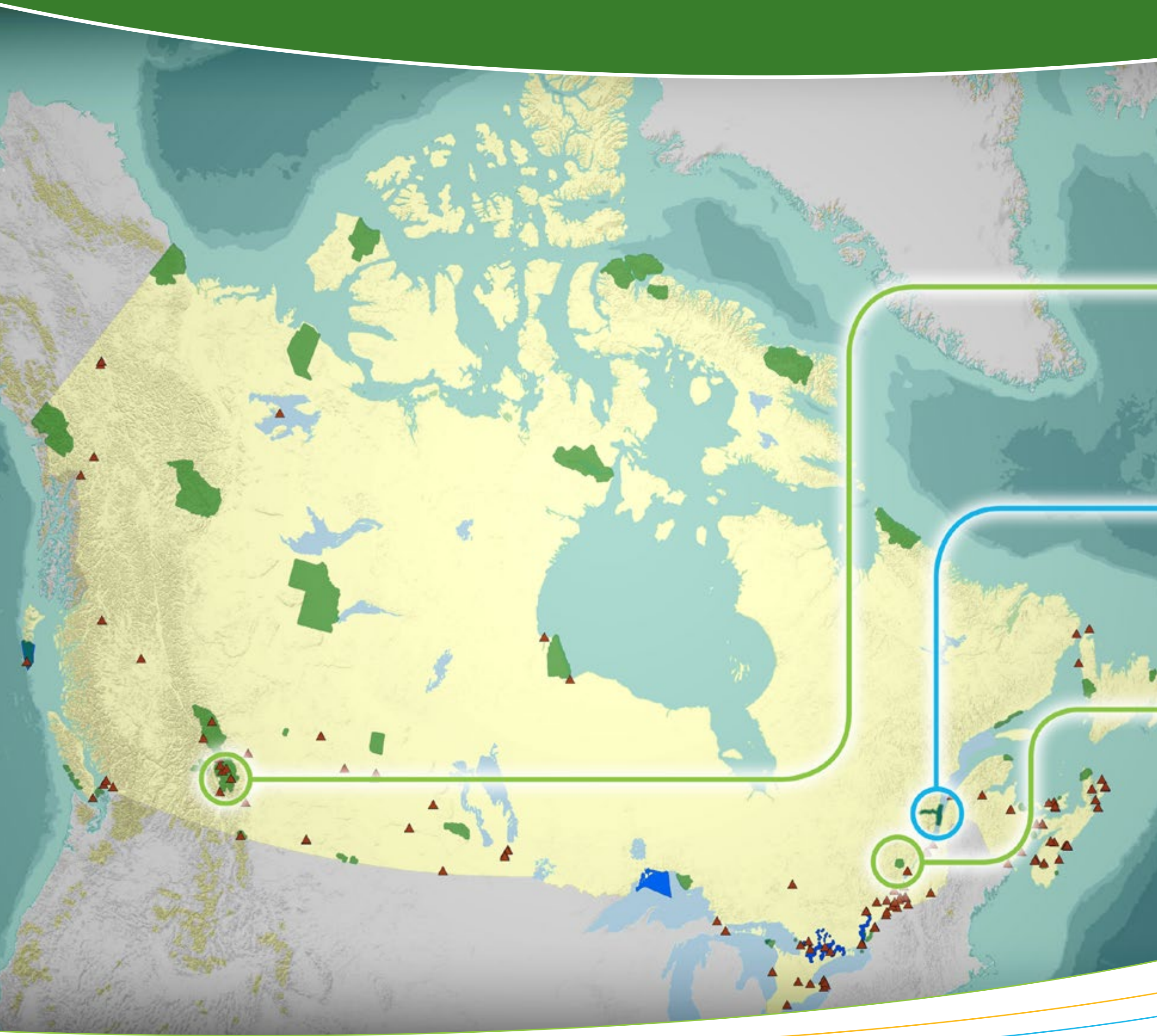
Volume 2, July 2014

Geomatics
in Parks Canada



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Geomatics in Parks Canada

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Message from the Chief Executive Officer of Parks Canada

It is my pleasure to introduce the second volume of *Geomatics in Parks Canada*. The initial volume was distributed in 2008. In this volume, Parks Canada's Geomatics team has provided updated examples of its work; they are examples that reflect today's context. This publication will serve as an important means to ensure that we witness first-hand our leadership and that we are informed of related Geomatics successes and challenges across our vastly distributed organization.

Whether it was using Fire Severity Mapping to help manage an area, analyzing Saguenay's marine habitat to reduce collisions between ships and whales, or deciding which culvert to install along a highway in La Mauricie, geomatics helped each team develop shared understanding and vision which lead to solutions. These accomplishments clearly exemplify a community striving to work as "One Team, with One Vision, speaking with One Voice".

Please join me in recognizing the teams involved in the three initiatives documented in this volume, and the Geomatics specialists who helped each team achieve its objectives. I am very proud to see our teams work collaboratively towards common goals. I look forward to reading future volumes and learning more about how our Geomatics professionals facilitate the resolution of a diverse range of challenges facing the Agency.

Alan Latourelle
Chief Executive Officer
Parks Canada Agency

This volume of *Geomatics in Parks Canada* outlines three examples where Geographic Information Systems (GIS) have helped Parks Canada Team members perform their work more effectively and more efficiently.

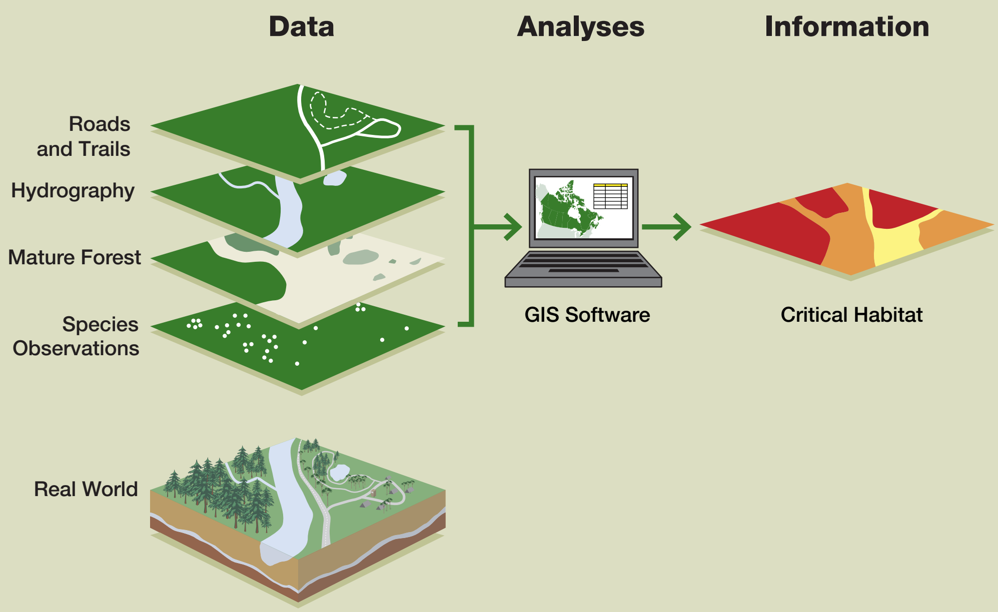
Featured Articles

Volume 2, July 2014

Since the mid 1980s, Parks Canada has invested in Geomatics technology to work more efficiently, to make better decisions, and to work in partnership with our visitors and neighbours.

"Geomatics is the science and technology of gathering, analyzing, interpreting, distributing and using geographic information. Geomatics encompasses a broad range of disciplines that can be brought together to create a detailed but understandable picture of the physical world and our place in it."

Natural Resources Canada



Sources: Parks Canada and ESRI Canada

These disciplines include:

Geographic Information Systems (GIS)
The principal tool of Geomatics. A GIS stores and analyzes geographic data, turning it into geographic "information".

