Digitize Selected Granular Resources Information Pertinent to MGP

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ENVIRONMENTAL GEOSOLUTIONS

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1.0 INTRODUCTION

Environmental Geosolutions, Inc. of Exeter (Ontario) was contracted by Indian and Northern Affairs Canada (Contract #A7133-06-0015) to summarize, digitize and update selected, currently available granular resource information in the vicinity of the Mackenzie Gas Project within the Northwest Territories. Output from this project will be used to enhance the utility of the existing Mackenzie Valley and ISR on-line mapping tools. The Departmental Representative responsible for this contract is Robert J. Gowan. This report describes the tasks performed to execute the contract, the resultant GIS and image files, and recommendation for the future.

2.0 BACKGROUND

The commodity-driven economy of the NWT is one of the fastest-growing in Canada, fueled by an array of resources including diamonds, oil, gold, uranium, and other base metals. The NWT also has one of the world's largest deposits of natural gas in the Mackenzie delta, resulting in plans to develop a pipeline south through the Mackenzie Valley (the Mackenzie Gas Project, or MGP) and potentially build a permanent road north to the Arctic Ocean. All of these on-going developments and proposed projects require another very important resource to form the basic infrastructure on which they are built – *granular resources*. The availability and proximity of granular resources for northern development projects can be a significant portion of a project's start-up costs, especially if granular materials have to be transported over long distances. There is an obvious need to provide information on the granular resources (location, amount, type) for a given area in an accessible and easy-to-use format. The management of granular resources is vital to ensure present reserves are used to their full potential and correctly allocated to prevent wasted resources. Proper management also ensures that the needs of future developments can also be reasonably accommodated.

Much work has already been done to develop products to distribute information on granular resources in Canada's north. The Northern Granular Resources Bibliographic Database (http://www.aina.ucalgary.ca/ngr/) contains citations and abstracts to over 1600 reports on granular resources in Canada's three northern territories and adjacent waters. This database has helped to provide a central point to search for granular information and provides many documents in downloadable formats. In addition to the database, two on-line mapping tools have been developed for the Mackenzie Valley (MV) and Inuvialuit Settlement Region (ISR; URLs withheld at request of INAC). These mapping products are the next logical step towards providing a usable and applied tool for stakeholders to obtain information about the granular resource information that exists for a certain area. There is already a significant amount of information, in digital form, on the known granular deposits in certain portions of the region, yet much of this was compiled from sources of uncertain accuracy. More recent access to detailed imagery and more accurate GPS now permits better representation of existing resources.

There is a large amount of interest, as was made evident at a recent workshop in Yellowknife[1], in providing even more detailed granular resource information to stakeholders through the on-

[1] Terriplan Consultants, in preparation. "The NWT Granular Users Forum – Summary Report: September 27 & 28, 2006, Yellowknife, NT"

line mapping tools. These tools can be an important component of the decision-making that deals with proposed and alternative locations of MGP facilities, and provide the spatial framework to contribute to a better understanding of the impact of the granular requirements of the MGP. The various groups involved with and affected by granular management planning are widely dispersed, resulting in travel and meetings that are expensive and difficult to arrange. Online tools provide an environment for data dissemination and dispersal and will be a critical component in the development of granular resource allocation plans which must involve an iterative process of recommendation and response.

3.0 SCOPE OF WORK

The contract document outlines the scope of work for this project as follows:

1. Identify and obtain, through the Departmental Representative and consultants designated by the Departmental Representative, library and Internet searches, pertinent reports and other background information on the MGP, and the location, extent and type of granular resources in the vicinity of the MGP.

2. Review existing digital information and systems pertinent to evaluation of the granular requirements of the MGP and other existing resources, identify key areas where information and/or resources are particularly abundant or deficient, and make recommendations to the Departmental Representative on the use, expansion or modification of these systems and information to evaluate the impact of the MGP on granular resources in the study area.

3. Compile, process and summarize selected additional granular resource information, based on quality of existing information and priority of importance to this study, as determined in consultation with the Departmental Representative.

4. Prepare, update and modify information on the location, extent and type of granular resources in the vicinity of the MGP, including georeferencing of existing airphoto and map-based site plans, digitizing deposit boundaries, subsurface investigations (boreholes, test pits), test samples, etc.

5. Document source, compilation methods, etc for all above data using metadata consistent with current industry standards.

6. Prepare digital archives including spatial information, descriptive attributes and scanned images for granular resources sites processed as part of this study.

7. Document, in tables, maps and a report, the work undertaken and results obtained through this project.

4.0 TASKS PERFORMED

4.1 Preliminary Work

At the onset of the project a short amount of time was required to become familiar with the existing status of digital granular resource information in the study area. The following sources of information were reviewed:

- the on-line granular resource mapping tools that have been developed for the Mackenzie Valley and Inuvialuit Settlement Region
- the individual geospatial datasets that are used to populate the on-line mapping tools (provided by the manager of the on-line tools)
- the original granular resource inventories from the 1970s in PDF format (provided by the Departmental Representative)

4.2 Assessment of Existing Digital Granular Resource Products

Existing digital granular resource layers (deposit boundaries, boreholes, test pits) for the MGP region that are currently available through the on-line mapping tools were evaluated for their accuracy. To date the efforts have focused on the digitized versions of the granular inventories compiled by both Ripley-Klohn-Leonoff (RKL) and EBA in the MGP region in the early 1970s.

RKL (1972) Inventories
A significant mis-registration exists between the existing digitized granular resource boundaries on the ISR on-line mapping tool and the orthophotographs which are used as the basemap for geo-referencing efforts in this project (Figure 1). Polygon and point errors are a random distance and direction compared to the photographs, negating the possibility of performing a simple linear shift to line up the existing granular resource layers. The original shapefile was provided in Lat/Long format, and was imported to Manifold (the GIS software used in this project) where it was re-projected to UTM Zone 8 with both NAD27 and NAD83 datums. This was thought to be a potential reason for the spatial discrepancy. However, it was determined that reprojecting the shapefile to NAD83 datum resulted in an even larger error. Given the random nature of the distance and direction of the mis-registration, attempts to correct the shift would have required considerable time and effort. It was decided that the granular resource layers would be re-digitized at the same time as the geo-referencing of the original granular resource inventory photographs occurred.

EBA (1974) Inventories
The MV on-line mapping tool currently hosts digitized granular resource deposit boundaries for the complete EBA 1974 inventory. There is a minor offset (approximately 50 metres) that exists between the digitized deposits and the underlying base image. However, it was determined that this offset is regular and consistent, thus rendering the existing digitized boundaries usable with a minor shift applied. Completion of the EBA inventory will require digitizing of borehole and test pit locations and geo-referencing of inventory aerial photographs.

Figure 1: Example of spatial error that occurs between the existing granular resource polygons and the orthophotographs. The error in this example is approximately 230 metres. Orthophotographs of the Mackenzie Delta were flown in 2000 at a scale of approximately 1:58,000, and were later scanned to a pixel size of 1.25 metres.

4.3 Georeferencing of Scanned Site Plan Photographs

The original granular inventory reports from the early 1970s typically contain a series of individual site reports with 'site plans'. These site plans consist of a half-tone copy of a portion of a standard NAPL aerial photograph that is annotated with deposit boundaries and subsurface investigations (boreholes, test pits, outcrops). Georeferenced versions of the site plan photographs from granular resource inventories could be a very useful source of information to users of the on-line mapping tools. Currently these site plan photographs are only available for a few sites. All site plan photographs from the following granular resource inventories (a total of 143 photographs) were georeferenced for future inclusion in the on-line mapping tools:

- Community Granular Materials Inventory – **Tuktoyuktuk** (RKL, 1972) – Northern Granular Resource Database #30397
- Community Granular Materials Inventory – **Inuvik** (RKL, 1972) – Northern Granular Resource Database #30396

- Community Granular Materials Inventory – **Arctic Red River** (RKL, 1972) – Northern Granular Resource Database #30394
- Community Granular Materials Inventory – **Fort McPherson** (RKL, 1972) – Northern Granular Resource Database #30395
- Community Granular Materials Inventory – **Zone 1** (RKL, 1972) – Northern Granular Resource Database #30398
- Community Granular Materials Inventory – **Zone 2** (RKL, 1972) – Northern Granular Resource Database #30399
- Community Granular Materials Inventory – **Zone 3** (RKL, 1972) – Northern Granular Resource Database #30400
- Community Granular Materials Inventory – **Zones 4, 5, 6** (RKL,1972) – Northern Granular Resource Database #30401
- Community Granular Materials Inventory – **Hay River** (RKL, 1974) – Northern Granular Resource Database #27494

Site plan photographs were first saved as JPEGs from the original PDF documents. These images were cropped to the photo edges, removing the remainder of the page. Cropped JPEG photos were imported to Manifold GIS, and were georeferenced using an average of 5-7 control points to tie to the orthophotos or Landsat imagery (where orthophotography was not available) with affine transformations (Figure 2). Site plan photographs were georeferenced to UTM Zone 8 (NAD83) to be compatible with the native projection of the ISR on-line mapping tool. The one exception to this was the Hay River inventory which was georeferenced to UTM Zone 10 (NAD83) to be compatible with the native projection of the MV on-line mapping tool. Following the georeferencing, site plan photographs were exported as PNG files, the image format requested by the manager of the on-line granular resource mapping tools.

4.4 Digitizing of Granular Inventories

From the georeferenced site plan photographs, the following components of the inventories were digitized in ESRI shapefile format:

- granular deposit boundaries (polygons)
- boreholes (points)
- test pits (points) ;

For each individual deposit, test pit, or borehole, the unique identification number from the original inventory was included as an item in the shapefile. This item is used to relate the pit/borehole/deposit to the digital report pages which are provided as a pop-up option in the on-line mapping tool (described in more detail in the next section).

