Watershed Delineation and Stream Classification for Foothills Model Forest

Proposal

GISmo Solutions Ltd.
1000, 10707 - 100 Avenue
Edmonton, Alberta T5J 3M1
www.gismo.com

Prepared For:
Foothills Model Forest
Hinton, Alberta

Prepared By:

GISmo Solutions Ltd.

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Executive Summary

Request for Proposal from Foothills Model Forest (FMF) has clearly identified the requirements for stream classification and watershed delineation for a partial area of FMF. These requirements are very similar to the recently completed project for Chisholm / Dogrib Fires Research Initiative and include:

1. Creation of hydrologically corrected Digital Elevation Model (DEM)
2. Design and classification of reaches.
3. Delineation and classification of watershed drainage sub-basins.
4. Report and documentation of data and processes

Following completion of Chisholm / Dogrib project GISmo Solutions Ltd. is proposing to use the same processes to deliver all mandatory products with client desired topological reach breaks and with Arc View project for $20,000.00.

This price reflects pro-rated cost for a larger area estimated at 1.4 of a 1:250,000 block, and a reduction for Strahler classified source stream data. All requested products can be delivered as per the client’s schedule.

However, in our opinion the results of utilized ArcInfo processes including hydrologically corrected DEM, stream channel elevation readouts and watershed delineation for specific drainage points could be improved with additional efforts. GISmo Solutions Ltd. has inquired about possible improvements by using ANUDEM product and has also initialized internal developments to enhance products. The Value Added Product paragraph outlines possible improvements. GISmo Solutions Ltd. would like to propose an alternative delivery of all requested products with extra cost new enhanced processes within same timeframe for $25,000.00. Such increased budget would allow us to create better mandatory products and also add route structures not currently requested but anticipated and desired for future use.

GISmo Solutions Ltd. has completed many similar projects in the past, and is very familiar with required processes, and the related, emerging government standards.

GISmo Solutions Ltd. considers Foothills Model Forest as one of our most important clients, and will provide most appropriate resources to meet the data quality, budget, and schedule objectives. We are looking forward to working with the FMF representatives and to supporting your requirements.

This project proposal was prepared by Michal Pawlina M.Sc., P.Eng. - principal consultant of GISmo Solutions Ltd.
1. Introduction / Background

Foothills Model Forest requires a variety of spatial digital data sets to support analysis and management of natural resources. Assessment of changes due to natural causes and business activities requires functional, current, accurate and easily accessible information. Request for Proposal from Foothills Model Forest (FMF) has clearly identified the requirements for classified streams, reaches and watershed data. These requirements emphasize proper handling of the provided source data to generate correct, consistent watersheds and classification. Both the single line hydrography network (SLNET) and the Digital Elevation Model (DEM) should be subjected to complex quality control and reconciliation preprocessing.

Process options for the creation of accurate watersheds and classified streams have been recently analysed by the original data provider Resource Data, at provincial government of Alberta. Watershed Delineation and Hydrocoding Project team led by Kathleen Bennett, includes FMF representative Christian Weik, and GIS consultant Michal Pawlina. GiSmo Solutions Ltd has applied a similar process to the recently completed project for Chisholm / Dogrib Fires Research Initiative.

The outline standards and the data processing methodology from the government’s project and from the Chisholm / Dogrib Fires Research Initiative project are applicable to the current Foothills Model Forest project. A list of available documentation and reference data sets is provided in the Appendix A.

GiSmo proposes to address the FMF’s need for all mandatory data sets by following the Chisholm / Dogrib project specifications and process, or by improving ArcInfo capabilities by extra cost developments (as depicted in the Value Added Product paragraph) within required timeframe.
2. **Contractor Experience**

GISmo Solutions Ltd. has a considerable experience with similar projects as outlined in paragraph 6: Past Experience and Resources Assigned and specific client references can be provided if required.

3. **Deliverables and Cost**

The deliverables for this project include:

1. Hydrologically corrected DEM in ESRI’s grid format
2. ArcInfo line coverage representing reaches with reach attributes present in the feature attribute table.
3. ArcInfo point coverage representing reaches with reach attributes present in the feature attribute table.
4. Watershed boundaries with key providing a link to reach attribute table.
5. Final report describing the process to produce the classification. The report should include basic if data descriptions and flow charts that document the data preparation, processes and final products. If preparation is feature specific, modifications should be documented for the purpose of updating the master FMF datasets.

All digital products will be supplied on CD. Three hard copies of the final report will be provided.

