Envision 2030: Geospatial Planning, Analytics, and Water Quality Monitoring Project for the Georgian Bay Geopark

A Global Planning Model for Regional Stewardship

The Challenge

The Georgian Bay Geopark represents one of Canada's most unique geological and ecological regions. It is under serious threat in the short and medium term.

The Georgian Bay Geopark including Georgian Bay, the North Channel, the contributing watersheds and Manitoulin Island, is commonly recognized as a unique and irreplaceable Canadian mosaic of landscapes, waters, ecosystems, and cultures. (See Annex 1. About the Region, for regional details). Often referred to as the Sixth Great Lake, the region sits entirely within Ontario's borders. The rapidly expanding Greater Toronto Area (GTA) has brought an unprecedented wave of seasonal visitors and ongoing permanent urban development. Compounding these factors are the ever-increasing effects of climate change and the potential loss of biodiversity that results from unplanned development. The region's communities and stakeholders are not prepared to manage these pressures to ensure a sustainable and resilient future.

To achieve resilient and sustainable development, communities ultimately rely on comprehensive geospatial and non-spatial data to understand how the ecological, biophysical, and human systems overlap and function seasonally and over longer periods. Such data can promote understanding of climate change, urban development, biodiversity loss, and the legacy of past industrial activity. The data can also help assess and model the effects of agriculture, forestry, fisheries, tourism, and mining to predict future conditions and facilitate successful proactive (versus reactive) planning and management. This is especially true regarding the long-term future of the Great Lakes and their communities.

Our current knowledge of the waters, lands, and watersheds of this region is limited. So too, our understanding of the many dimensions of human settlement in the region is riddled with fundamental data gaps. As a result, municipalities, townships, and Indigenous communities around the Bay are challenged to effectively plan for and manage population pressures, development initiatives, water quality and quantity issues, threats from potential biodiversity loss, and climate change. Local conservation groups and authorities such as Provincial and National Parks and the two UNESCO Biosphere Reserves in the area face specific challenges such as those described below:

1. **Fragmented geospatial data and planning efforts**: Local planning lacks a cohesive regional planning and knowledge base and perspective because of separate areas of focus within specific administrative boundaries.

2. **Inconsistent access to key geospatial data essential for planning**: Critical information on biodiversity, water quality, tourism, climate change assessments and resilience strategies, carbon stock, watershed health indicators, census data, and Indigenous knowledge is incomplete or inaccessible.

3. **Reactive versus proactive planning**: Limited planning capacity and expertise hinder the development of fully informed forward-looking strategies across administrative boundaries.

4. **Geospatial data gaps**: Typically, available datasets are inconsistent, incomplete, or siloed, especially related to Indigenous resources and knowledge and information about the water resources of Georgian Bay, the North Channel, and contributing watersheds.

5. **Lack of integration across stakeholders and rights holders**: Limited collaboration is apparent among counties, municipalities, First Nations, conservation groups, and stakeholders.

6. **Missed opportunities**: There is difficulty identifying and executing both local and multi-community, across-Georgian Bay regional initiatives.

The Project

Envision 2030: Geospatial Planning, Analytics, and Water Quality Monitoring Project for the Georgian Bay Geopark

Vision and Purpose

Establish a comprehensive, open-source geospatial data and analytics platform and planning framework and water quality monitoring project that will support all governments, communities, and stakeholders in proactively managing and preserving the region's natural and cultural mosaic while fostering resilient and sustainable economic growth.

The digital platform will make use of advanced scientific knowledge, contemporary geospatial data and analytic techniques, advanced water quality monitoring methods and approaches, Indigenous traditional knowledge and data, and community and citizen involvement to achieve a shared vision of socioeconomic and environmental stewardship and sustainable and resilient economic vitality.