Global Positioning System (GPS)
GPS is a technology that records geographic location through a satellite-based radio navigation system.

Cartography
The art and science of the visual display of the earth and its conditions or properties.

Remote Sensing
The science of deriving information about the earth's land and water areas from images acquired at a distance.

Surveying
The science of measuring distances and angles on the earth so that they can be mapped.

Parks Canada uses geomatics

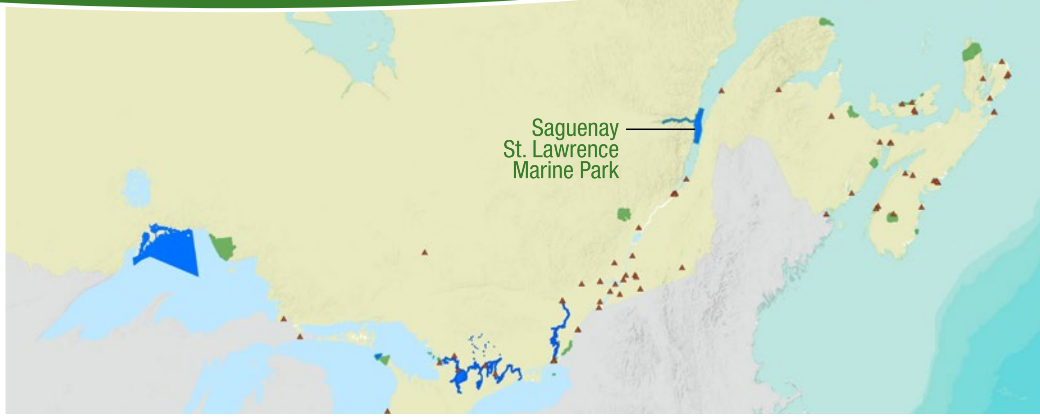
to obtain or create data and then to transform this data into information. The data can be acquired directly by GPS field-work, radio-telemetry of animals, satellite imagery, marine-based sensors, or aerial photography. It can also be acquired from other agencies, partners, and First Nations. Information about ecological phenomena and human activity is created when data is integrated and knowledge is applied.

Geomatics supports Parks Canada's mandate in the following areas:

- biological inventories and monitoring
- species at risk
- ecological restoration
- visitor studies
- visitor presentations
- search and rescue
- new site development
- boundary delineation
- infrastructure management
- data and information sharing to help partners achieve mutual goals

Using GIS to Reduce Whale/Vessel Collisions

in Saguenay St. Lawrence Marine Park



Background

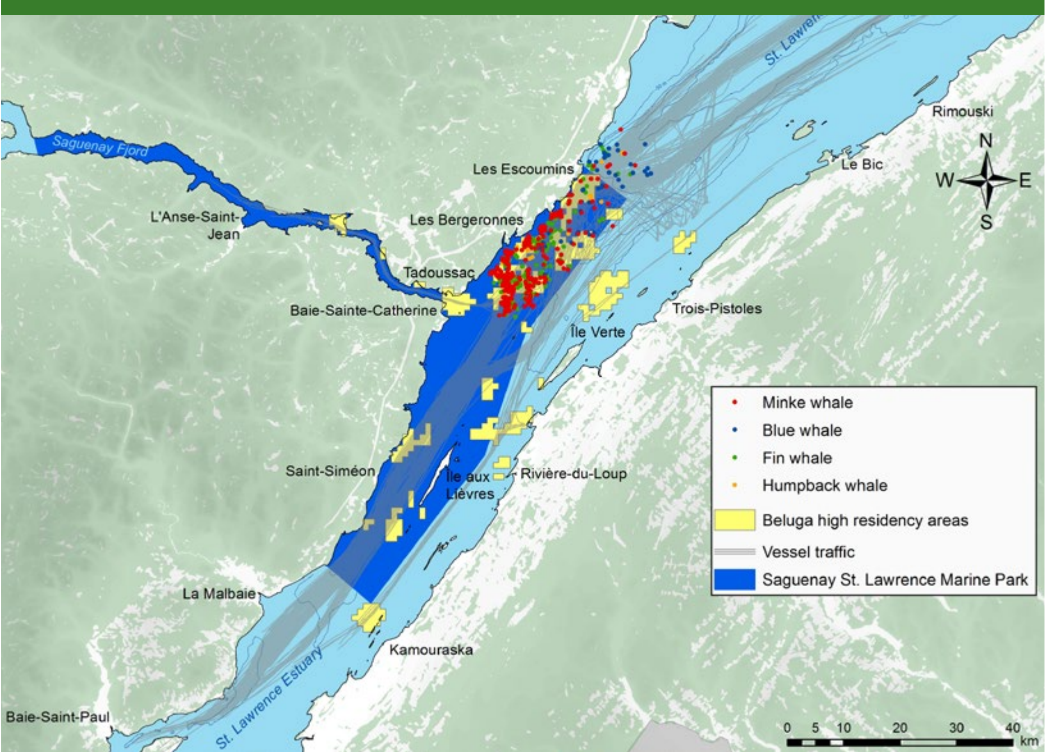
The Saguenay St. Lawrence Marine Park is a protected area that is jointly managed by Parks Canada and Parcs Québec. The Marine Park protects and presents unique ecosystems at the confluence of waters of the St. Lawrence Estuary and the Saguenay Fjord. These waters are vital calving and rearing areas for the threatened St. Lawrence beluga whale as well as feeding grounds for five other species of whales and three of species of seals. It is thus not surprising that the area has become known as one of the best places in the world for whale watching.

The St. Lawrence River is also a major shipping route linking the ports of the Great Lakes to the rest of the world, with an average of 7 500 trips of commercial ships travelling through

> "Mapping whale feeding areas and navigational routes allowed us to identify the areas of high risk for collisions between boats and whales. This helped us define measures the shipping industry can take that conciliate whale protection needs, navigational safety and the economic reality."

Simon Mercier, Corporation des Pilotes du Bas Saint-Laurent.