**Cost table**

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Option 1. Base ESRI functions</th>
<th>Option 2. GISmo extra cost developments</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hydrologically corrected DEM</td>
<td>$4,000.00</td>
<td>$6,800.00</td>
<td></td>
</tr>
<tr>
<td>2. Streams network with Strahler order assigned</td>
<td>No cost provided source data</td>
<td>No cost provided source data</td>
<td></td>
</tr>
<tr>
<td>3. Point / line coverages of reaches with full list of attributes assigned</td>
<td>$ 7,000.00</td>
<td>$ 8,000.00</td>
<td></td>
</tr>
<tr>
<td>4. Watershed boundaries, classification, regions</td>
<td>$ 6,500.00</td>
<td>$ 7,500.00</td>
<td>Provided at no extra cost</td>
</tr>
<tr>
<td>5. Client preferred reach delineation, ArcView project</td>
<td>Provided at no extra cost</td>
<td>Provided at no extra cost</td>
<td></td>
</tr>
<tr>
<td>6. Report, Documentation</td>
<td>$ 1,000.00</td>
<td>$1,200.00</td>
<td></td>
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<tr>
<td>7. Client communication, 2 meetings with travel to Hinton, materials</td>
<td>$ 1,500.00</td>
<td>$1,500.00</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$20,000.00</strong></td>
<td><strong>$25,000.00</strong></td>
<td></td>
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</tbody>
</table>
4. Project Schedule

Table 1. Project Schedule

<table>
<thead>
<tr>
<th>Task #</th>
<th>Description</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Initial Meeting.</td>
<td>Week of Sept. 23</td>
</tr>
<tr>
<td>2.</td>
<td>Completion of preliminary classification.</td>
<td>Week of Oct. 28</td>
</tr>
<tr>
<td>3.</td>
<td>FMF review of preliminary classification.</td>
<td>Week of Nov. 4</td>
</tr>
<tr>
<td>4.</td>
<td>Meeting to review preliminary results and revision of classification rules.</td>
<td>Week of Nov. 4</td>
</tr>
<tr>
<td>5.</td>
<td>Completion of classification with revised rules.</td>
<td>Week of Nov. 11</td>
</tr>
<tr>
<td>6.</td>
<td>FMF review of revised classification.</td>
<td>Week of Nov. 11</td>
</tr>
<tr>
<td>7.</td>
<td>Completion of basin delineation and stream classification.</td>
<td>Week of Nov. 25</td>
</tr>
<tr>
<td>8.</td>
<td>Meeting to review final product.</td>
<td>Week of Nov. 25</td>
</tr>
<tr>
<td>9.</td>
<td>FMF review of final product.</td>
<td>Week of Dec. 2</td>
</tr>
</tbody>
</table>

GISmo Solutions Ltd. agrees to follow the proposed schedule. If Foothills Model Forest desires to review details of the proposed enhanced processes, GISmo would prepare appropriate information for the initial meeting with client.

5. Value Added Products

As an extra cost (ie. additional $5,000.00) value added process and product GISmo proposes to improve ESRI's hydrological enhancement process (ie TOPOGRID, FILL functions) to include additional internally developed functions. This enhancements were based on the assumption that the interpreted, observed hydrography should take precedence over minor DEM disagreements. The initial results presented below for Chisholm study area suggest that minor corrections to DEM cells next to the stream channels can improve DEM response (ie creation of derived flows and drainage areas). Once developments are finalized we could promise:

6.1 Derived flow lines should better correspond to streams allowing for more accurate reading of slope gradients (and delineation of reaches) (See Fig 6.1)

6.2 Allocation of headwater sub-areas will improve so initial stream segments will not be outside of corresponding sub-drainage basin (See Fig 6.2)

6.3 Calculation of watershed drainage basin from DEM using specific points will be more appropriate. (See Fig 6.3)
Figure 6.1 DEM derived flow lines after TOPOGRID (purple) and with additional GISmo processes (green)
Figure 6.2 Allocation of headwater sub-areas

Minor disagreements of stream and DEM flow after TOPOGRID

Corresponding individual drainage sub-areas and major drainage boundary
Stream and DEM flows after enhanced process

Corresponding individual and major drainage boundary
Figure 6.3 Calculation of watershed drainage basin from DEM for a specific drainage point

Streams and
DEM flows
TOPOGRID
process

Streams and
DEM flows
after enhanced
process
Boundary of watershed drainage basin

Boundary of watershed drainage basin for enhanced DEM
6. Past Experience and Resources Assigned