The Project Initiators: The Georgian Bay Geopark and its Role

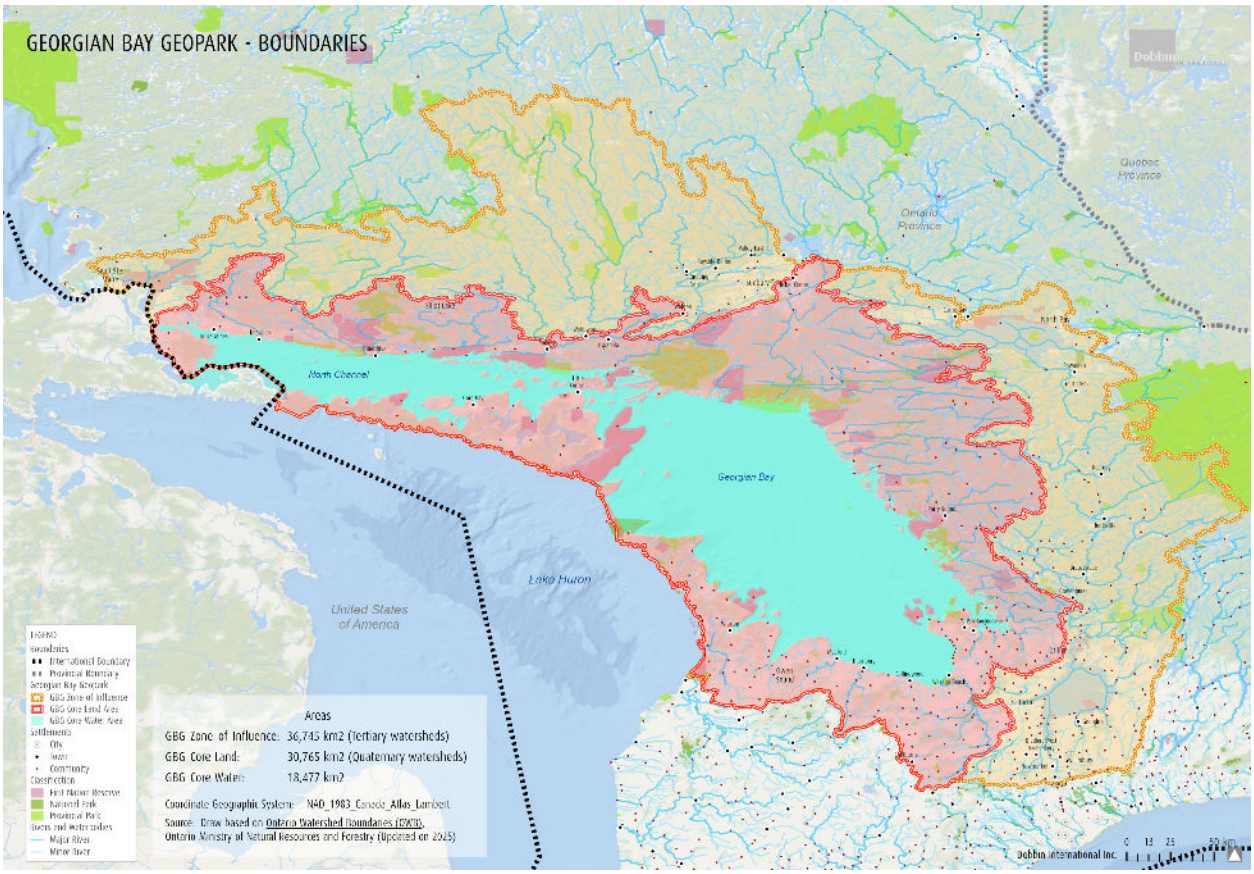
The geology of Georgian Bay is among the most varied anywhere in Canada. It records several events of global significance, such as—

- Oxygenation of the Earth's atmosphere 2.1 billion years ago
- A major meteorite impact at 1.8 billion years
- Various growth phases of the North American continent over the past 2.5 billion years
- Geologically recent glaciations
- A long history of cultural interaction with geology and landscapes over the past 11,000 years since the region's first settlements

This extraordinary record is the foundation for the recent establishment of the Georgian Bay Geopark (for eventual UNESCO designation). When formally designated by UNESCO, this site will be the largest (49,242 km^2) UNESCO Geopark in the world defined by natural land, river, and water boundaries. Of more than 220 UNESCO Global Geoparks located in 48 countries, 5 are in Canada. All are working together to protect geological, cultural, hydrological, and environmental heritage, putting in place measures to promote sustainable and resilient development. Global Geoparks have no legal restriction on title, development, or Indigenous lands or treaties and are intended to promote research, education, and sustainable social, economic, and environmental conservation and development. The Georgian Bay Geopark is an incorporated not for profit working toward UNESCO designation.