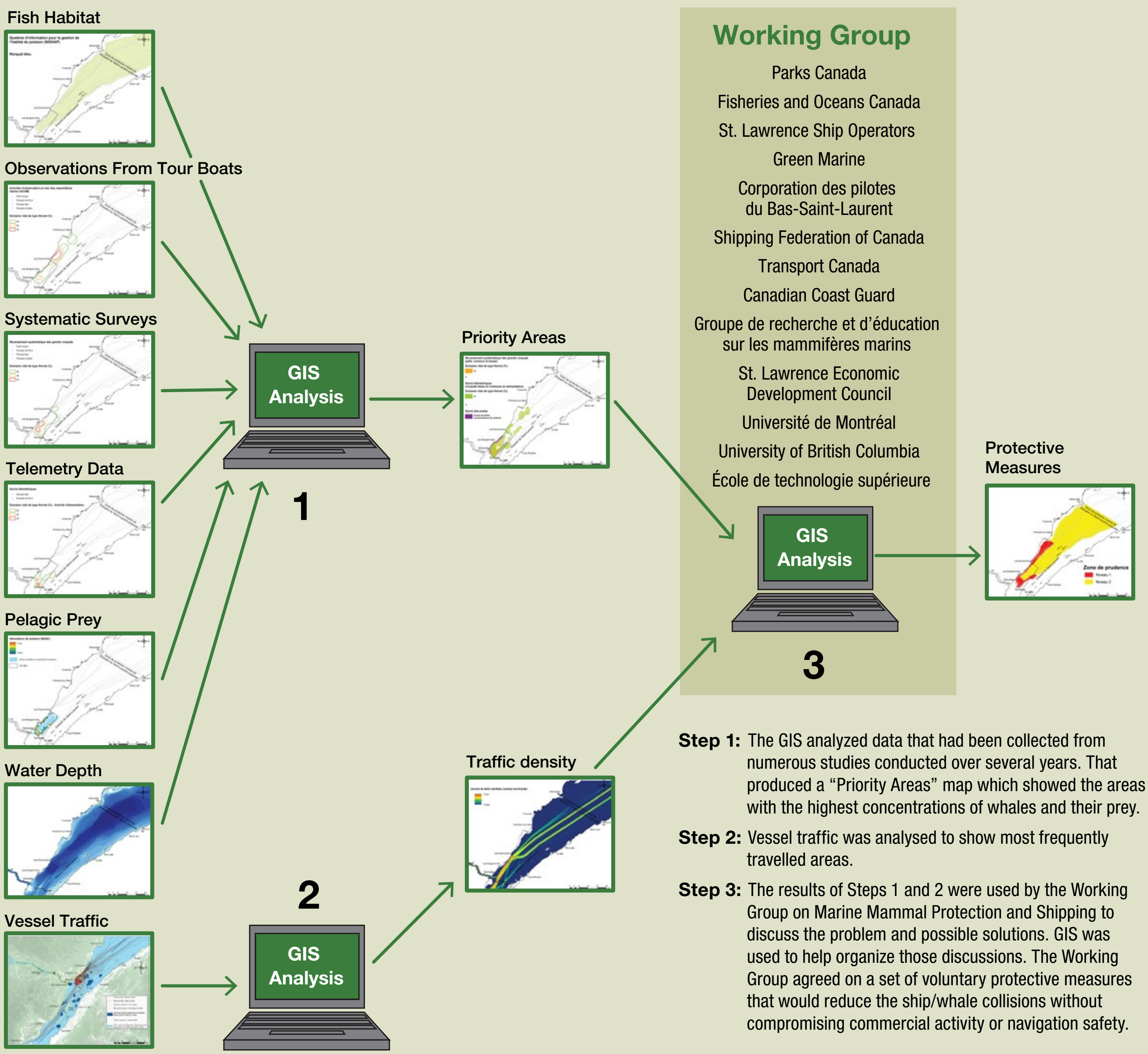
Figure 1: This GIS map shows vessel traffic, whale observations and beluga whale areas of high residency in waters in and around Saguenay St. Lawrence Marine Park.



The St. Lawrence beluga whale is a threatened species that uses the Marine Park and surrounding waters as calving and rearing areas. (Photo: W. Lynch., Parks Canada) every year. Added to that is marine traffic from tourism, with approximately 13 000 commercial whale watching trips and over 9 000 recreational boat trips.

In the Marine Park area, the width of the St. Lawrence diminishes and whale feeding areas overlap with navigational routes (see *Figure 1*). This can lead to some very close encounters between ships and whales which can not only disturb the animals, but can also result in whale/ship collisions. Since 1992, Parks Canada has documented over 45 incidents of collisions and injured whales in the Marine Park and surrounding waters. However the number of collisions that actually occur is thought to be much higher. For species at risk such as the endangered blue whales, even a low number of collisions can have a significant effect on the population.

Figure 2: This flowchart describes the GIS analysis used by the Working Group on Marine Mammal Protection and Shipping to establish a set of voluntary protective measures to reduce the risk of collisions with whales and vessels without compromising navigation safety or shipping activity.



Step 1: The GIS analyzed data that had been collected from numerous studies conducted over several years. That produced a "Priority Areas" map which showed the areas with the highest concentrations of whales and their prey.

Step 2: Vessel traffic was analysed to show most frequently travelled areas.

Step 3: The results of Steps 1 and 2 were used by the Working Group on Marine Mammal Protection and Shipping to discuss the problem and possible solutions. GIS was used to help organize those discussions. The Working Group agreed on a set of voluntary protective measures that would reduce the ship/whale collisions without compromising commercial activity or navigation safety.

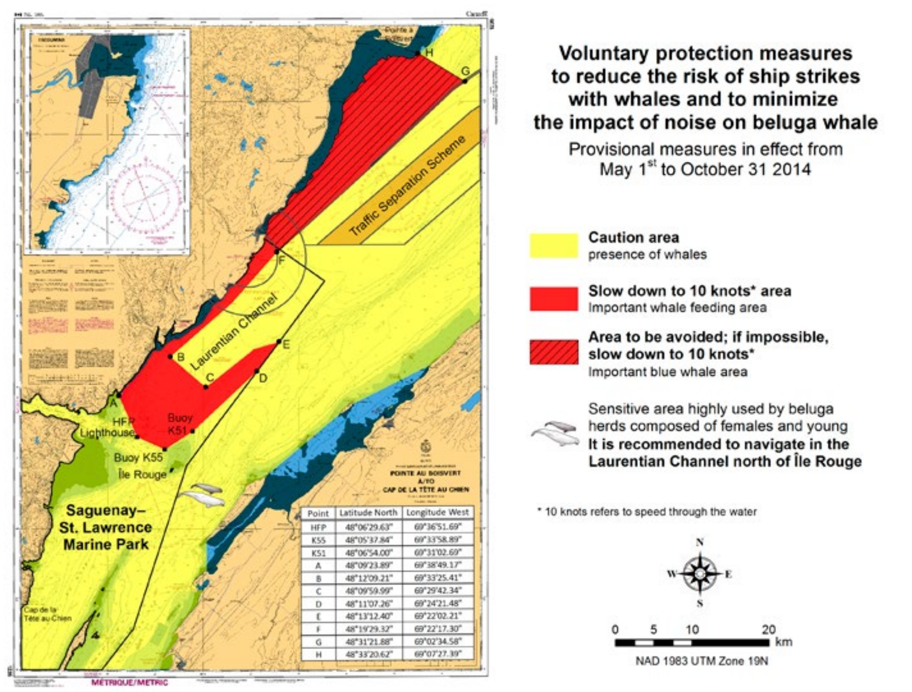
Commercial vessels make 7,500 trips through the Saguenay St. Lawrence Marine Park and surrounding waters each year. (Photo: S. Roy, Parks Canada)

Methodology

In 2011, the Working Group on Marine Mammal Protection and Shipping was created. It consists of members of the shipping industry, economic development groups, academia, a research group and the federal government (see *Figure 2*). The Working Group's mandate is to explore and recommend solutions to reduce the risks of vessel/mammal collisions without compromising shipping activity or navigational safety.

Parks Canada's Geographic Information System (GIS) helped the Working Group discuss and reach consensus on the best protective measures that would reduce the risk to whales while taking into account navigational safety and profitability. The process is shown in *Figure 2*.

Figure 3: The GIS map that appears in the Notice to Mariners published by the Canadian Coast Guard.