Although Manifold GIS provides some auto-tracing features, these were not utilized in this project. The graininess and imperfections of the site plan photographs were not conducive to the auto-trace option, which detects line or polygon features with the same colour. Manual digitizing was performed for all polygons, tracing the centre of the hand-written boundary. Two GIS post-processing procedures were evaluated (Figure 3), both of which were intended to ‘clean-up’ the deposit boundaries to match the original hand-written versions as much as

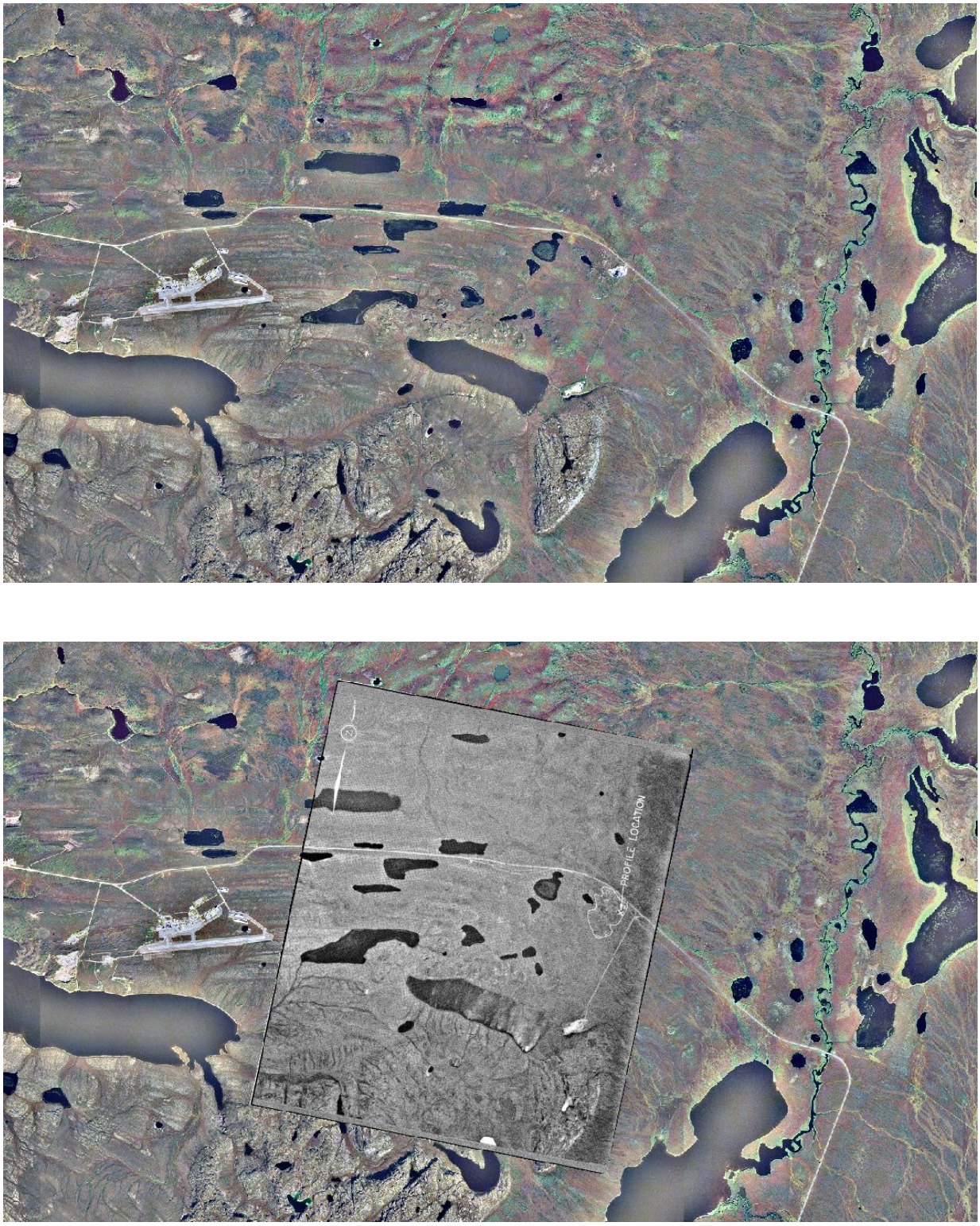


Figure 2: Example of the orthophotography (top) used to georeference the inventory site plan photographs, shown overlaid (bottom) east of Inuvik.

possible. Manifold's 'Spline' command smooths deposit boundaries by inserting additional midpoints and using a spline algorithm to replace sharp corners with curves. This command was used as a post-processing procedure to 'clean up' the digitized boundaries and create a smoother appearance that is closer to the original hand-drawn outlines on the site plan photographs (Figure 4). The use of Manifold's 'Buffer' command to extend a deposit's boundary by a specified amount was also evaluated. Buffering would ensure that the newly-digitized deposit encompasses all of the original handwritten deposit on the site plan photograph (Figure 4).

Both the spline and buffer procedures exhibited the expected decrease in post-processing influence with increasing deposit size. However, the increase in deposit surface area introduced by the buffer command was deemed to be unacceptable for the majority of deposits. It was decided that the spline command would be the only post-processing procedure used.

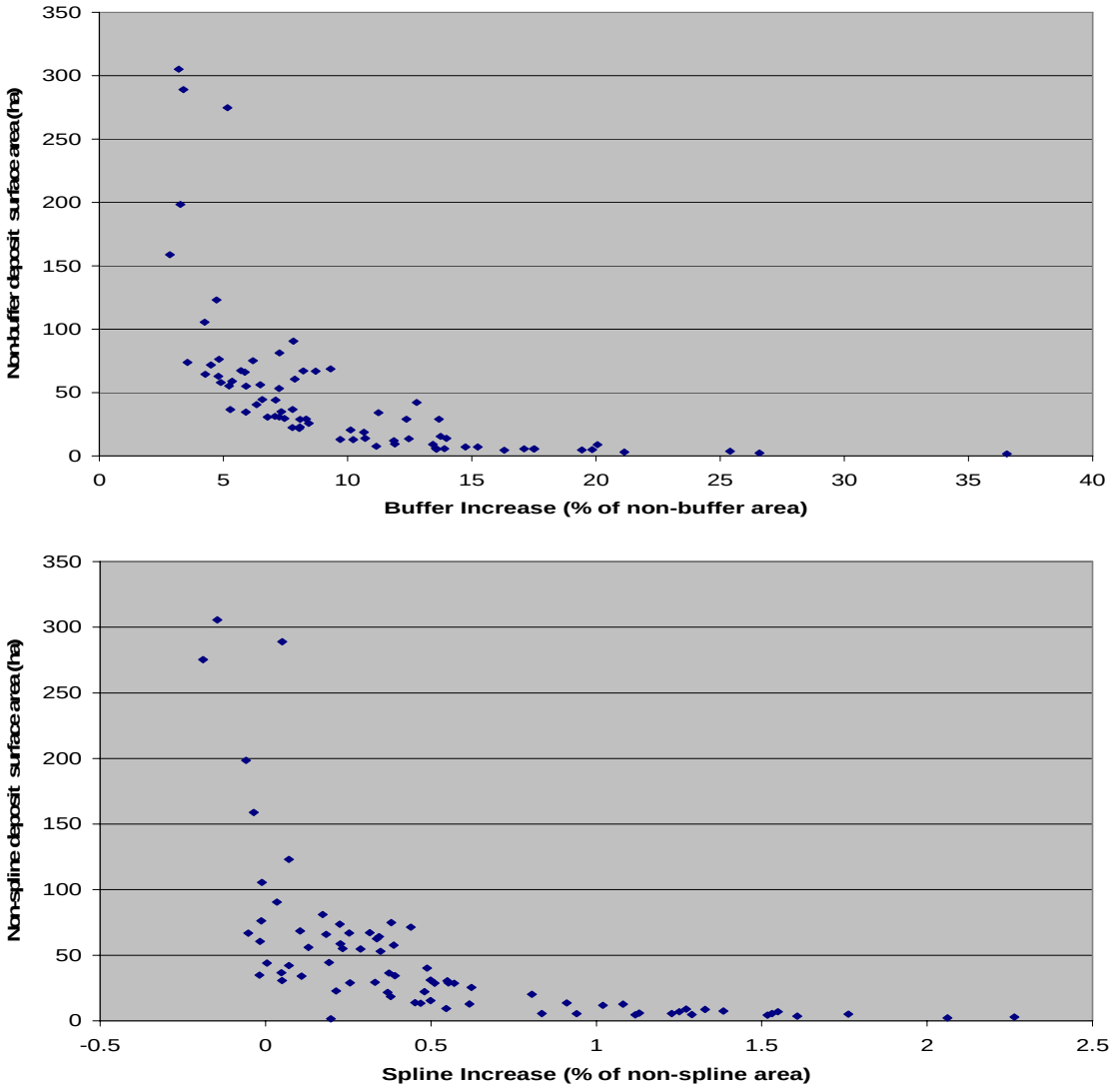


Figure 3: The impact of the buffer (top) and spline (bottom) post-processing procedures that were evaluated (Zone 2 data shown). X-axis represents the increase/decrease of deposit areas resulting from application of post-processing procedure relative to raw digitized boundaries.