GISmo Solutions Ltd. is a company that specializes in GIS applications development and services. Each of our senior consultants has over fifteen years of experience with Environmental Systems Research Institute (ESRI) GIS tools including ARC/INFO and ArcView, and we use efficient, proprietary systems to deliver quality products for our clients. Our staff has been involved with the Base Features (BF) Hydrography Conversion Project since early 1998 and delivered significant amount of data to Resource Data Division (RD) standards. We participate in RD activities for Base Features Hypsography, Access Update and Geo-administrative Boundaries projects. We also supported a variety of hydrography and DEM-related projects for other government agencies, the Alberta Research Council, Alberta Conservation Association, and forestry clients in Alberta and BC. Projects included integration of NTDB, CDED and NP DEM data sets, flow and drainage analysis, Quality Control of hydrography and hypsography data, route creation and classifications, and watershed delineation. Recently we have supported a significant initiative to develop common requirements, standards and data processing methodology for provincial Watershed Delineation and Hydrocoding Project for Resource Data, Government of Alberta. In addition to data and consulting services in this area, GISmo has completed several software development projects for detailed DEM analysis, manipulation, and display using Java, C++, VB, or component software.

Resources Assigned:

Michal Pawlina M.Sc. P.Eng  Principal Consultant
Project Role: Project Leader, Senior Technical Advisor, process design, client communication

Igor Kezhis NAIT Diploma  GIS Specialist
Project Role: Software development

Bev Tschritter B.Sc. Geogr  GIS Technologist
Role: Data processing and QC

Other resources with significant experience in DEM processing may be also assigned.
Resource Profiles

Michal Pawlina, M.Sc., P.Eng  
Principal Consultant  
Project Role: Project Leader, Senior Technical Advisor, Client Communication

Summary of Qualifications:

- Over twenty years experience in software development supporting a wide range of geo-processing, scientific, and engineering applications.
- Private industry and government agencies employment history with a focus on the development of custom applications using leading mapping and GIS technology.
- Extensive knowledge of spatial, digital data as well as of the supporting structures and systems allowed for the successful integration of custom software and commercial offerings across a range of different hardware and software platforms.
- Considerable experience with GIS tools including 15 years of ARC/INFO and other ESRI products, as well as Microstation, SPANS, MapInfo, SURFER, Blue Marble tool sets, etc.
- Programming skills including C, AML, Avenue, and Visual Basic.
- Responsible for the design and development of hydrography-related applications and Quality Control procedures for route building, stream classifications, watershed delineation, and DEM corrections.
- Experience in planning and co-ordinating projects and human resources in the development of various scale systems and applications.
- Consultation, presentation and communication skills.
- Organizational and management skills required for operating a successful business.

Igor Kezhis  
NAIT Diploma  
GIS Specialist  
Project Role: Software development

Summary of Qualifications:

- Experience in developing GIS software using C++, Avenue, VB.
- Experience in complex DEM algorithms and processing options.
- Completed development of hydrocoding and classification software.
- Completed VB, Surfer application for DEM derived product display.
- Knowledge of Microsoft Access, FOXPRO, and Oracle database.
- Completed development of ArcView environment for Hydro QC, Strahler coding, route design and edit, watershed delineation (Spatial Analyst).
Bev Tschritter  B.Sc. Geogr
GIS Technologist
Project Role: Data processing and QC

Summary of Qualifications:

- Experience with hydrography, routes, and watershed data sets.
- Experience with DEM and TOPOGRID processes
- Completed hydrography structuring for NES and JNP projects.
- Completed watershed delineation for Northern Watershed Project and Sounding Creek Basin project.
- Completed DEM and Single line hydrography reconciliation for Federal areas in NE Alberta.
- Responsible for process documentation and quality data presentation.
- Experienced with ARC/INFO, ArcView, and related automated systems.

Past Related Experience

Our Team is representing substantial GISmo experience with the three critical data sets of Hydrography, DEM and Watersheds. We have grouped projects according to the main focus, but much of the information and activities are interrelated in a comprehensive GIS data-structuring project. Michal Pawlina was a project leader, process / software developer, or senior technical advisor on all of the listed projects, and specific client references can be provided.

HYDROGRAPHY

- Development of an Automated Hydrography Structuring System to generate single line networks, watersheds and route systems to support various needs of both government and forestry industry. Subsequently used in all Base Features Hydrography projects.

- Creation of hydro networks for FMD C5 study area.

- BF Hydrography Conversion Project(s) for Alberta provincial government.

- BF Federal Hydrography project for 84I. Processing of NTDB data sets consistently with the requirements and standards of the Base Features Hydrography Project.

- Creation of 1:20K network, route layout and transfer of attributes between 1:50K and 1:20K hydrography in BC (Chetwynd area). Integration of hydro-coding and various existing point data (falls, barriers etc). Defining reaches as linear events and calculation of DEM derived attributes (gradient, steepest 25, 100m segment etc.) Routes, reach events and subsequent modeling data sets were used for Fish Management Plans.
• QC and Strahler classification for SLNET in Northern East Slopes (NES) region of 1:20K Base Features hydrography. A significant extent (20% of Province of Alberta) of BF SLNET was processed, corrected, and attributed to benefit Foothills Model Forest, NES government, and Jasper National Park users.

