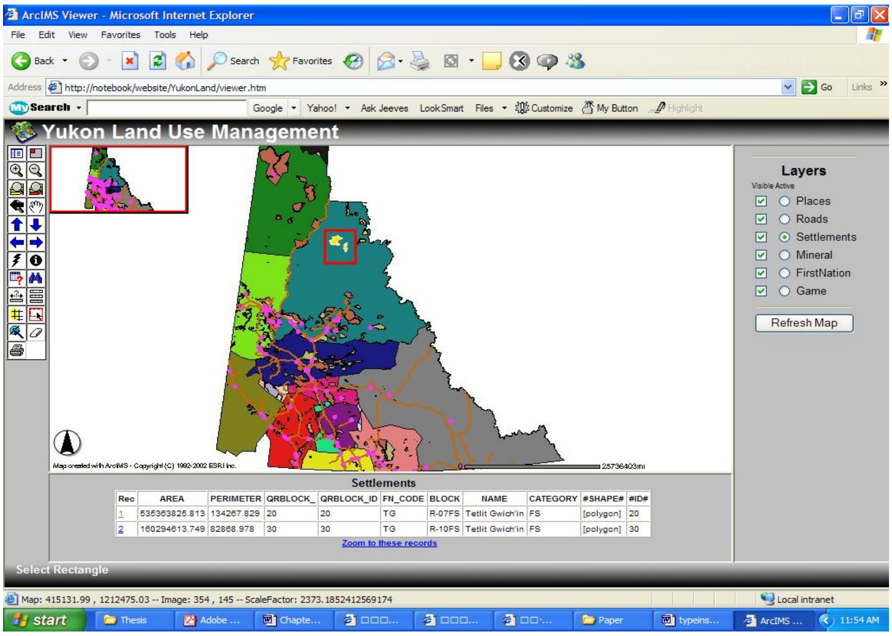


Figure 7: Window selection and identification

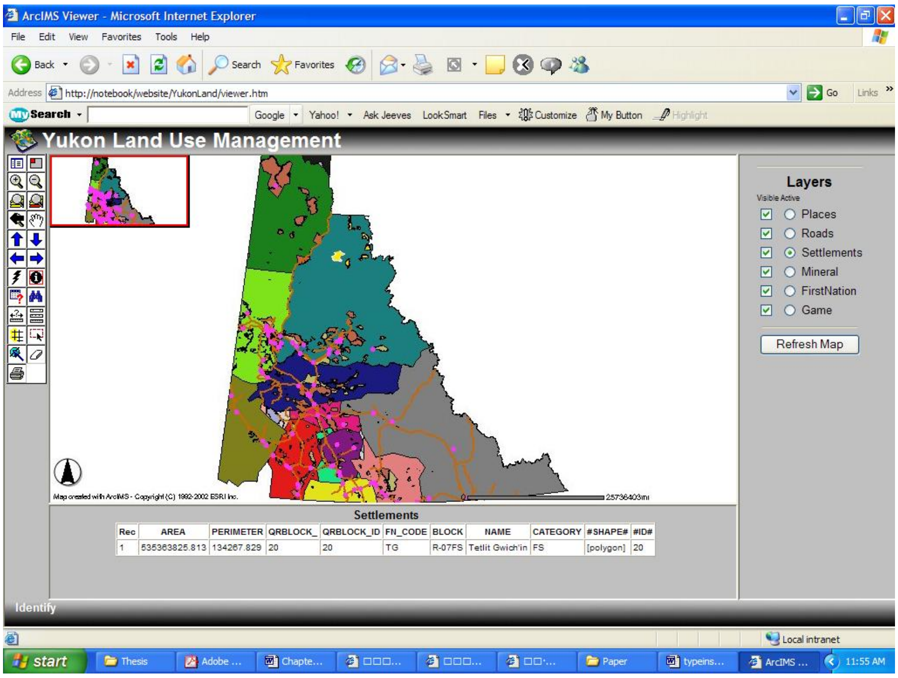


Figure 8: Type of the settlement land of the selected area

Figure 9 shows the query result for the query ”Find the mining claim placers that will be expire on December 2010”.