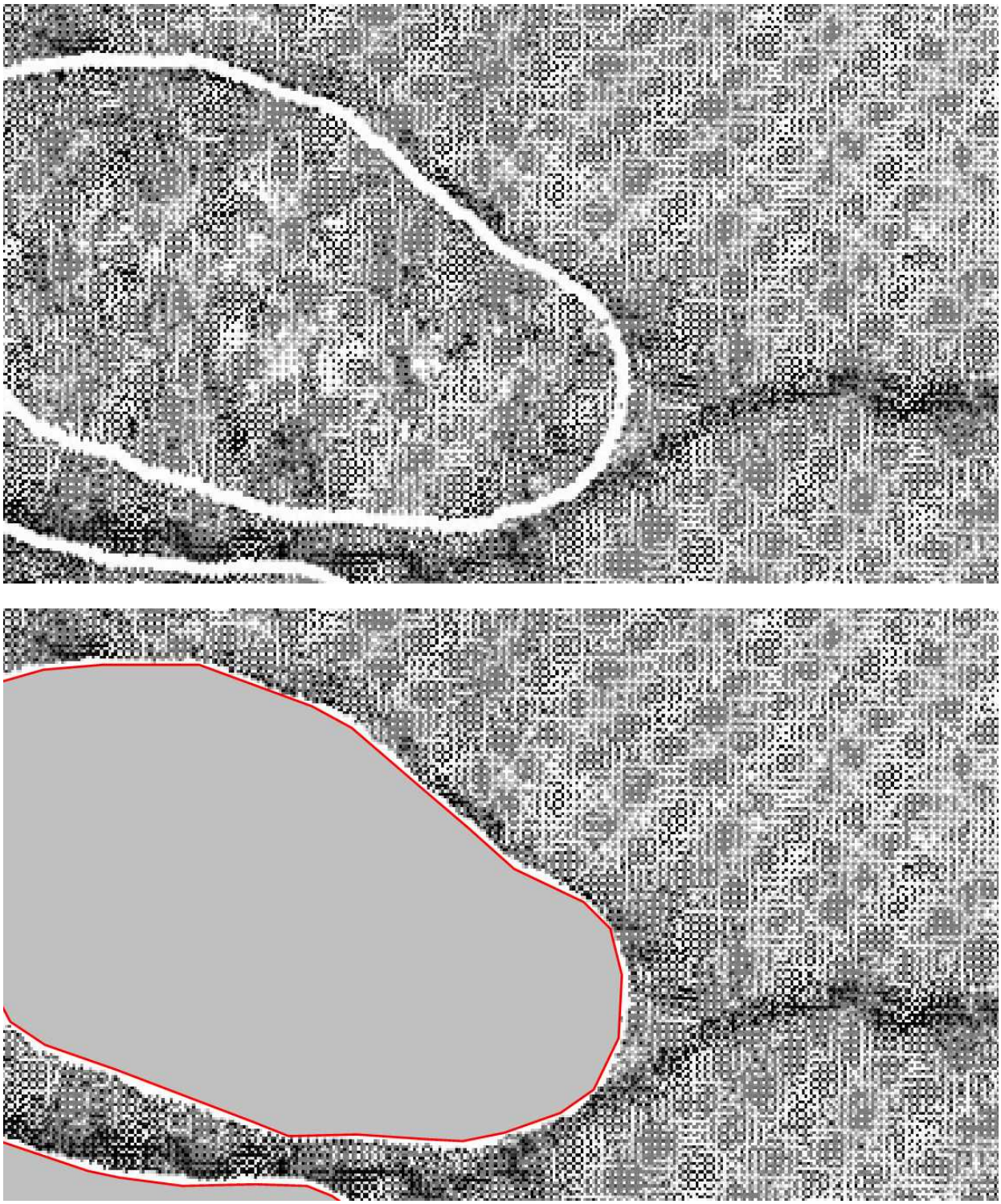
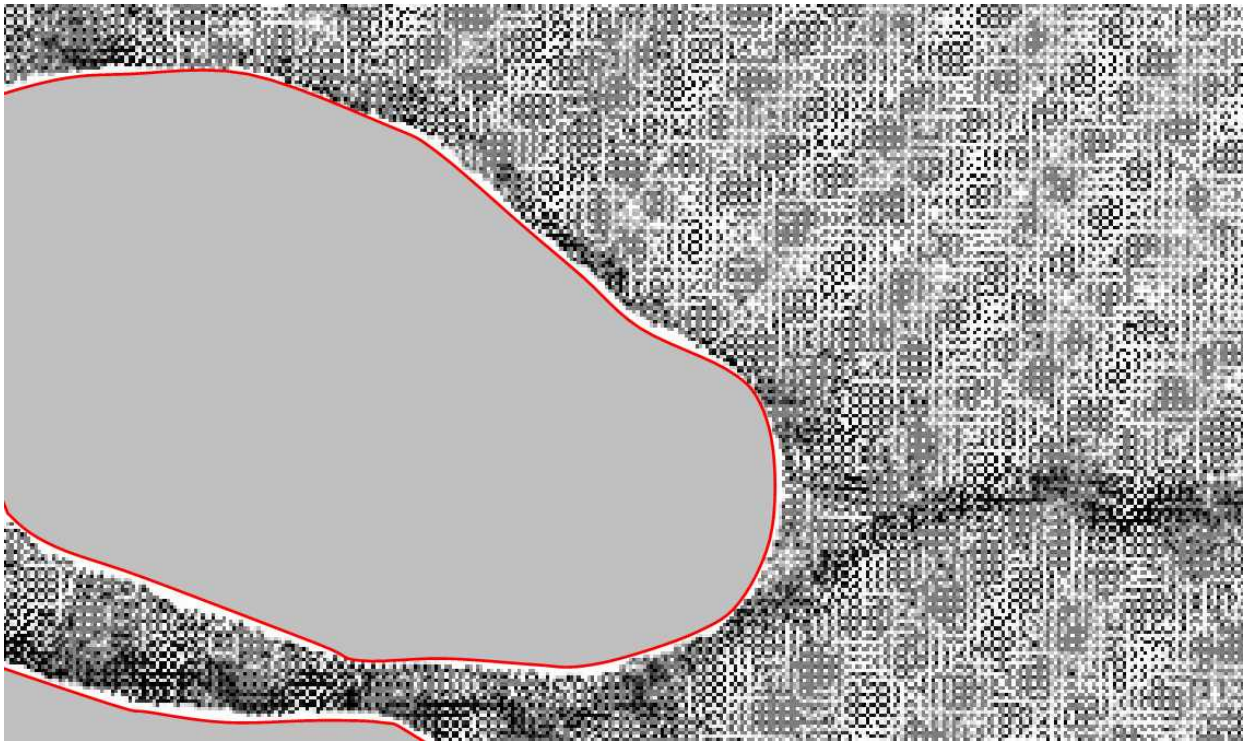
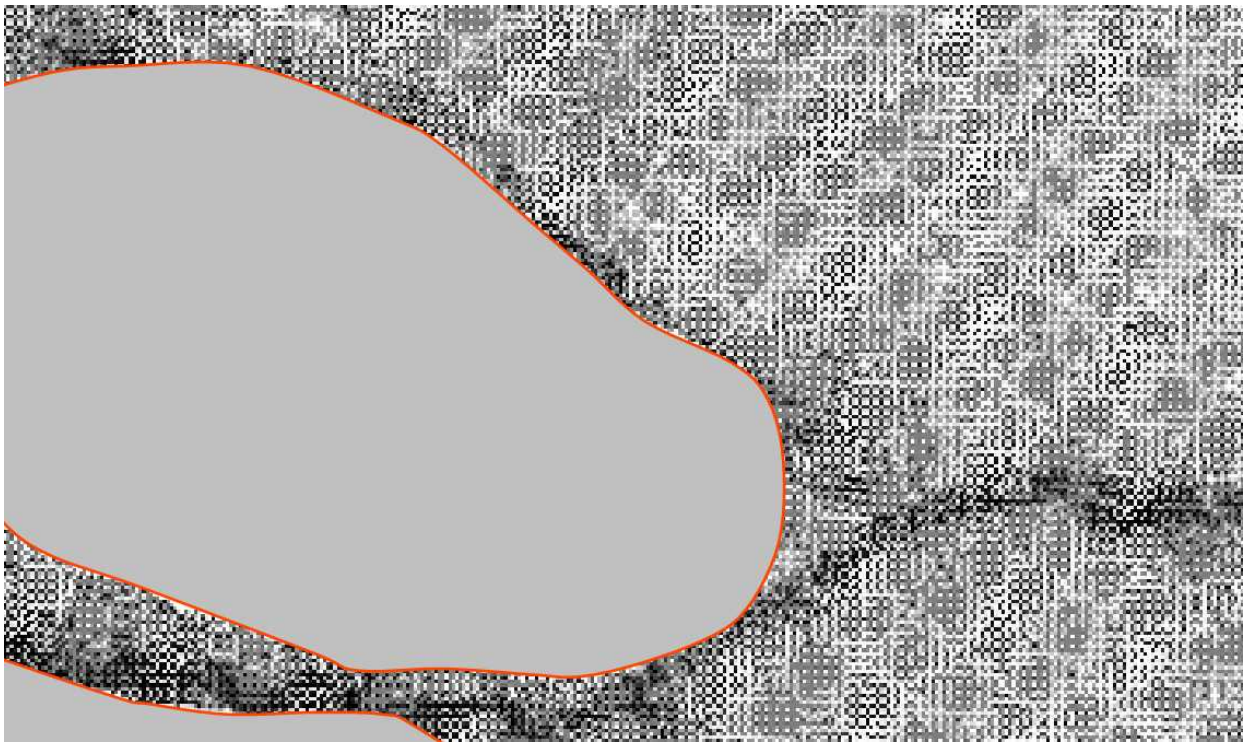


Figure 4: Example of the post-processing steps that were evaluated. (Top): Granular deposit outline on original site plan photograph. (Bottom): Digitized un-modified granular deposit outline. (Opposite page, top): Smoothed granular deposit outline using Manifold 'Spline' command. (Opposite page, bottom): Deposit outline expanded using the Manifold 'Buffer' command to cover the entire written outline on the site plan photograph





The digitizing of the granular resource information (deposit boundaries, test pits, boreholes) will allow users to compare the original interpretations from the georeferenced site plan photographs to the recently-flown orthophotagraphy (Figure 5) that is used as a base image in the on-line mapping tool.