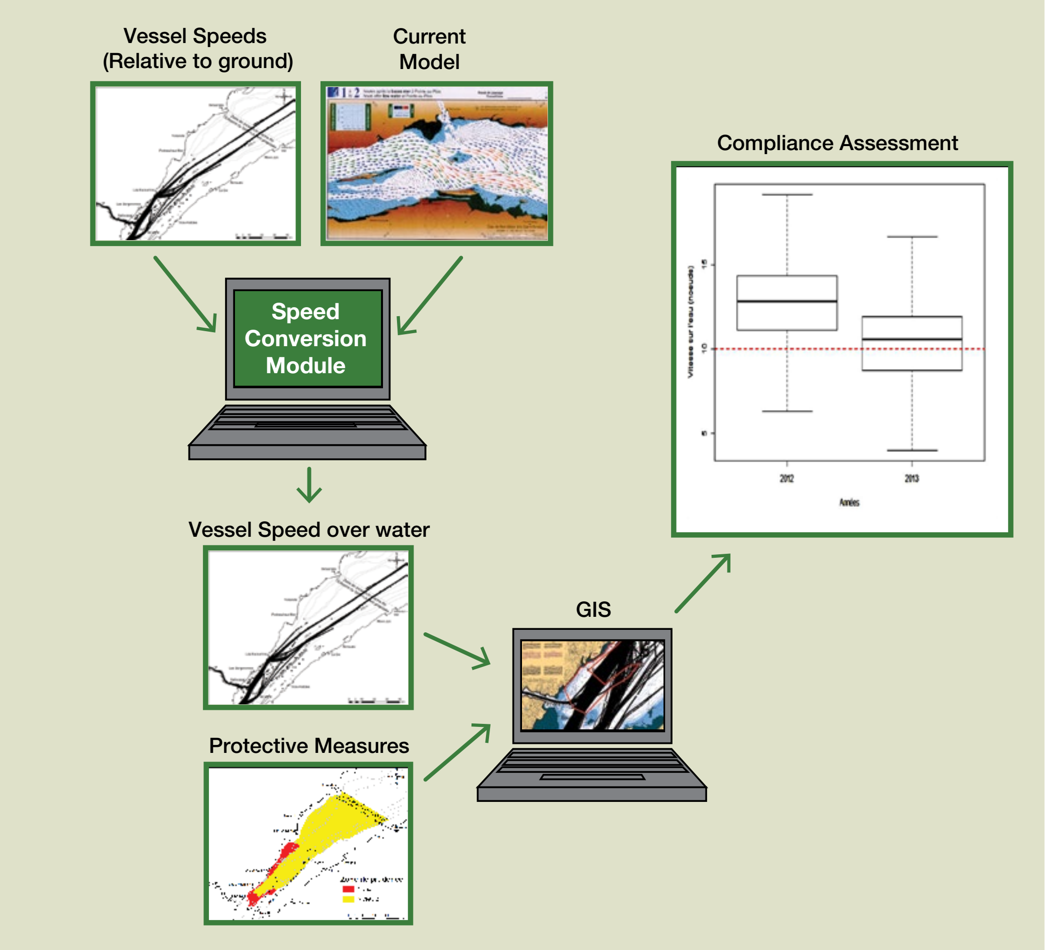


(Photo: L. Levesque, Parks Canada)

The output of that process was a set of voluntary protective measures illustrated on a GIS map showing where those measures would apply. That map was sent to the Canadian Coast Guard for inclusion in its *Notice to Mariners* (see *Figure 3*).

In 2013, following the first year of protective measures, the Working Group asked Parks Canada to assess the levels of compliance. This presented another challenge that required GIS: the speed limits in the protective measures were specified as the speed over water because of the particularly strong currents in the area. However, the vessel speed data was derived from GPS, which measures speed relative to the ground. A numeric model developed by Innovation Maritime in Rimouski (Quebec) calculated the speed over water of vessels by integrating the velocity of water currents at the time and place a ship was navigating. Finally, by overlaying the vessel speed over water data with the map of protective measures, the GIS evaluated the levels of compliance (see *Figure 4*).

Figure 4: This flowchart shows how GIS was used to assess levels of compliance to the voluntary protective measures. Vessel speeds (relative to the ground) were converted to speed over water using a GIS module developed by Innovation Maritime Rimouski Ltd. Vessel water-speed was then overlaid with the protection measures. Results showed a decrease in average vessel speed.



The results showed some good news. When comparing the months of August 2012 and 2013, which was the first year of implementation of these measures, the average speeds had dropped significantly from 12.3 knots to 10.3 knots in the slowdown area. Already in the first year, the average speed of ships passing through whale feeding grounds was very close to the 10 knot recommended speed. However, the analysis also showed that there had been an increase in traffic south of the Marine Park, in an area frequented by female beluga whales and their young. A science advisory report on the effects of increasing traffic in this area for the beluga whale population was requested by the Working Group. The findings were reported back to the Working Group and the notice to Mariners was adapted in 2014 to take into consideration the scientific advice. Testing of the voluntary protective measures is underway for the second year.

Below: Whale watching boat tours, Sagueanay St. Lawrence Marine Park. (Photo: M. Mills, Parks Canada)

GIS helped resolve the problem in several ways:

- It helped organize and process ecological data from many sources and methodologies that was collected over several years.
- It helped present the analysis in a transparent way that all stakeholders could understand.
- The GIS maps helped the Working Group structure its discussions and arrive at a common solution to a shared problem.
- The GIS map was used by the Canadian Coast Guard to publish the protective measures in the *Notice to Mariners*.
- GIS enabled the Working Group to measure the results of its efforts, and in doing so, identified some unintended consequences (an increase in traffic to the beluga nursing grounds in the south).
- GIS maps were used to describe an unintended consequence, which enabled the Working Group to improve its solution.

Kayakers in Saguenay Fjord, Saguenay St. Lawrence Marine Park. (Photo: J.F. Bergeron/ENVIROPHOTO, Parks Canada)

"I call it the 'Million-dollar Map'. The GIS helped us take advantage of over $ 1 million worth of data collected over 20 years by various partners, and organize it in a way that helped the Working Group arrive at a shared solution to a shared problem. Without the GIS, it would have been very difficult for us to consider all of the elements together and come to an agreement."

Nadia Ménard, Ecologist Team Leader, Parks Canada.

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Saguenay-St. Lawrence Marine Park on Parks Canada website:
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Saguenay-St. Lawrence Marine Park website:
www.marinepark.qc.ca

Notice to Mariners:
http://www.notmar.gc.ca/go.php?doc=eng/services/annual/default-eng and **http://www.notmar.gc.ca/allez.php?doc=fra/services/notmar/index**

Department of Fisheries and Oceans Canada Science Advisory Report:
http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2014/2014_004-eng.html

Using GIS Technology to Strengthen Fire Management Planning

Background

Fire is a powerful natural force that shapes ecosystems in fundamental ways. While fire creates habitat for different species and helps to release nutrients into the soil, it also causes significant damage and can threaten nearby towns and communities.

Our understanding of fire and its role in ecological integrity has evolved over the past 30 years. In the past, Parks Canada extensively engaged in fire suppression across the national parks system. Today, the Agency sees fire as a natural process, a tool for ecological restoration and even a way to inform Canadians about the natural world.

Parks Canada's National Fire Management Program has two primary objectives. The first is to protect people, infrastructure, cultural resources and ecological components by controlling, and in many cases preventing, wildfires. The second objective is to restore ecological integrity using prescribed fires in fire-dependant ecosystems.

Figure 1: Fire plays a critical role in the functioning of healthy ecosystems and maintenance of habitat for species at risk. At the same time, fire poses serious risks to human activities and communities, and therefore requires careful management within our national park system. (Photo: R. Komar, Parks Canada)

Pipestone River near Lake Louise in Banff National Park. (Photo: A. Krause, Parks Canada)

Monitoring and Mapping Fire — A Key Challenge

Post-fire monitoring is an important component of Parks Canada's National Fire Management Program. The program actively monitors and reports on the overall area burned on a park-by-park basis every year. Managers are also interested in understanding *burn severity*, or the magnitude of ecological change caused by a fire event. This can be difficult to determine given that the severity of different fires can vary. To complicate matters further, the intensity within a single fire can vary across a small area of the landscape, as shown in *Figure 2*.

Monitoring and reporting on fire events requires detailed data and analysis over large areas. Once managers have determined the severity of fire in an area, they can predict the *fuel load* (i.e., the amount of easily ignited vegetation and trees). Understanding the amount of fuel on the ground helps Parks Canada predict the behaviour and effects of future fires.

Forest fire in Banff National Park.

"The mapping of burn severity is an excellent example of the role GIS can play in providing tools to assist with accurate, cost-effective solutions for park management, engaging Canadians and creating memorable visitor experiences."

Salman Rasheed, National Manager, Active Management and Ecological Restoration, Parks Canada.