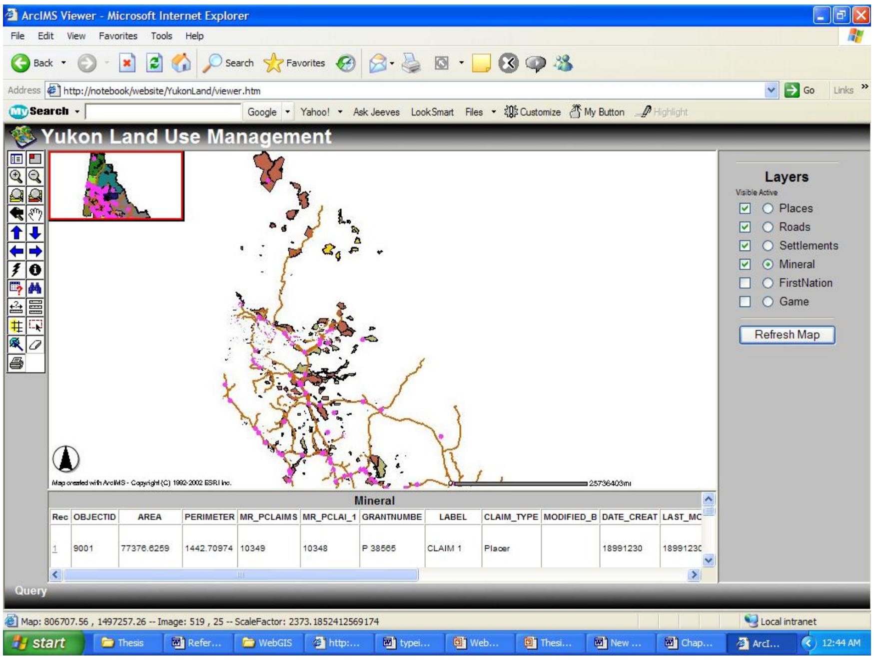


Figure 9: Mining claim placer that will be expire on December 2010

## ArcXML Programming for Advanced Spatial Queries:

By using the existing tools provided at the client viewer, simple queries showed in the examples can be easily carried out. However, combining more complex spatial and attribute queries is still very limited. This is mainly because multi-step analysis is not supported. A new query that is based on a previous query result cannot be done. Within ArcIMS, we can rewrite and customize the code for advanced spatial queries using ArcXML, thus improving the limited query abilities of ArcIMS. In our Web-based Information system prototype, ArcIMS connector is used, and all query requests sent by the client has been changed into ArcXML format. In the following section we will discuss the implementation of complex spatial queries through ArcXML programming.

In this research project many advanced queries based on combining spatial and attribute queries have been developed using ArcXML. Below is an example illustrating the capability of programming in ArcXML for executing more complicated spatial analysis queries.

This is an advanced query that is reutilizing the result of the buffer query: “Select Game Area, within the buffer distance of 20 miles of the major roads”. Below is the ArcXML code used for executing this query request, and Figure 10 shows the query results.

```
<ARCXML version="1.1">
<REQUEST>
<GET_IMAGE>
<PROPERTIES>
<ENVELOPE minx="-141" miny="60" maxx="-124" maxy="70" />
<IMAGESIZE width="500" height="350" />
</PROPERTIES>
<LAYER type="featureclass" name="theBufferTarget" visible="true" id="buffertarget">
<DATASET fromlayer="5" />
<SPATIALQUERY>
<BUFFER distance="20" bufferunits="miles">
<TARGETLAYER id="2" />
</BUFFER>
<SPATIALFILTER relation="area_intersection">
<ENVELOPE minx="-141" miny="60" maxx="-124" maxy="70" />
</SPATIALFILTER>
</SPATIALQUERY>
<SIMPLERENDERER>
<SIMPLEPOLYGONSYMBOL fillcolor="255,255,0" filltype="solid" filltransparency="1" />
</SIMPLERENDERER>
```

```
</LAYER>
<LAYER type="featureclass" name="theBuffer" visible="true" id="buffer">
<DATASET fromlayer="5" />
<SPATIALQUERY>
<BUFFER distance="20" bufferunits="miles"/>
<SPATIALFILTER relation="area_intersection">
<ENVELOPE minx="-141" miny="60" maxx="-124" maxy="70" />
</SPATIALFILTER>
</SPATIALQUERY>
<SIMPLERENDERER>
<SIMPLEPOLYGONSYMBOL fillcolor="100,100,100" filltype="solid" filltransparency="0.5" />
</SIMPLERENDERER>
</LAYER>
</GET_IMAGE>
</REQUEST>
</ARCXML>
```