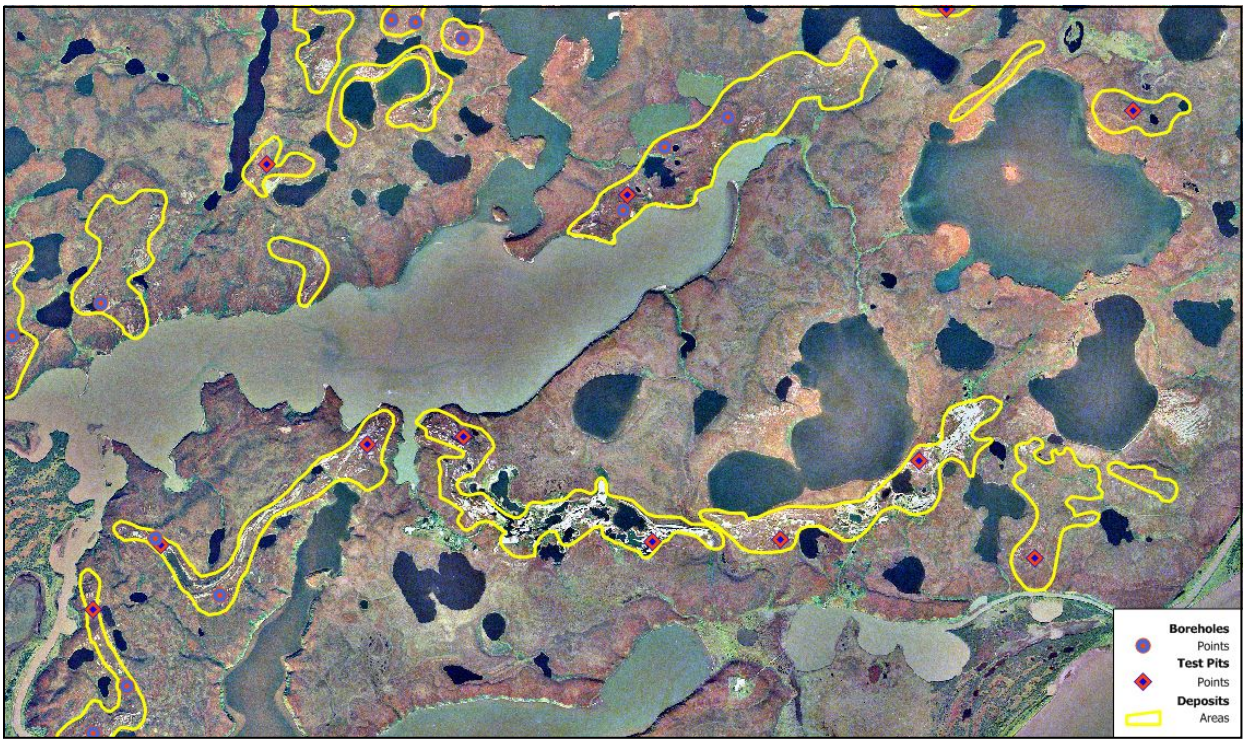


Figure 5: Digitized granular resource information (deposit boundaries, test pits, boreholes) overlaid on the orthophotography base image for the Yaya Lake area in Zone 2.

4.5 Inventory Report Pages

One of the features of the on-line granular resource mapping tools is the ability of the user to "drill-down" to access the digital inventory report pages that pertain to the item of interest (deposit, borehole, test pit). Upon user request, the on-line mapping site's reporting tool (Cold Fusion) delivers report pages to the screen through a pop-up interface. The report pages that are viewed by the user are actually a series of JPEG files (one JPEG per report page). The existing ISR mapping tool contains links to a set of JPEG report pages that were produced from INAC scanning of original paper inventory documents.

The existing scanned files are not in colour and lack much of the contrast and detail that was contained in the original inventory, particularly with regards to the site plan photographs. In the time since the original inventories were scanned, INAC retained the services of the engineering consultants who authored the reports to provide vastly improved digital versions. New JPEG files of the improved digital report pages were generated at 150 dpi.

Columns were added to the shapefile databases that represent the range of page numbers in the report (start and end) that pertain to the deposit, borehole or test pit. These page ranges are referenced by Cold Fusion to generate the report delivered to the on-line user.

5.0 FILE NAMING CONVENTION

The files generated in this project are named using a combination of site-specific variables (Table 1) including ASTIS record number, inventory code, and deposit number. Three sets of files were generated for each inventory: a) JPEG files of individual inventory report pages; b) georeferenced site plan photographs; c) shapefiles of granular resource locations. For each inventory, separate shapefiles were generated for deposit boundaries, borehole locations, and test pit locations. The following file nomenclature was used:

INVENTORY	CODE	ASTIS RECORD	RC CODE*
Arctic Red River	AR	30394	RKL72AR
Fort McPherson	FM	30395	RKL72FM
Hay River	HR	27494	RKL74HR
Inuvik	IN	30396	RKL72IN
Tuktoyuktuk	TK	30397	RKL72TK
Zone 1	Z1	30398	RKL72Z1
Zone 2	Z2	30399	RKL72Z2
Zone 3	Z3	30400	RKL72Z3
Zones 4, 5, 6	Z46	30401	RKL72Z46

Table 1: The inventory-level codes used in the file naming nomenclature. * RC Code refers to “Report Code”, a reference to the source document from which all digitized data has been derived. This item is used as a reference variable in shapefile databases

JPEG files of individual inventory report pages

Nomenclature: ASTIS Record_Page_*n*.jpg, where *n* = page 1 to the last page of the inventory

Example: 30394_Page_07.jpg = Page 7 of Arctic Red River inventory

Georeferenced site plan photographs

Nomenclature: InventoryCode-Deposit#_utm.png

Example: AR-601_utm.png = Deposit 601 of Arctic Red River inventory

Shapefiles

Nomenclature:
InventoryCode_borehole.shp
InventoryCode_deposit.shp

InventoryCode_testpit.shp

Example: AR_deposit.shp = Deposit boundaries (polygons) of Arctic Red River inventory

6.0 RESULTS

The work completed in this contract (shapefiles – deposits, test pits, boreholes, georeferenced site plan photographs, inventory report pages) for each granular resource inventory is summarized in Table 2.

Inventory	**Deposits**	**Boreholes**	**Test Pits**	**Site Plan Photographs**	**Scanned Inventory Pages**
Arctic Red River	25	10	10	10	96
Fort McPherson	9	3	5	6	62
Hay River	34	100	33	23	278
Inuvik	22	24	8	8	98
Tuktoyuktuk	15	0	19	16	136
Zone 1	10	0	7	5	51
Zone 2	152	56	60	28	276
Zone 3	52	94	52	29	333
Zones 4, 5, 6	38	15	41	21	158
Total	**357**	**302**	**235**	**146**	**1488**

Table 2: Inventory-level summary of work performed in this contract, including digitized granular resource information (deposits, test pits, boreholes), site plan photographs, and scanned inventory pages.

Site maps are provided for each of the inventory areas in Appendix B. A regional index map (Figure 6) is provided to reference the site maps in Appendix B.

7.0 METADATA

For each granular resource inventory, metadata was generated in FGDC format for each of the individual shapefiles (deposits, boreholes, test pits). A program called Corpsmet 95 was used to develop the template metadata format, an example of which is provided as Appendix A.

8.0 RECOMMENDATIONS

This project accomplished the complete revision and update of the digital version of the RKL 1972/1974 granular resource inventory series. INAC has also made the investment to obtain improved digital copies of other original inventories, including those prepared by PEMCAN and EBA in the early 1970s (and any other similar inventory reports). Because of the improved quality of the original inventories, the documents can serve important roles on the on-line

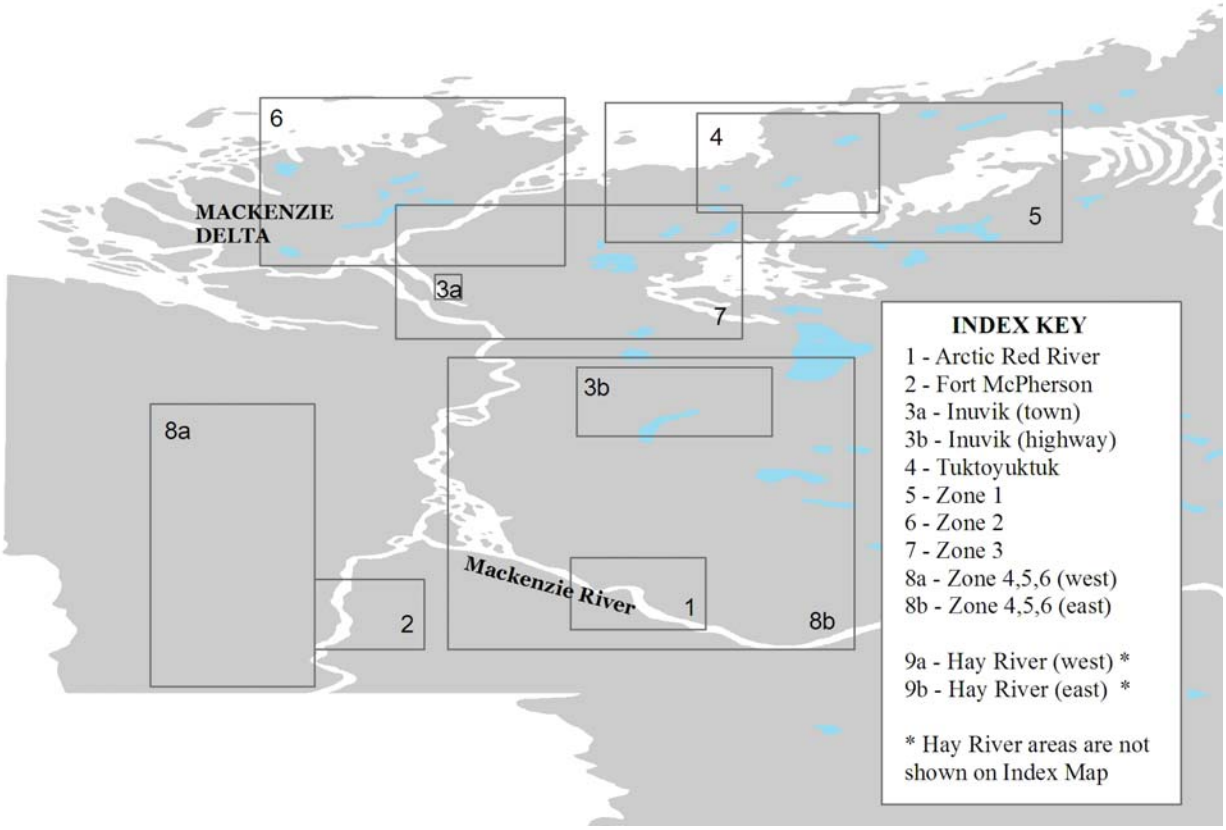


Figure 6: An index map used to reference the detailed inventory-level maps of Appendix B.

mapping tool beyond their use as a base for digitizing granular resources. Some other benefits of converting the inventories to an on-line product include the ability to:

- extract descriptive information (text, graphics) about the granular resource characteristics of a particular deposit
- view the original interpretation of the engineer who mapped the site
- perform qualitative assessments of the amount of landscape change that has occurred

It is recommended that INAC continue to invest in the digitizing of these inventories due to the information-rich nature of the resource.