The creation of the Georgian Bay Geopark creates a regionally coherent framework for investigating the Bay and its ecosystems/watersheds in their entirety, both onshore and offshore, employing a wide array of modern biophysical, geophysical, and geochemical autonomous monitoring and various remote sensing techniques. The boundaries of the park were defined specifically to incorporate the surrounding tertiary and quaternary catchments (watersheds) to permit data collection at a meaningful regional scale (see Figure 1). The regional boundaries of the larger Georgian Bay project area (zone of influence) cover approximately 85,987 km^2 representing a distinct, coherent, natural, ecoregion that includes all the waters that drain into Georgian Bay and the North Channel. A project of this magnitude is exceptional in Canada and a potential template for systematic investigations of other Great Lake Basins and their watersheds.

Figure 1. Georgian Bay Geopark: Boundaries



Georgian Bay Geopark: Zone of Influence – Orange Area

The **orange boundary line** is defined by the tertiary (third-level) watershed as defined by the Ontario Ministry of Natural Resources and Forestry. This area includes all the rivers in the tertiary watershed that drain into Georgian Bay, the North Channel, **and Lake Huron.** This is the zone of influence where all activities and actions have a direct and indirect impact on Georgian Bay and the North Channel. This tertiary catchment region also defines the broader areas of First Nations' historic use and activities for the last 10,000–13,000 years (annual migrations inland for winter hunting). It also closely resembles the boundaries of the ancient geological lake—Lake Algonquin—which covered Georgian Bay and the North Channel 13,000 years ago, the predecessor of the current Georgian Bay and Lake Huron.

Georgian Bay Geopark: Core Land & Water Area – Red Area and Light Blue Waters

The **red boundary line** is defined by the quaternary (fourth-level) watershed as defined by the Ontario Ministry of Natural Resources and Forestry. This area includes all the rivers and small quaternary sub catchments located directly or indirectly facing onto Georgian Bay and/or the North Channel and flowing into only Georgian Bay and the North Channel (not including Lake Huron). This is the core area of the Georgian Bay Geopark. The quaternary catchment includes First Nation Reserves, upper-tier municipalities, districts, municipalities, townships, national parks, provincial parks, sub catchments, main towns and

cities, environmentally sensitive areas, wetlands, and areas of high biodiversity, to mention a few themes that currently exist in the Georgian Bay Geopark geospatial database.

Project Details

The project is divided into two phases:

Phase 1: Geospatial Planning and Analytics for the Georgian Bay Geopark

Phase 1 will—

- Provide an integrated digital platform and geospatial database and analytics for data-driven and scientifically based decision-making across the region.
- Integrate Indigenous traditional knowledge within the geospatial database, analytics, and planning.
- Align with the United Nations Declaration on the Rights of Indigenous Peoples (known as UNDRIP), the First Nation Principles of OCAP (ownership, control, access, and possession), and the 17 United Nations Sustainable Development Goals.
- Establish the foundation and framework for Phase 2 that focuses on the water quality monitoring programme for the region and other future research and spatial planning initiatives.

Phase 1 details are described below - See Annex 2: Phase 1, Comprehensive Geospatial Planning, Analytic Framework, and Spatial Planning for the Georgian Bay Geopark and Annex 3: Existing Georgian Bay Geopark Geospatial Database.

Phase 2: Permanent Water Quality Monitoring System and Assessment for the Georgian Bay Geopark

Phase 2 will -

- Leading Ministries and NGOs are developing essential research on Georgian Bay and its waters. The project would collaborate with these organizations and together establish an enhanced, integrated, and comprehensive science-based framework for the waters of Georgian Bay, the North Channel, and contributing river basins and watersheds.
- Conduct regional-scale characterization of water quality and seasonal changes in flow, temperature, and quality in all these settings, both onshore and offshore, through installation of permanent monitoring stations to measure short-term events (e.g., storms) and seasonal and long-term geochemical fluctuations.
- The role that fractured rocks play in contributing groundwater to Georgian Bay is poorly known but likely very important in areas of Shield terrain along the north and eastern coast, and from fractured limestones to the west.
- The nature of groundwater flows from the thick glacial sediments that plug the southern end of the Bay is also not well known but fundamental to water quality in the Bay, especially from urbanized catchments and from agriculture.