• QC and Strahler classification for SLNET for Jasper National Park.

• BF Hydro Update project to extract all SLNET changes from NES and JNP projects, link it to SDE storage attributes, and provide easy to utilize lists of required corrections.

• Development of routes, and hydrocodes for Base Features Watershed and Hydrocoding project.

DEM

• Development of GIS desktop software for interactive watershed delineation and mapping using hydrologically corrected DEMs. (for ArcView + Spatial Analyst). Creation of seamless terrain from individual tiles, delineation of watersheds for points, arcs and sub-networks.

• Development of Visual Basic, Surfer applications for display and analysis of DEM-related information

• Creation of seamless Alberta DEM coverage from PDBM, NTDB, CDED and National Parks data sets. In addition to QC and edge-matching processes, high quality map products were created.

• Utilizing DEM for flight pattern design and corrections in air photo acquisition

• Rewrite of complex DEM / Watersheds analysis algorithms into efficient C++ application. LANDMAPPER WEPPMAPPER

• BF Federal Hypsography project. Creating provincial DEM coverage for NTS Blocks 74L, 74M, 84P, 84I and 84O consistently with the requirements and standards of the Base Features Hydrography and Hypsography Data Conversion Project.

• Creation of DEM for Kluane National Park

• Software development for DEM creation, QC, storage, distribution, and derived products (TIN, GRID, TIFF, Slope, gradient, etc.)

WATERSHEDS

• Reach and Watershed delineation for Foothills Model Forest fire research initiative for Chisholm and Dogrib fire study areas. Development of processes for DEM based reach delineation and upstream aggregated region data structures. Source data: BF Hydrography, BF and National Parks DEM

• Creation of watershed drainage areas for the Swan River. Strahler classification, drainage accumulation and Strahler based route systems were generated using Base Features Hydrography and DEM.
• Watershed delineation for the Milk River Basin in support of Base Features Watersheds and Hydrocoding project. User requirements definition, development of provincial standards and prototype data sets and software utilities. Development of data capture methodologies for processing and quality control of BF DEM and SLNET
  Source data: BF Hydrography and BF DEM

• Watershed delineation for Northern Watersheds Project: Notekiwin, Kakwa, Simonette Basins. Unique routes definition, Strahler classification, and drainage accumulation attributes were generated.  Source data: BF Hydrography and BF DEM

• Generation of Hydrography, DEM and Watershed Data Sets for Canadian Forest Products Ltd. This project included methodology research and prototype development and was validated by the Forest Resource Improvement Program (FRIP). Source data: 1:20K PDBM and DEM

• Creation of watershed drainage areas for the Wapiti River. Strahler classification and drainage accumulation attributes were generated with respect to, and integration with, external BC data sets.
  Source data: BF Hydrography and BF DEM, BC Watersheds, Fish Wizard

• Drainage Areas delineation for Sounding Creek Basin. The focus was to determine the quality of the DEM / hydro. based methodology in relation to the existing mylar data set.
  Source data: BF Hydrography and BF DEM, scanned mylar watersheds

• Support for Chain Lakes project in determining DEM-derived drainage areas for gauge stations. Demonstration of point and arc based drainage area results.

• Drainage Areas accumulation for BC TRIM data sets. Linking watershed and hydro network information in Peace River basin. Source data: BC Watershed Atlas Hydrography and TRIM

Typical processes in an integrated Hydrography, DEM, and Watershed delineation project were:

• Validation or creation of additional data for the single line network (Centerlines, DEM derived connectors, selection of contributing features)
• Single line network SLNET data assembly / initial QC / Strahler coding, route connectivity test and grouping of classified data.
• Processing DEM data and SLNET for hydrologically corrected surface and enhanced connected network
• Validation of changes / issues with client or local data authorities
• Creation of a final DEM (fully or partially filled and draining), SLNET and watersheds.
• Edit / enhancement process for watershed polygons
• Adding area accumulation attributes
• Creation of unique stream routes, adjustments for named features, creation of point and linear events.
• Data (Process) documentation and preparation of deliverables
Appendix A  Watershed Delineation and Stream Classification reference information

Information provided to Foothills Model Forest for Chisholm / Dogrib Fires Research Initiative

Chisholm final delivery  CDROM  July 20, 2002
Dogrib final delivery  CDROM  July 20, 2002

Relevant documents and data set provided to Foothills Model Forest from Watershed Delineation and Hydrocoding Project include

BF_WATERSHEDS_STA_21_02_2002.doc
BF_WATERSHEDS_DSC_21_02_2002.doc
Prototype CDROM  March 22 for Milk River Basin