9.0 CONTRACTOR QUALIFICATIONS

Environmental Geosolutions Inc. is a federally-incorporated entity with a mandate to develop custom geospatial products and tools for targeted user groups that lead to more applied uses of geospatial data. Stephen Boles, the founder and president of Environmental Geosolutions, has been active in the computer modeling and GIS communities for over a decade, including several years as a research scientist at the University of New Hampshire. Boles began his geomatics career in the early 1990s as a University of Waterloo co-op student working for DIAND on an assignment to assess the utility of using Landsat satellite data for granular resource

identification in the Slave Geological Province of the NWT. Later in his career, Boles continued to gain extensive experience working on remote sensing projects pertaining to circumpolar regions (Alaska, Russia). Because of these years of experience working on remote sensing applications in the North, Boles is well poised to contribute to the continued development and refinement of the on-line mapping tools for northern granular resources.

APPENDIX A – Metadata Sample

```
Identification_Information:
        Citation:
                Citation_Information:
                        Originator: Stephen Boles(ed.)
                        Publication_Date: Unpublished material
                        Publication_Time: Unknown
                        Title: Digital Granular Deposit Boundaries, Zone 2,
                        1972
                        Edition: 1.0
                        Geospatial_Data_Presentation_Form: map
        Description:
                Abstract:
                        Indian and Northern Affairs Canada acquired digital versions
                        of several granular resource inventories performed in Canada's
                        Arctic in the 1970s and 1980s. The original granular inventory