Phase 2 details are described below. See Annex 4: Phase 2: Comprehensive Permanent Water Quality Monitoring System and Assessment for the Georgian Bay Geopark.

Phase 1: Goals and Outcomes - Geospatial Planning and Analytics for the Georgian Bay Geopark

What the Initiative Will Enable

- **Identification of Key Assets**
  - Detailed geological mapping/analytics of shorelines and watersheds
  - Biodiversity hotspots
  - Ecological corridors/gaps
  - Water sources, groundwater recharge, and tributary hotspots
  - Indigenous and non-Indigenous cultural/historic sites
  - Carbon sequestration zones
  - Watershed health assessments
  - Long-term flood zones

- **Support Programs and Projects**
  - Comprehensive engagement/collaboration with Indigenous communities
  - Indigenous coastal guardian programs
  - Conservation-focused tourism, including geotourism, ecotourism, Indigenous tourism
  - Economic development aligned with sustainability goals
  - Data-driven flood management and environmental resilience planning
  - Climate-smart planning guidelines

What are the Benefits to Stakeholders?

- **Municipalities, counties, and First Nations**: Centralized geospatial database for regional-, and watershed-based land-use planning, economic development, and growth management
- **Indigenous communities**: Tools for cultural mapping, traditional knowledge integration, and territory stewardship
- **Conservation and parks authorities**: Enhanced knowledge and modeling for biodiversity protection, ecosystem management and preservation, improved efficiency in the planning process
- **Businesses and tourism operators**: Insights for development, planning, and monitoring of conservation-based tourism and sustainable growth opportunities

Why this Strategic Spatial Planning Approach?

The initiative applies globally proven spatial development planning approaches and methodologies using advanced geospatial tools and multi-sector and multi-thematic analysis at a regional level. Efforts will be grounded in collaboration and informed by local, regional, and international data sources and research. The initiative will include an early and ongoing engagement process with Indigenous communities documenting existing, Indigenous community planning processes, and traditional knowledge.

What Are the Key Components?

1. **Fully develop an integrated geospatial and non-spatial data platform (a "digital twin" of Georgian Bay Geopark)**: A comprehensive, interactive system with unparalleled access to biophysical, socioeconomic, cultural, geological geospatial and non-spatial data and analyses including—
   - Biophysical natural boundaries
   - New global datasets potentially from Esri (USA & Canada), the National Aeronautics and Space Administration (NASA), the International Joint Commission, and others

- Detailed light detection and ranging (LiDAR) imagery, geological analysis of shorelines and watersheds
- NASA Global Ecosystem Dynamics Investigation (GEDI) data on carbon stocks, forest health and height, and trends
- Sensitive environmental areas
- Traditional Indigenous knowledge
- Economic and tourism data
- Flood zones and climate projections
- Identify potential ecological corridors
- Climate change scenarios

2. **Complete ecosystem planning and analysis of the land and watersheds of Georgian Bay and the North Channel** using multispectral satellite imagery such as Sentinel II imagery and drone-based 5 cm resolution LiDAR (from NASA and others), incorporating existing data on floral and faunal species. Watershed (catchment) evaluations for 67,510 km^2 land area including—
   - Environmental Sensitivity Index, watershed health assessment
   - Watershed vulnerability
   - Impervious surface ratio
   - Habitat fragmentation ratio
   - Watershed integrity
   - Watershed naturalness (percentage of vegetative cover)
   - Watershed carbon sequestration and carbon stock (NASA data)
   - Up-to-date high-resolution Land Use and Land Cover (known as LULC), including various categories of land use and land cover including wetlands, forest types, lakes, rivers, and streams
   - Percent (%) shield, limestone, and/or glacial deposits; soil permeability
   - Economic activity, land uses, and land cover analysis with 5 cm resolution LiDAR and Sentinel 2 satellite imagery
   - Environmental quality indicators (points and areas), including pollution sources, discharges, nutrient loading, heavy metal discharges, organic discharges, etc.)