Figure 2: The severity of a single fire can vary significantly across the landscape. This picture demonstrates the patchy nature of most wildfires. (Photo: Parks Canada)

Traditional methods of post-fire monitoring involve helicopter flyovers, which are expensive. The National Fire Management Program in the Protected Areas Establishment and Conservation Directorate of Parks Canada has therefore been exploring ways to map and track the impacts of fire in a more cost-effective manner. Geomatics responds to two major challenges. First, the field of remote sensing collects data from vast geographic areas that would otherwise be too difficult or expensive to survey. The second challenge is the need to process the hundreds of millions of observations (pixels) into information that tells us something useful.

Harnessing the Power of Landsat Technology

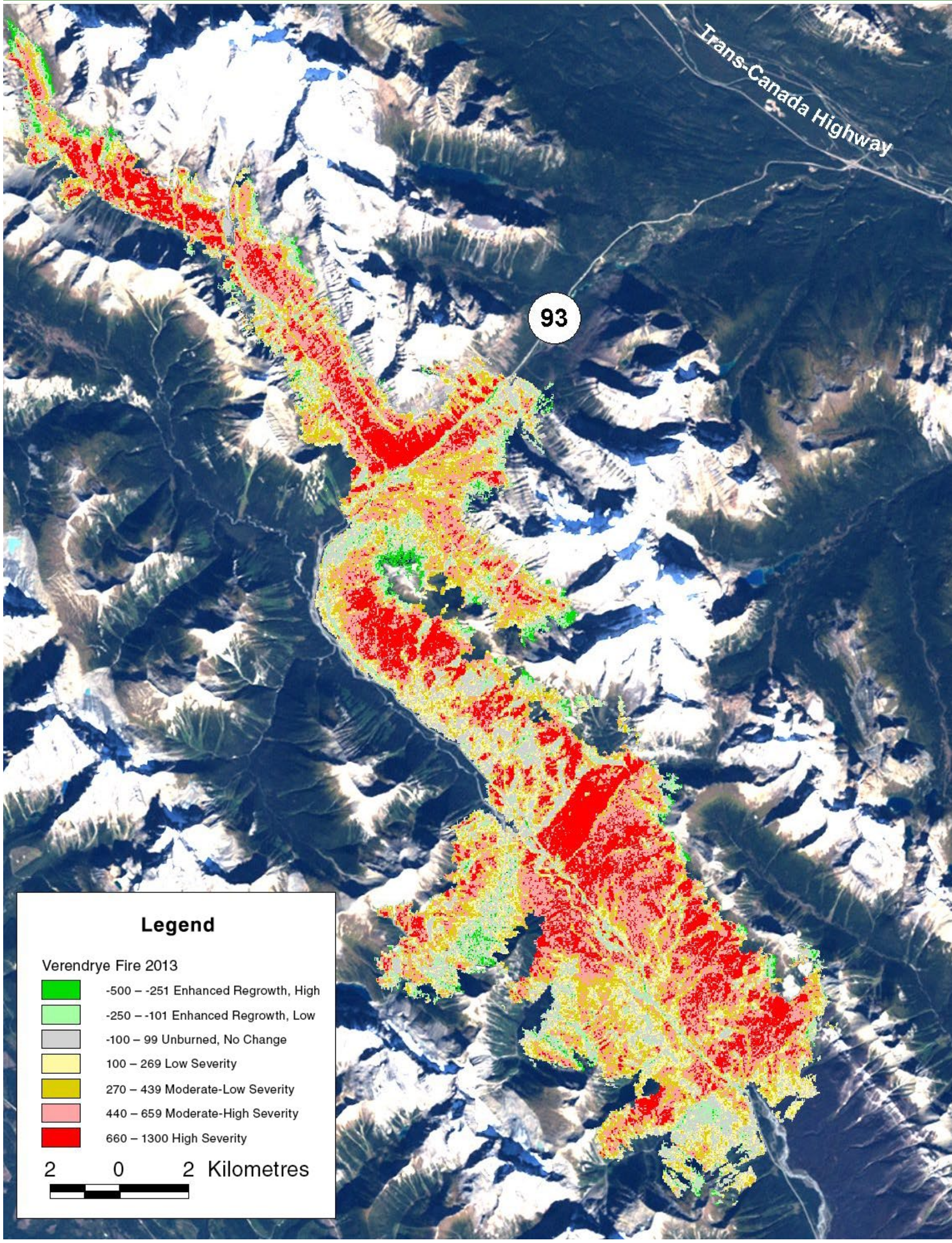
Landsat is an American satellite program that continuously captures information about the earth, allowing scientists to measure ecological change over time. Since the early 1970s, Landsat satellites have been collecting data over our national parks every 16 days on average. Building on work by the Rocky Mountain Research Station in Utah, Parks Canada fire ecologists in the Protected Areas Establishment and Conservation Directorate (Natural Resources Conservation Branch) have been using Landsat imagery to produce information products that help evaluate and compare burn severity within individual fires and between fires across the national park system.

Results to Date

Since 2005, Parks Canada's National Fire Management Program has mapped the severity of all fires greater than 200 hectares in Canada's national parks and national historic sites. These maps are now used by other Resource Conservation specialists at individual national parks to support park management planning. For example, they can be used to describe areas that are suitable habitat for species at risk.

In addition, the information can support a greater understanding of the relationship between fire, ecosystems and wildlife. This informs ecological restoration efforts that have reintroduced fire (through prescribed burns) where it is needed in some park ecosystems. Predicting the severity of future fires also helps Parks Canada create enjoyable visitor experiences that are less prone to disruption from dangerous fires. It also gives the Agency the opportunity to increase the level of understanding of the natural role that fire plays in healthy ecosystems. This can include providing firsthand, safe opportunities to see fire working on the landscape.

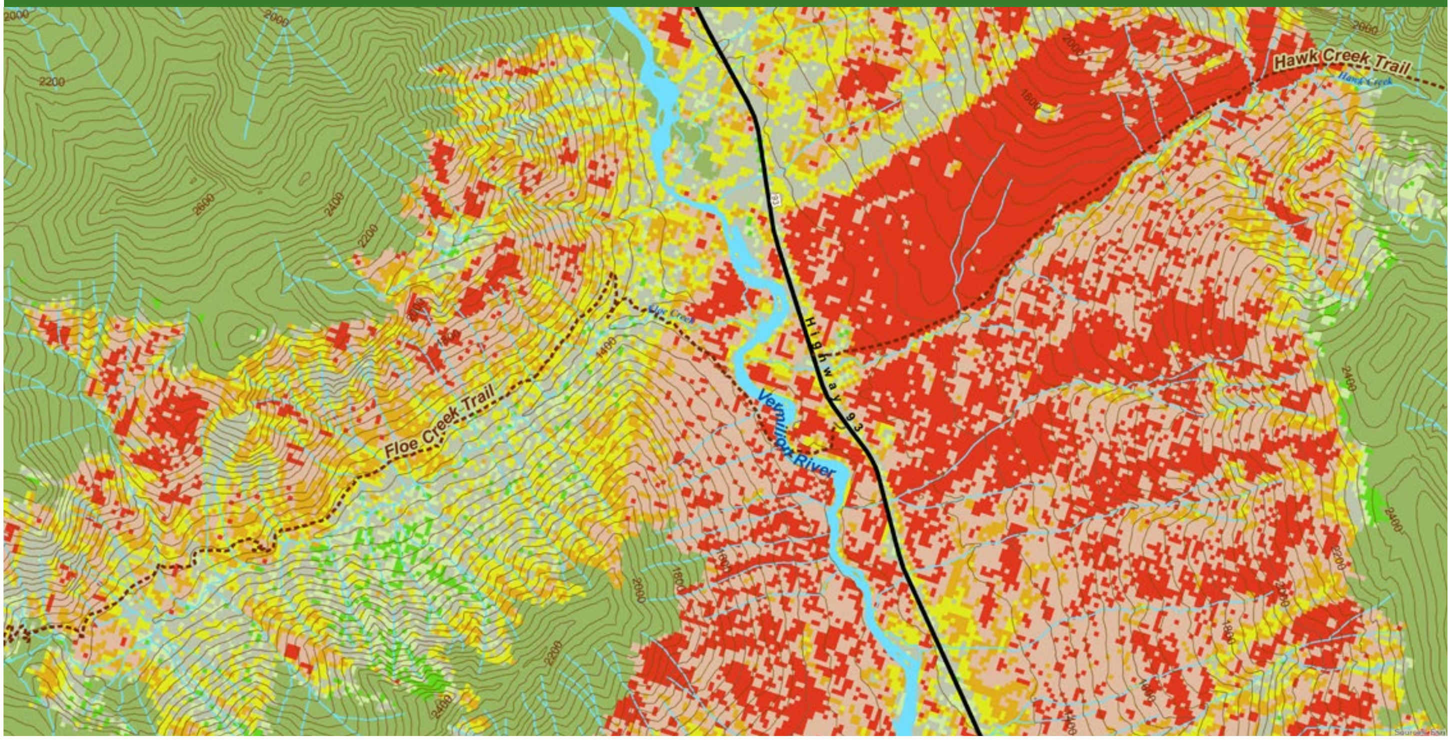
Figure 3 : Fire severity map for a fire that took place in Kootenay National Park in 2003. More intense red colours indicate places where the fire burned severely, yellows burned with low severity.