                        reports from the early 1970s typically contain a series of
                        individual site reports with ‘site plans’. These site plans
                        consist of a half-tone copy of a portion of a standard NAPL
                        aerial photograph that is annotated with deposit boundaries
                        and subsurface investigations (boreholes, test pits, outcrops).
                        All site plan photographs were georeferenced to an orthophotograph
                        base image. Deposit boundaries and subsurface investigations
                        could then be digitized. Deposit boundaries were manually
                        digitized and a smoothing algorithm was applied after. The
                        following citation references the source publication for this
                        data:
                        Digital granular resource deposit boundaries from the
                        Zone 2 Community Granular Materials Inventory,
                        1972   /
                        Ripley, Klohn and Leonoff International, Ltd., 1972.
                        ASTIS record 30399.
                        English
                        //pubs.aina.ucalgary.ca/gran/30399.pdf
                        Community Granular Materials Inventory - Zone 2, NWT
                Purpose:
                        The digital granular resource boundaries will be used to enhance
                        the utility of the Mackenzie Valley and ISR on-line mapping tools.
        Time_Period_of_Content:
                Time_Period_Information:
                        Single_Date/Time:
                                Calendar_Date: 20070331
                Currentness_Reference: Publication Date
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                Progress: Complete
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                        East_Bounding_Coordinate: -133.94