3. **Complete aquatic ecosystem and physical processes planning and analysis of the waters of Georgian Bay and the North Channel** (18,477 km^2 water area) including—
   - Currents, upwellings, water temperatures, ice coverage; time series
   - Water levels; time series
   - Water flows
   - Distribution and life history of living aquatic resources: invertebrates, fishes, reptiles, mammals
   - Delineation of critical aquatic habitats (shallow waters, wetlands, etc.) and "aquatic spatial zoning"

4. **Undertake climate change assessments and analyses to determine trends in the Georgian Bay Geopark to 2050, and prepare climate-smart planning, adaptation. and resilience strategies.**

5. **Collaborative Framework**
   - Establish working groups with representation from First Nations, municipalities, conservation authorities, and Federal/provincial agencies.
   - Facilitate knowledge sharing and consensus-building.

6. **Capacity building**: Establish training programs for local and Indigenous leaders to use data and tools for effective planning.

Who Are the Implementation Partners?

Over the last 36 months, Dobbin International and founder and regional planner, Canadian James Dobbin, in collaboration with leading geologists at the University of Toronto and the Georgian Bay Geopark Spatial Planning and Analytics Working Group and the Indigenous Working Group, have developed an initial geospatial database. The group has assessed the needs of the region, laid the groundwork and established key relationships for this initiative. Phase 1 of the project will be led by Dobbin International, in collaboration with leading geologists at the University of Toronto, working potentially with various institutions and agencies in Canada and the United States:

- Parks Canada: Ecological Corridors, the Ontario Ministry of Natural Resources (MNRF), Environment and Climate Change Canada, the Great Lakes Ecosystem Management, the International Joint Commission, the Council of the Great Lakes Region, and others
- Anishinabek Nation, Huron-Wendat Nation and other Indigenous Organizations/Institutions.
- NASA GEDI Program, the Canadian Space Agency, and the Royal Canadian Geographic Society
- Esri USA and Canada with possible access and integration of their geospatial datasets into the Georgian Bay Geopark's existing and developing geospatial database for planning and analysis, including their (1) Globalization Action Model, Esri's ArcGIS Living Atlas of the World; (2) Esri's Global Carbon Assessment; and (3) United States Geological Survey and Esri's "Probability of Ecological and Land Use Change by 2050"
- University of Guelph, Biology Department (e-DNA assessments)

What Is the Proposed Timeline?

1. **Year 1**: Establish partnerships, secure funding, undertake workshops with partners and communities, initiate digital platform development, and initiate additional regional data compilation and analytics.
2. **Years 2–3**: Conduct additional data collection, integration; continue geospatial analyses at the Georgian Bay regional level; and undertake pilot projects in key regions (local level).
3. **Year 4**: Continue to expand regional-level database and analyses as needed for Geopark planning and management. Expand pilot projects and implement across all counties, First Nations, and conservation areas.
4. **Year 5**: Evaluate success and refine tools for long-term sustainability and planning.

Conclusion and Call to Action

The Georgian Bay Geopark is an irreplaceable Canadian mosaic of landscapes, waters, ecosystems, and cultures. Through this collaborative initiative and the support of government and major funders, we can address sustainable and resilient approaches to managing the entire mosaic and each of its unique communities and stakeholders. This initiative will serve as a model for holistic ecoregional planning, blending traditional Indigenous and scientific knowledge with community and citizen involvement to achieve a shared vision of environmental conservation and sustainable and resilient conservation and development.

We invite your organization to join us in bringing this vision to life. Together, we can protect one of Canada's most treasured landscapes while fostering a vibrant, sustainable future.