> "Not all fires are alike. Some burn hotter than others. Even within a single fire there is variation. Understanding what fuel is left over from the last fire helps us predict what the next fire might look like."

Darrel Zell, Ecosystem Data Specialist, Parks Canada.

Figure 4: The burn severity map for the Kootenay Verendrye Fire 2003 with contour lines, highways and park trails. The area along the Hawk Creek Trail burned severely, which may have increased the risk of erosion, but lowered future fuel loading. By contrast, the area around the Floe Creek Trail burned with moderate to low severity indicating that there may be fuel for another fire. This information can be used to plan memorable experiences for visitors and also develop a sustainable network of trails within the Park.



How Geomatics Contributes

Geomatics helps Parks Canada understand, plan and react to fires in the following ways:

- Remote sensing collects observations (data) across vast areas and long time periods. That data would be too expensive to collect through field surveys, fly-overs, or manual interpretation of airphotos.
- GIS performs complex processing that would be impossible for humans to perform on the hundreds of millions of pixels (30m x 30m squares) that cover our national parks.
- Fire severity GIS products can be used in additional GIS analyses that better inform the work of other Parks Canada Team members (Asset Managers, Conservation Biologists, Visitor Experience staff and Park Planners).
- Operationally, GIS helps fire teams plan and monitor their responses to fire responses as they unfold.

Burn Severity Mapping is an example where GIS helps to bring the Parks Canada Team closer to a shared understanding of fire on the landscape.

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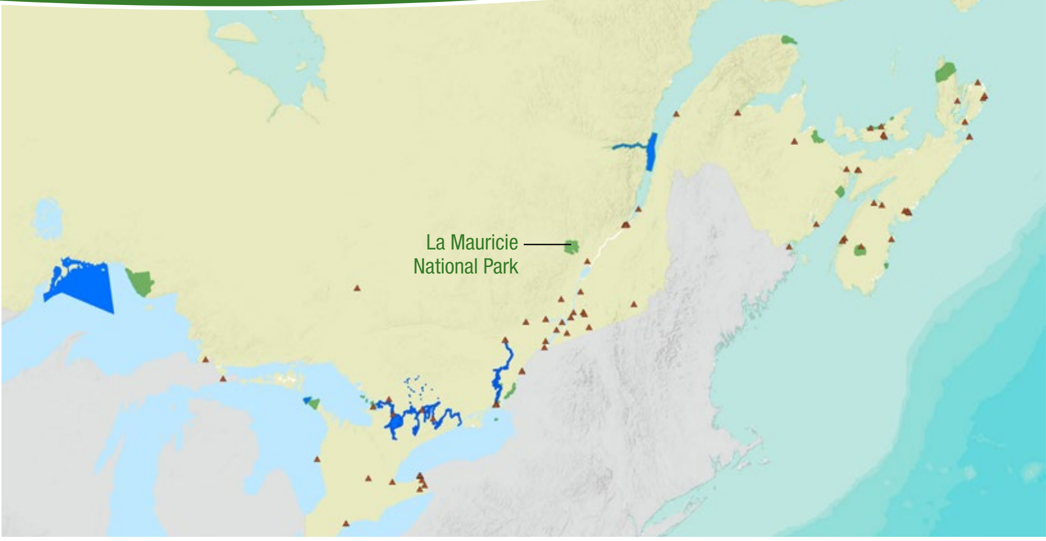
Fire Management website:
http://www.pc.gc.ca/eng/progs/np-pn/eco/eco5.aspx

How GIS Improves Culvert Replacements

in La Mauricie National Park



Why Culverts are Important

Think of a family driving through La Mauricie National Park. The car passes over a highway culvert, nobody in the car feels a bump, no one sees the culvert and the family continues on with the vacation. Now think of a second family, on another highway approaching different culvert. This culvert failed a few hours ago, and road is now overflowing with water and traffic is blocked. The driver managed to stop safely, and the family is standing on the highway looking at a scene similar to the one shown in *Figure 1*.

Figure 1: A flooded road at La Mauricie National Park. To avoid situations like this in the future, the Park is installing culverts designed to handle peak water flows seen every 50 years.

Consider the differences in the two stories that each family will tell their friends about their visits to La Mauricie National Park and the differences in opinion of Parks Canada as a steward of the environment. Consider the costs to the Park to repair the washout and the damage to the environment, all of which could have been avoided had a more appropriate culvert been installed.

La Mauricie National Park has more than 500 culverts, many of which are at the end of their useful lives. A failed culvert can result in serious erosion, change a wetland, and cause traffic accidents or other property damage. However, when properly selected and installed, culverts protect Parks Canada's investments in infrastructure, protect fish spawning areas, and reduce the severity of intense weather events.

> "GIS is an effective management tool that has contributed greatly to the success of the culverts project facilitating the preparation and monitoring of interventions."