                        North_Bounding_Coordinate: +69.58
                        South_Bounding_Coordinate: +69.00
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                Theme:
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                        Theme_Keyword: Zone 2
                        Theme_Keyword: inventory
        Access_Constraints: None
        Use_Constraints: None
        Point_of_Contact:
                Contact_Information:
                        Contact_Person_Primary:
                                Contact_Person: Robert J. Gowan
                                Contact_Organization: DIAND, Land Programs
                        Contact_Organization_Primary:
                        Contact_Position: Manager
                        Contact_Address:
                                Address_Type: mailing and physical address
                                Address:
```

```
                                Les Terrasses de la Chaudière,
                                15-25 Eddy St
                        City: Gatineau,
                        State_or_Province: QC
                        Postal_Code: K1A 0H4
                        Country: Canada
                Contact_Voice_Telephone: 819-994-7464
                Contact_Facsimile_Telephone: 819-997-7623
                Contact_Electronic_Mail_Address: gowanb@inac.gc.ca
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        Spatial_Reference_Information:
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                        Planar:
                                Grid_Coordinate_System:
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                                                        False_Northing: 0
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Metadata_Reference_Information:
        Metadata_Date: 20070331
        Metadata_Contact:
                Contact_Information:
                        Contact_Person_Primary:
                                Contact_Person: Stephen Boles
                        Contact_Address:
                                Address_Type: mailing address
                                Address: 38 John Street East
                                City: Exeter
                                State_or_Province: Ontario
                                Postal_Code: N0M 1S6
                                Country: Canada
                        Contact_Voice_Telephone: 519-913-1054
                        Contact_Electronic_Mail_Address: sboles@enviro-geo.com
        Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
        Metadata_Standard_Version: 1994
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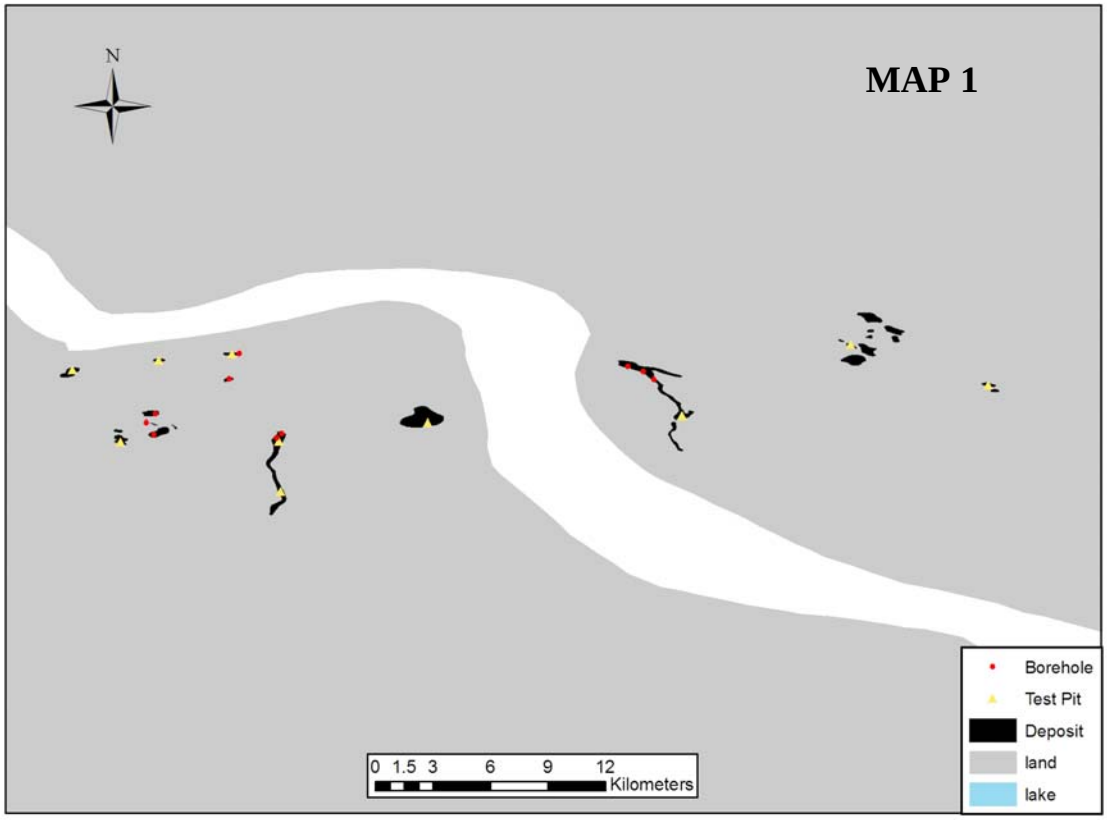
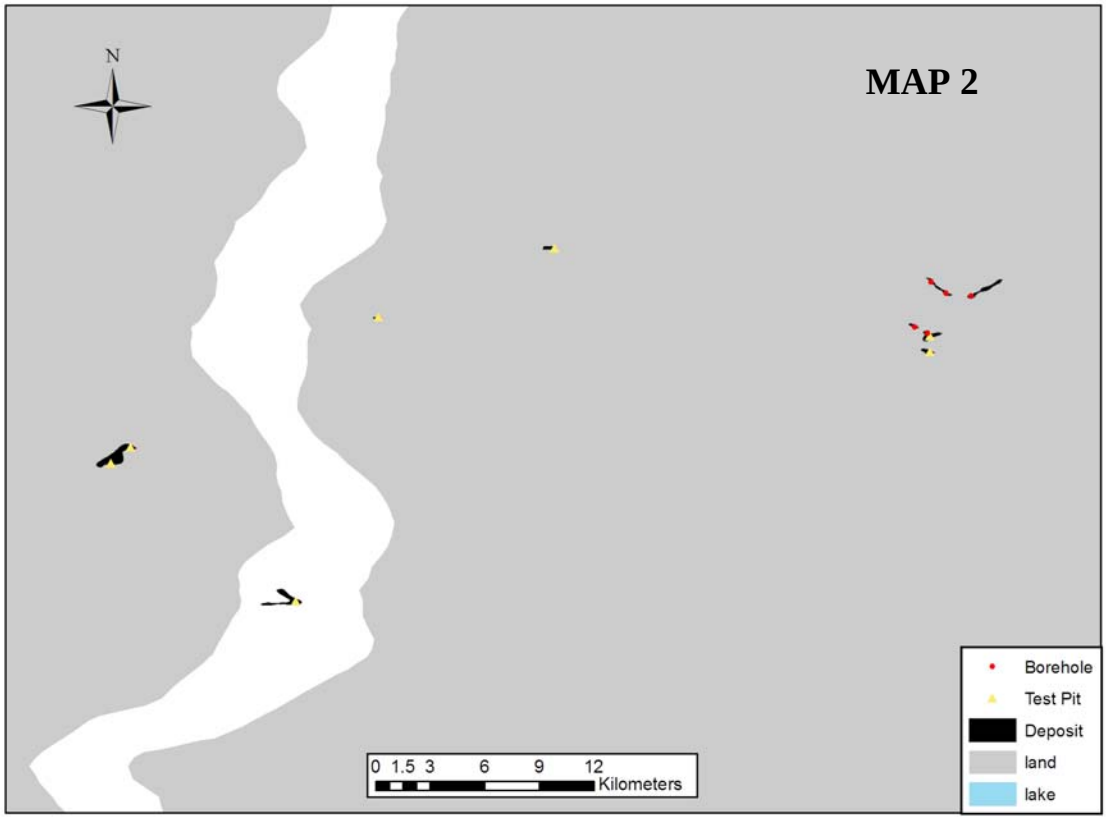
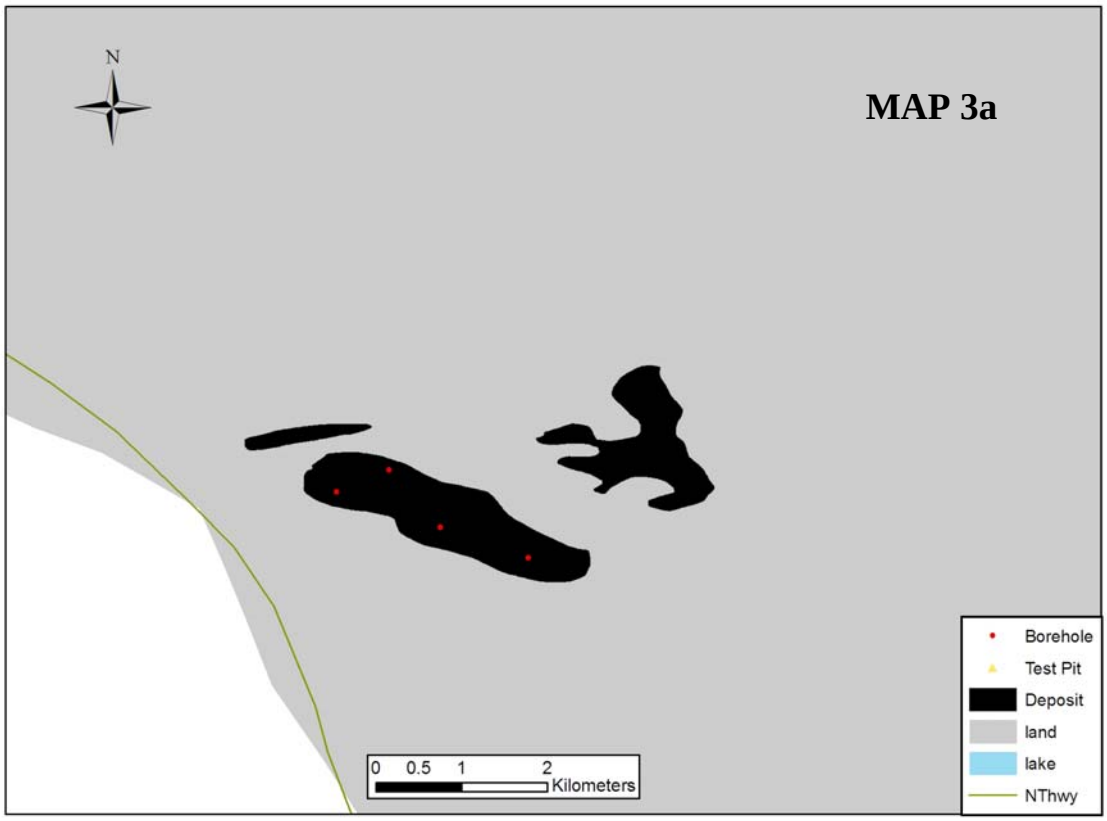
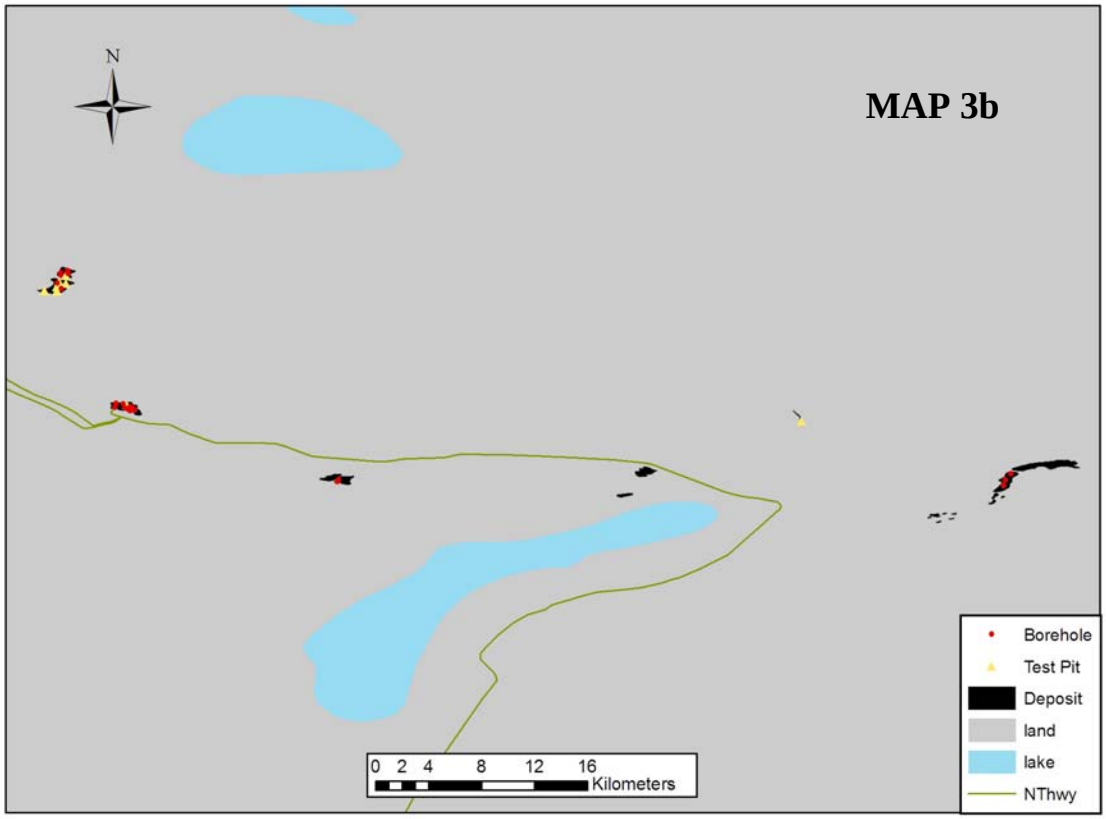
APPENDIX B – Inventory Site Map






N
MAP 3a
0 0.5 1 2
Kilometers
Borehole
Test Pit
Deposit
land
lake
NThwy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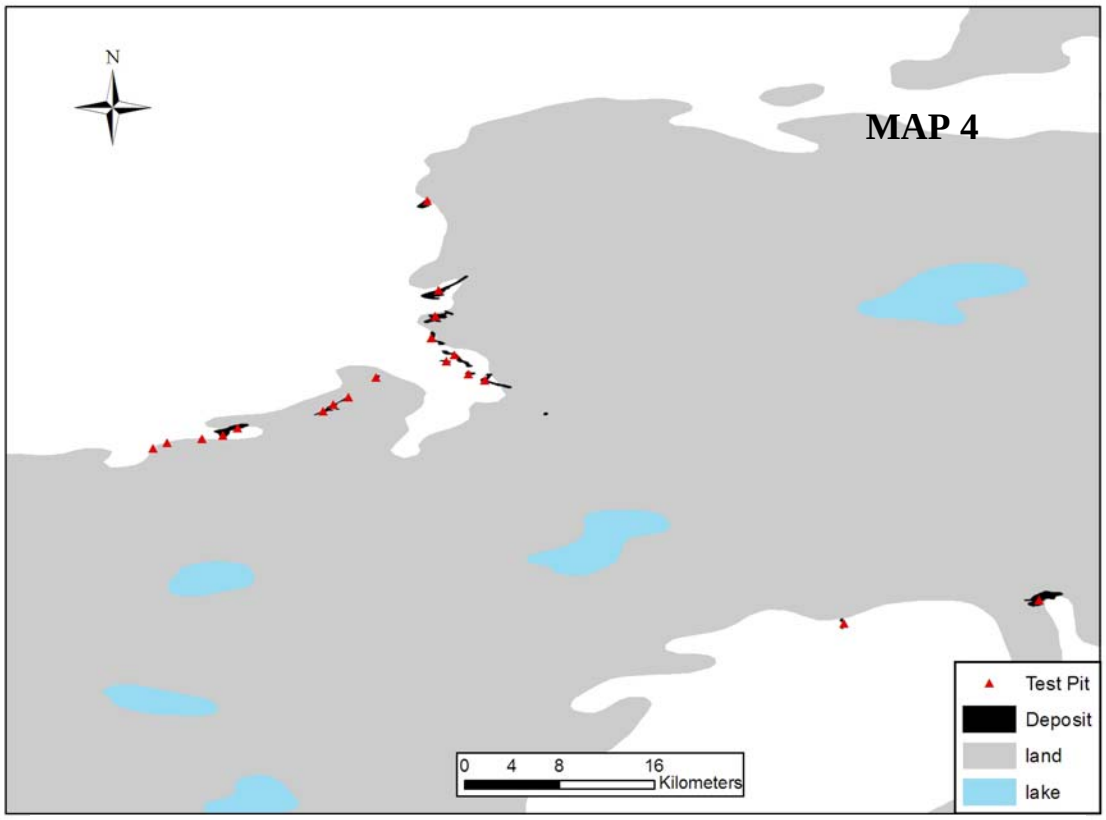
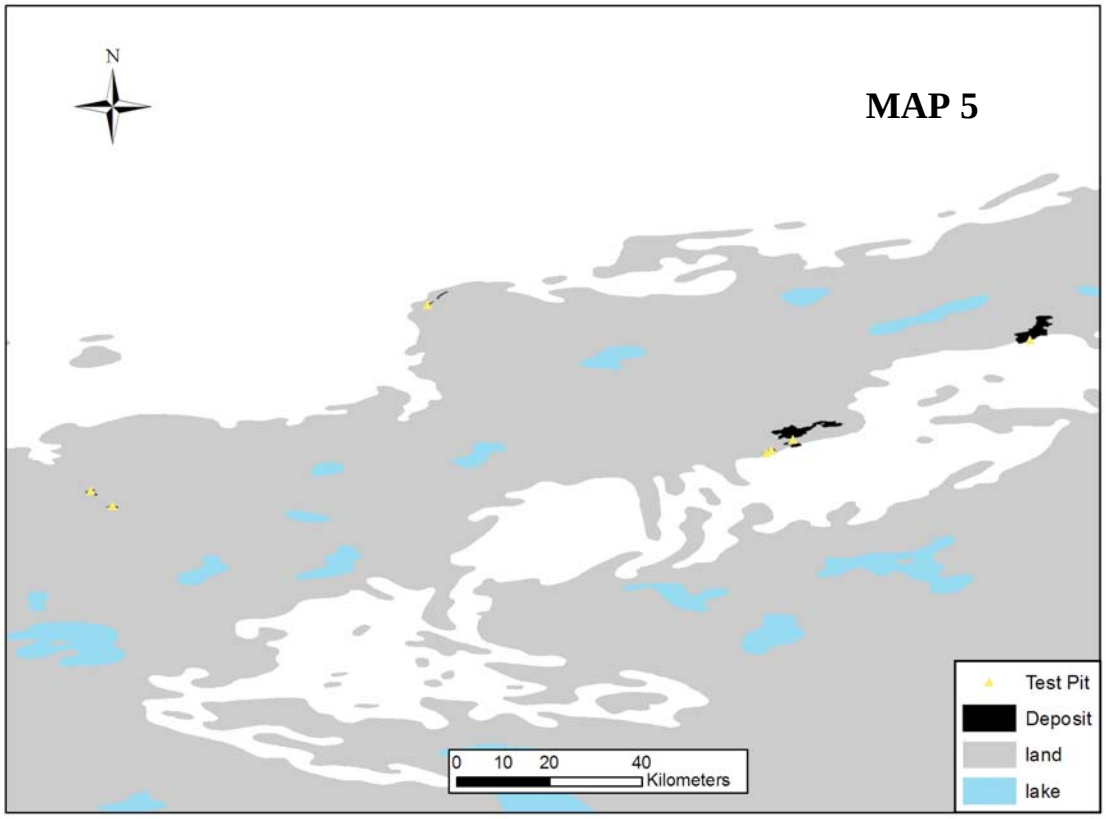
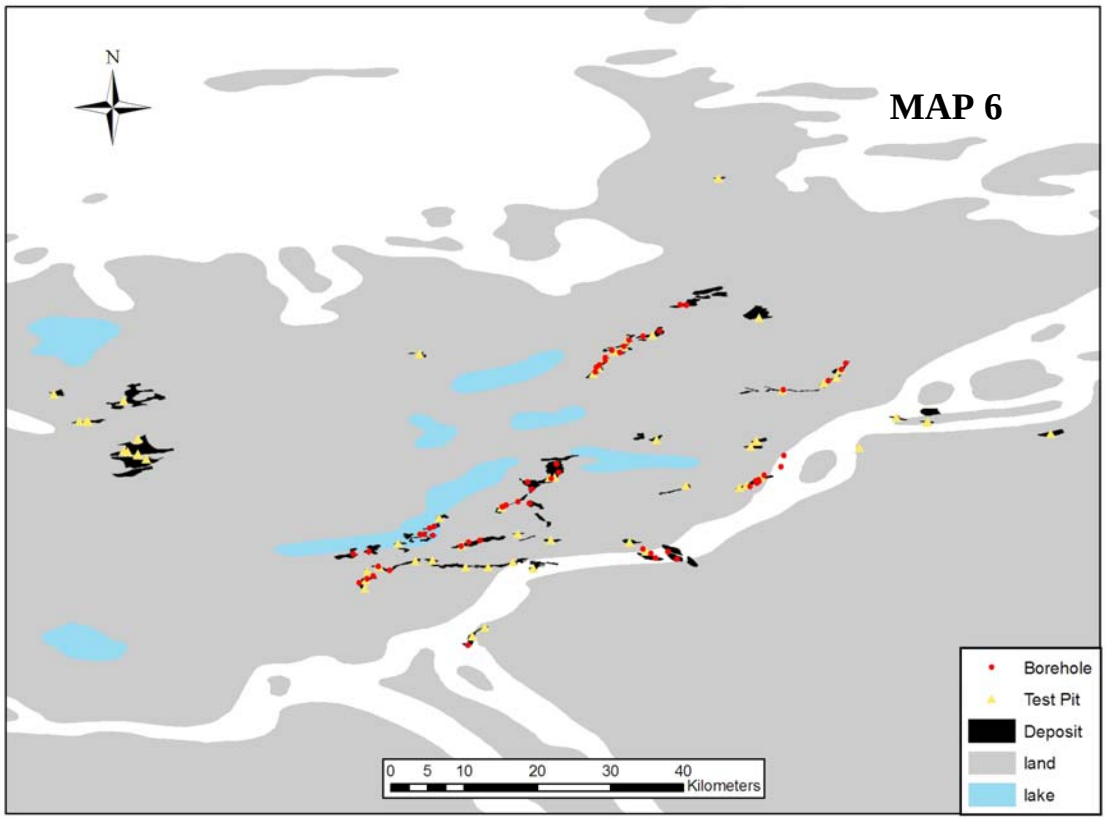
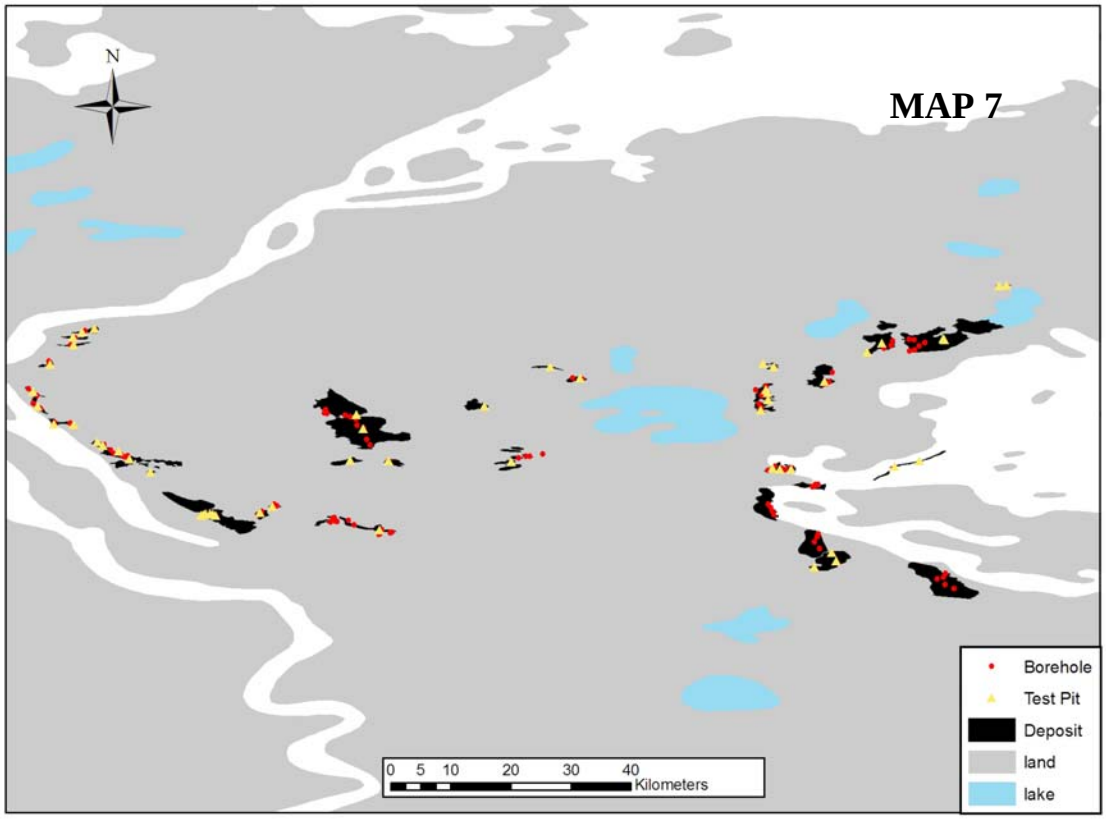
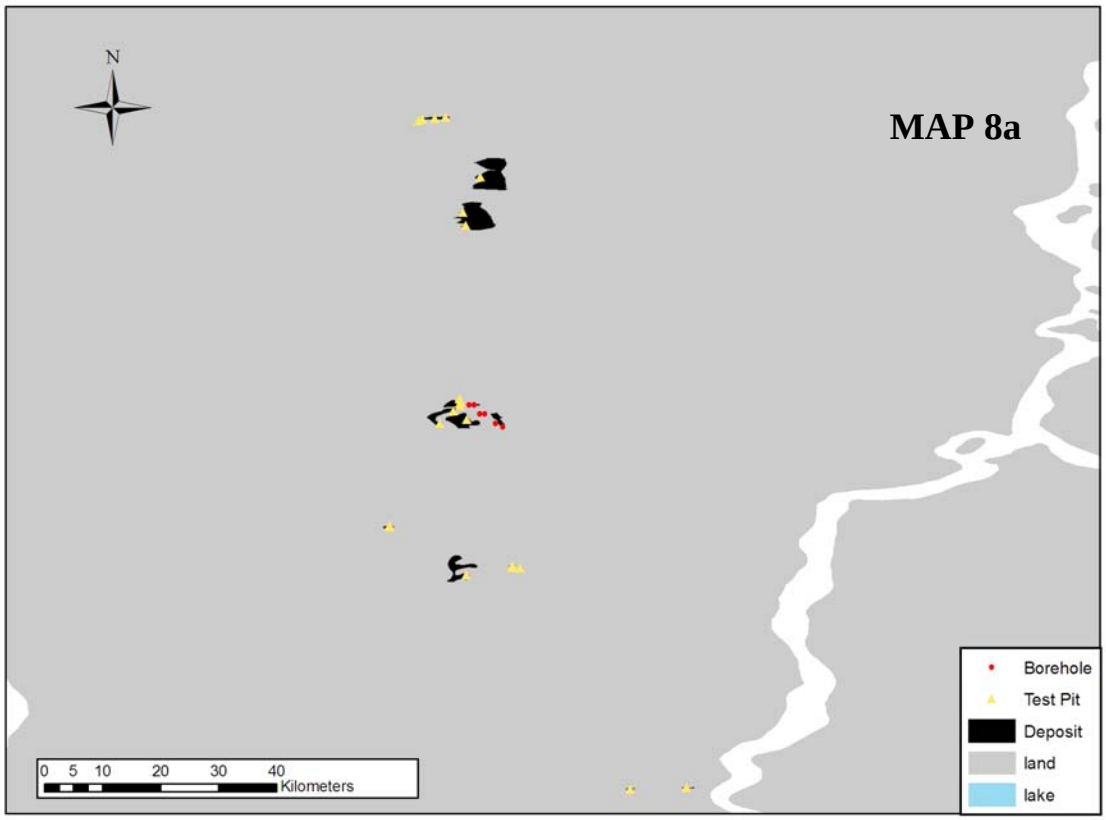


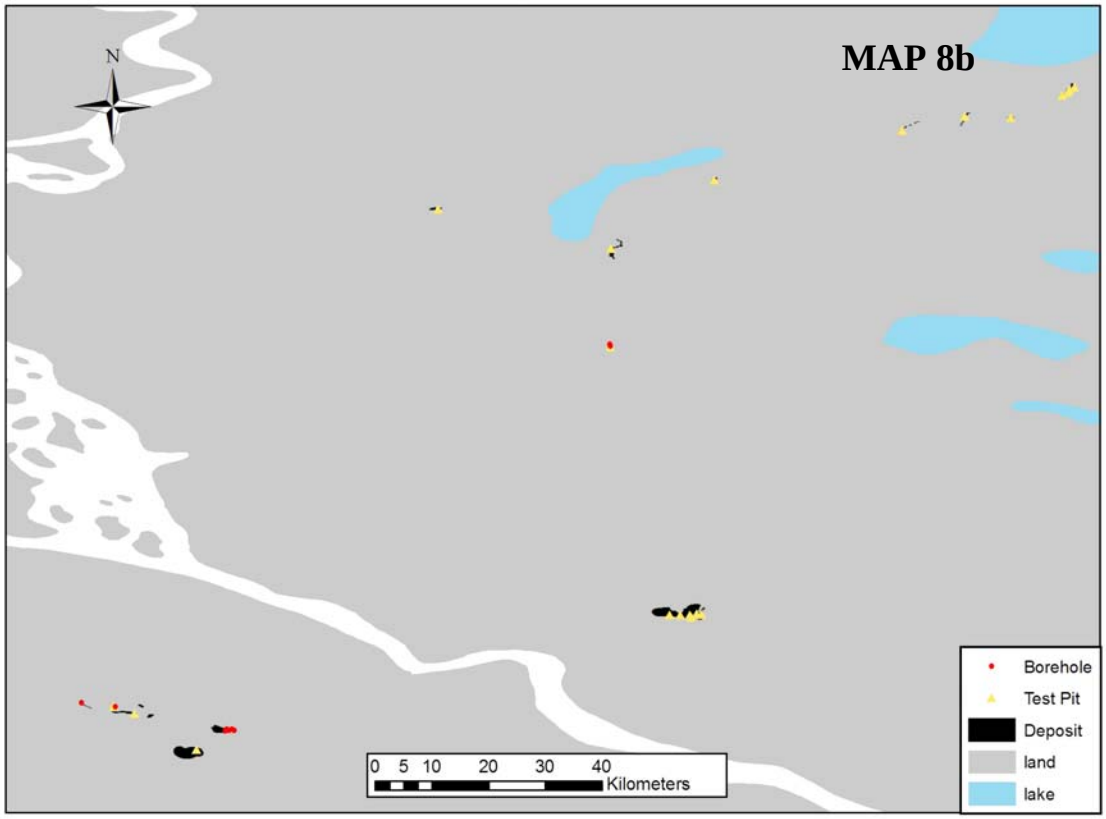
* NOTE: In this map, test pit symbols are coloured red to provide better contrast against ocean

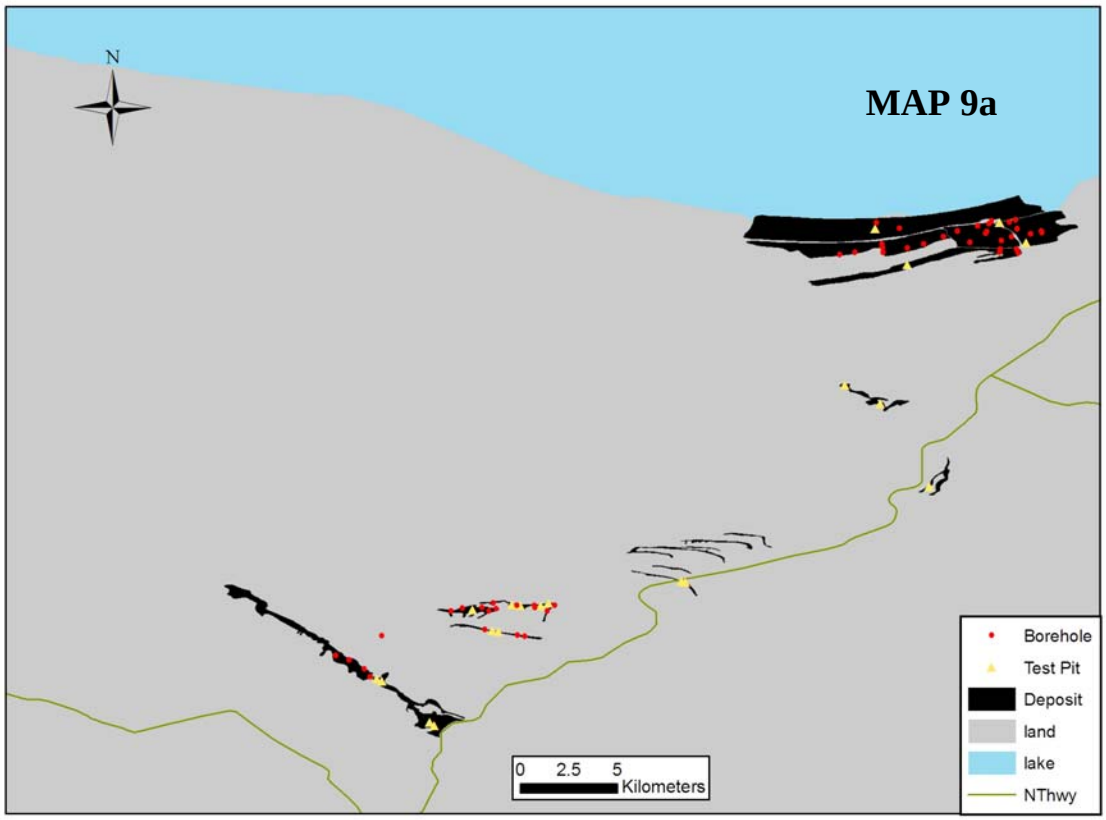


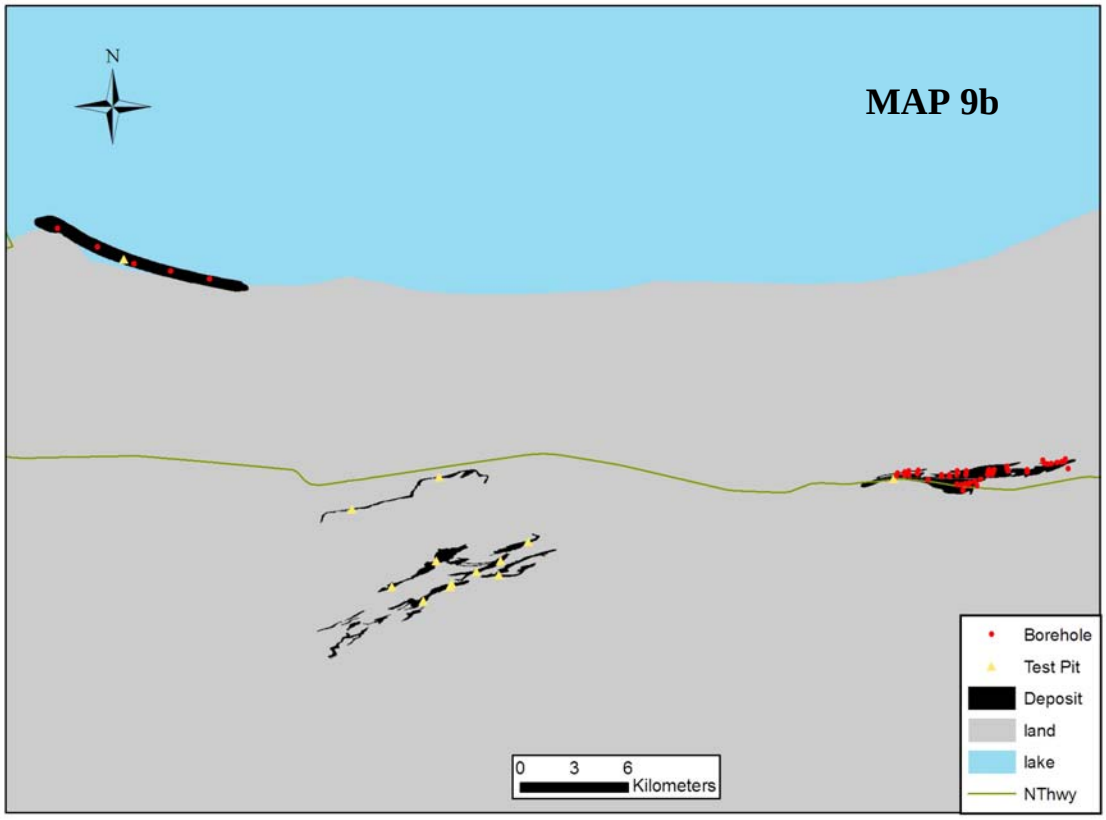

N
MAP 6
0 5 10 20 30 40
Kilometers
Borehole
Test Pit
Deposit
land
lake


N
MAP 7
0 5 10 20 30 40
Kilometers
Borehole
Test Pit
Deposit
land
lake


N
MAP 8a
0 5 10 20 30 40
Kilometers
Borehole
Test Pit
Deposit
land
lake


N
MAP 8b
0 5 10 20 30 40
Kilometers
Borehole
Test Pit
Deposit
land
lake


N
MAP 9a
0 2.5 5
Kilometers
Borehole
Test Pit
Deposit
land
lake
NThwy


N
MAP 9b
0 3 6
Kilometers
Borehole
Test Pit
Deposit
land
lake
NThwy