Result:

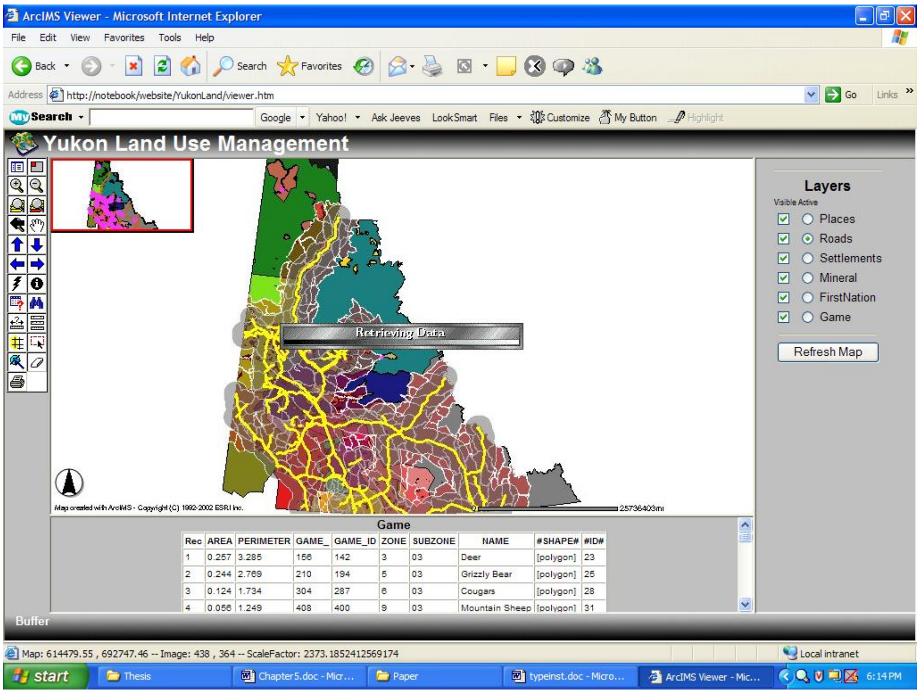


Figure 10: Query Result

The advantages of the ArcXML syntax are the multi-use of the spatial filter, where we can set "buffer target" to use the buffer result for overlay with other thematic data.

The disadvantages are that the spatial queries (especially intersection and overlay) are not efficient! This is partly because the intersection involves only two layers, and it can't perform queries if there are many layers to be overlaid. Also, inside one spatial query, multiple use of the spatial filter is limited. It is impossible to embed spatial filter several times inside the spatial query. These problems mainly arise due to the restrictions set by the ArcXML syntax.

## CONCLUSIONS

In this paper, the procedures for developing a prototype of web-based information system for Aboriginal land management have been presented. In this research, spatial and non-spatial data for the Yukon First Nations has been collected and processed. Spatial data preparation was an important part of this research project. Spatial data has to be properly processed into one common projection and geodetic datum. The database has to be updated prior to being published on the website. In this application, an interactive users interface that requires many hyperlinks related to the spatial features was customized and enhanced within the ArcIMS server. Multi-media files and Hyperlinks can be incorporated into the website through proper database design and customization in ArcIMS. Furthermore, various spatial queries, basic and complex ones have been implemented. Spatial queries such as buffering and intersections created through ArcXML can be embedded into java functions at the client side. The database design allows spatio-temporal queries to be easily incorporated into the website. For example, displaying active mining areas that are shown in the prototype. This web-based information system for Aboriginal land management allows First Nations, interested individuals, and business to interactively access, browse, analyze and share information pertaining to the land use activities in Aboriginal communities.

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