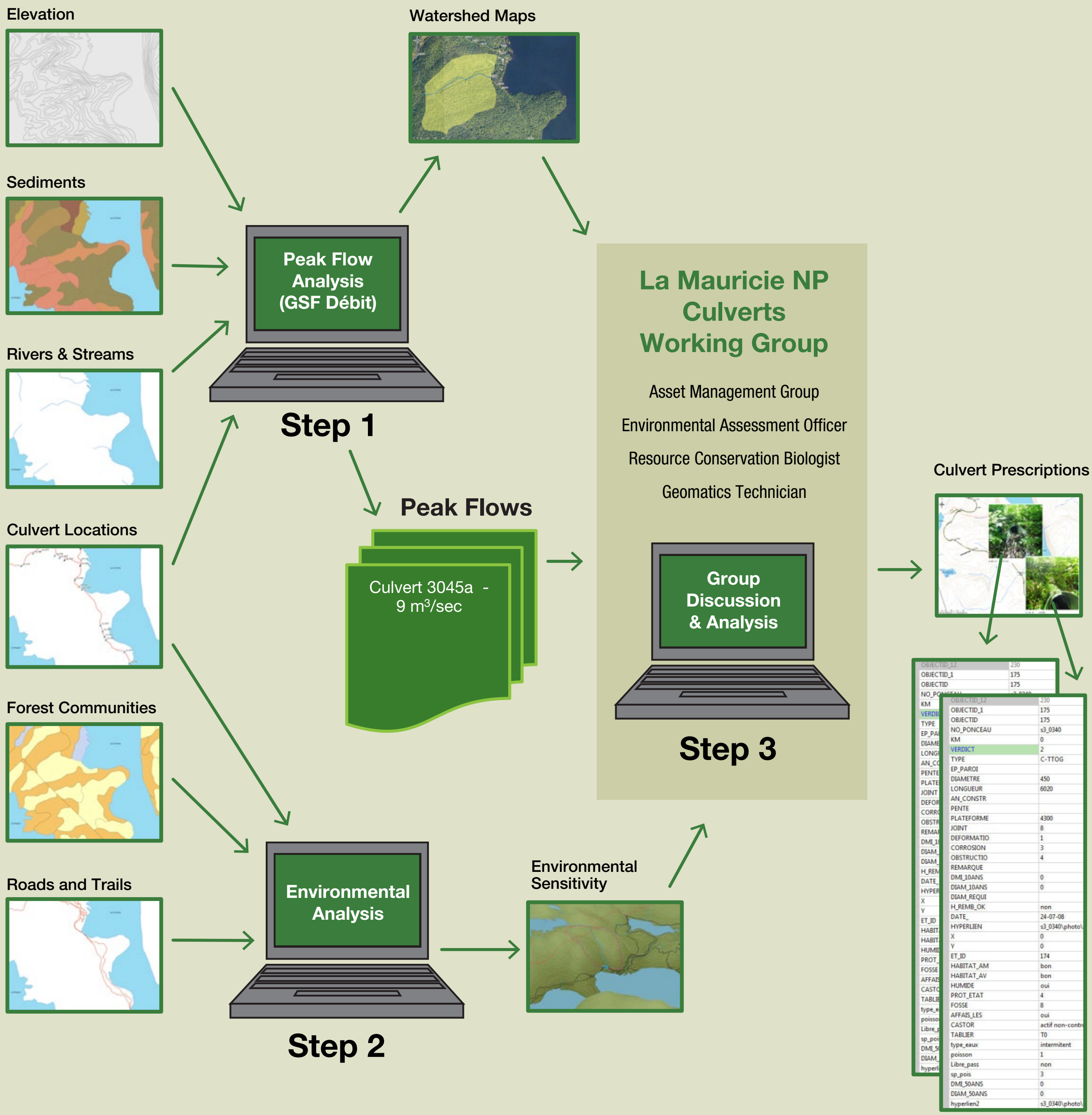
Chanhpasong Sayavongsa, Ing., Asset Manager, La Mauricie and Western Quebec Field Unit.
[quote translated from French]

Why Analyze Culvert Replacements?

Parks Canada cannot afford to install the biggest, most expensive culverts at every stream. In some locations, small culverts are sufficient while other locations need larger ones with more careful installation procedures. In determining which culvert goes where, one has to consider what is upstream, what is downstream, how wide the road is, and the traffic loads that the new culvert must support. For example, La Mauricie National Park now requires that each culvert handle peak water flows that are seen every 50 years. Previously, the standard was based on the 10-year peak, which explains why Park managers cannot simply replace an old culvert with a new one of the same size.

If not planned in advance, replacing a culvert can require several meetings and trips to the site by different team members. This costs the Agency time and fuel, and increases carbon emissions. Records need to be kept to help identify which culverts are ready for replacement, which replacements worked well, and which ones did not.

Figure 2: This flowchart shows how La Mauricie National Park uses GIS to improve the culvert replacement process. In Step 1, the GIS uses elevation and sediment data to estimate the 50-year peak water flow for each of the Park's 500 culverts. In Step 2, additional data on fish habitat and other environmental factors are used to identify environmental concerns. In Step 3, a working group uses the GIS information to determine how each culvert should be replaced. The result is a GIS application that can be queried and updated directly from the computers of the Asset and Resource Conservation Teams.



Étienne Creek in La Mauricie National Park. (Photo: J. Pleau, Parks Canada)

Culvert Analysis at La Mauricie National Park

In 2013, La Mauricie National Park formed a Working Group made up of members of the Asset Management group, an Environmental Assessment Officer, a Resource Conservation biologist and a Geomatics Technician. The group uses GIS to determine, in advance, how each culvert should be replaced, and which culverts are the top priorities for replacement. Their proactive approach has reduced the time and effort needed to make decisions, has standardized the process, and has established a system to monitor the environmental effects of each installation.

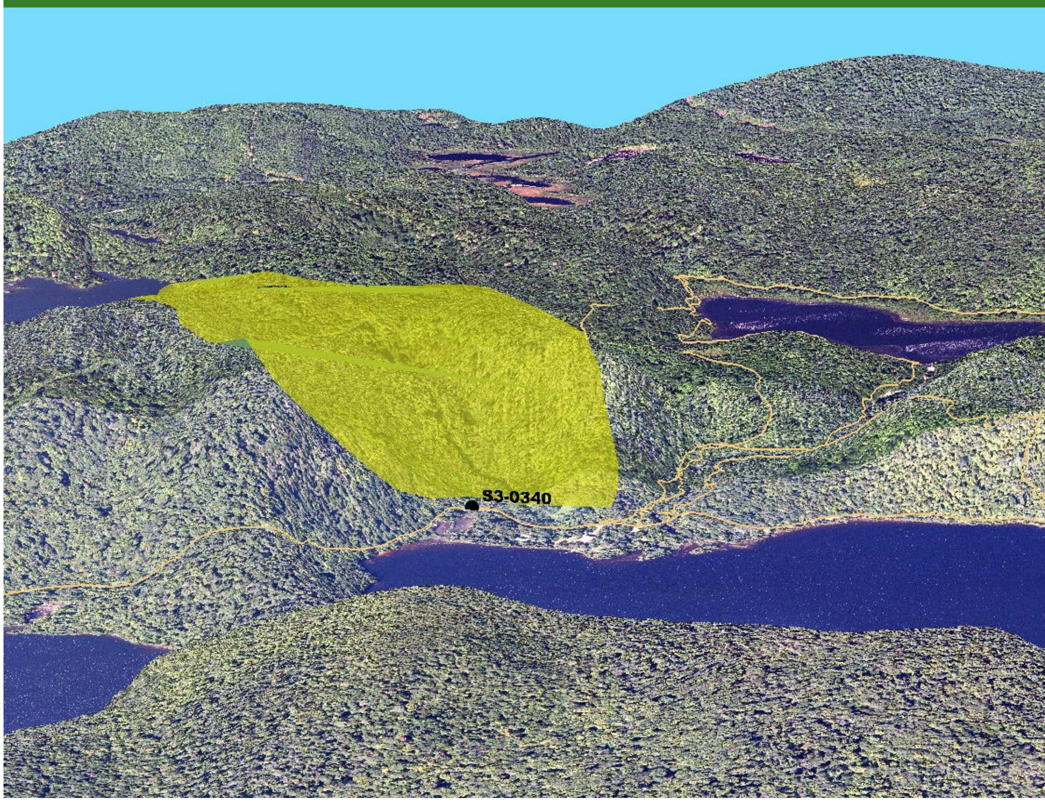
Figure 2 [flowchart] summarizes how the GIS supports the Working Group. To estimate flow-rate volumes, the GIS uses a special module (GSF Débit) which analyzes the watershed above the culvert (see *Figure 3*). The GIS also analyzes the locations of culverts, streams, fish habitat, roads and trails to help the Working Group identify environmental concerns that may not be apparent to managers standing at the culvert site.

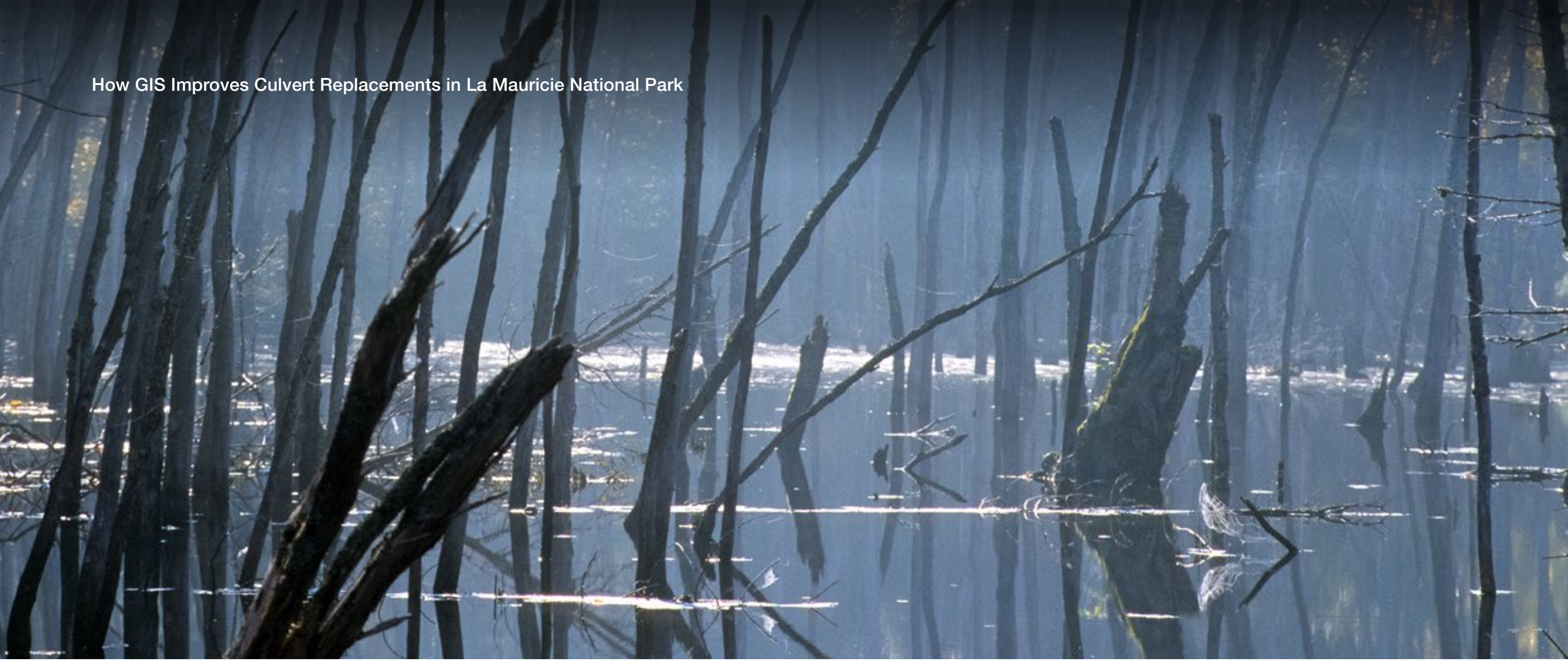
The Working Group's pre-planned approach is especially useful during emergency culvert replacements. From their desktops, Asset Managers can click on a GIS map and see which

> "Using GIS and data integration facilitate both conducting environmental assessments and monitoring as part of the Ecological Integrity Monitoring Program."

Denis Masse, Ecologist Team Leader, La Mauricie National Park.

Figure 3: Water flows for each culvert are based on the characteristics of the watershed above the culvert. This example shows a map of the watershed that drains through culvert # S3-0340.





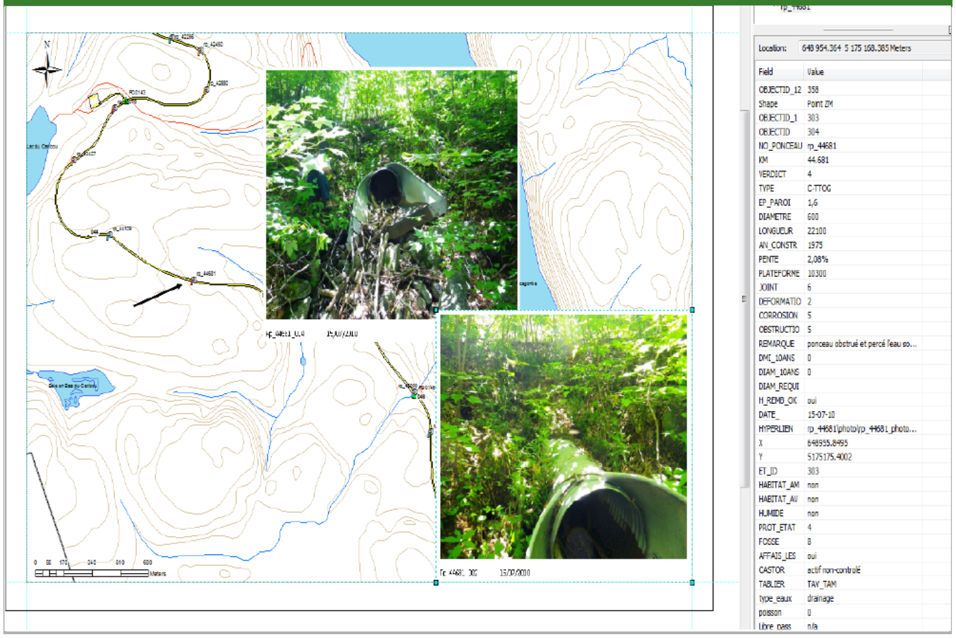
A marsh in La Mauricie National Park. (Photo: J. Pleau, Parks Canada)

culvert is required, and any additional mitigation that is required to protect the environment or safety. During non-emergency times, the GIS shows which culverts are top priorities for replacement. If, for example, other road work is being done in an area, the Park can see whether or not it makes sense to add a culvert replacement to the work order. *Figure 4* shows an example of what stakeholders see when they query the culvert database.

As part of this project, the park implemented a monitoring program to detect changes on aquatic ecosystems, notably on free passage of fish (aquatic connectivity) and sedimentation. This monitoring program also allows park management to evaluate the effectiveness of its actions, and the standards.

Figure 5: Yves Marcouiller inspects a failed culvert in La Mauricie National Park. When culverts become blocked or are too small to handle peak flows, the water erodes the gravel, creating a hazard to the public and sometimes covering fish spawning areas with sediments.

Figure 4: This screen shot shows what Asset Managers and other culvert stakeholders see when they access the GIS database from their desktops. By pointing and clicking on the map, any stakeholder can see the information about the culvert (shown in the list at the right) and photos of the culvert.



Outcomes

When culverts are replaced according to standards, the state of the environment is improved and the infrastructure is sustainable. The process of replacing a culvert at La Mauricie now requires fewer meetings and fewer site visits. *Figures 5–7* show an example of a problematic culvert that was replaced according to the Working Group specifications.

By being more confident that its decisions are correct, the Park can actually save money by not installing a culvert that greatly exceeds requirements. Other savings are expected to accrue over time from having to respond to fewer failures of recently replaced culverts.

Figure 6: The same site shown in *Figure 5* after culvert replacement that meets the Park's new 50-year peak flow standard. This culvert will be more resilient than the previous one; however, it is more expensive. This illustrates why it is important for the Park to determine the appropriate size of the new culvert.

Figure 7: La Mauricie's GIS Culvert Analysis Database shows additional environmental mitigations required at each culvert site. In this example, the large rocks were used to deter beavers from blocking the new culvert.

How GIS Helped

GIS helped the Working Group by performing analyses that would be too difficult for Park personnel to conduct for all 500 culverts. The simple point-and-click interface of the GIS enables operational staff to get the information they need, when they need it, without having to wait for a team of experts to assemble on site.

Enabling staff to update the GIS themselves improves information flow and helps Parks Canada relate funding spent at one geographic point to upstream and downstream effects on ecological integrity. In this way, the Park is able to relate financial accountability to environmental accountability.

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