Contacts

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- James Dobbin, President & CEO, Dobbin International; Lead, Georgian Bay Geopark Spatial Planning and Analytics Working Group.
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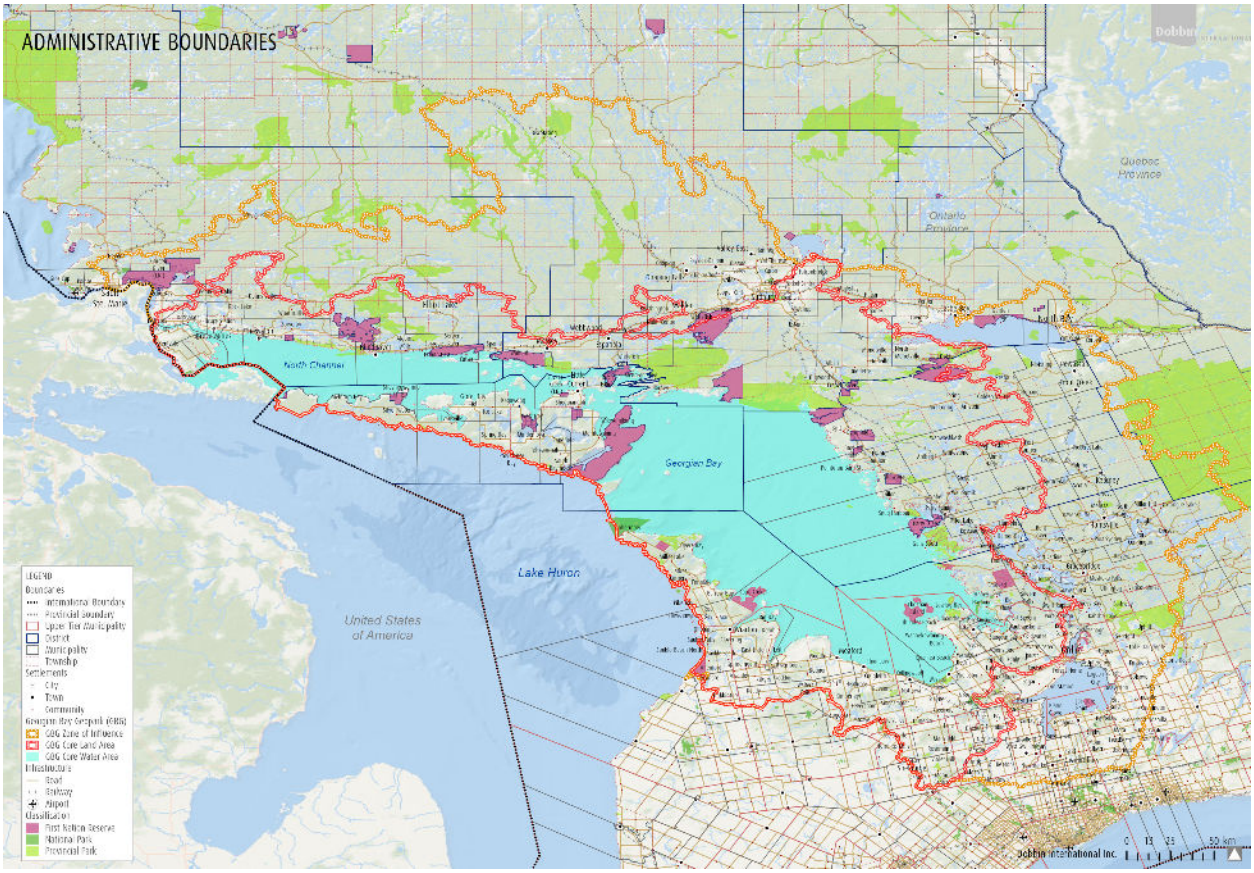
Annex 1. About the Region

- 49,242 km^2 including the waters and near watershed of Georgian Bay, Manitoulin Island, and the North Channel—larger than Vancouver Island and Haida Guia combined
- Globally significant geological heritage spanning 3 billion years
- A unique mosaic of biological, ecological, and human diversity
- The most biodiverse ecosystems in eastern Canada
- Deep and varied history and culture dating back 13,000 years
- Over 400,000 residents (permanent and seasonal) across 8 counties and districts, 33 municipalities
- 41 First Nations in 11 treaty territories
- Adjacent to 10 million people in the GTA/Golden Horseshoe, projected to grow to 15 million by 2051
- Canada's greatest concentration of parks and conservation groups: 12 provincial and 2 national parks, 5 major land trusts, 2 UNESCO Biospheres, 500+ Areas of Natural and Scientific Interest (ANSIs), and 10 major conservation authorities

Figure 2. Administrative Boundaries



Annex 2: Phase 1: Geospatial Planning and Analytics for the Georgian Bay Geopark

The planning and management of the Georgian Bay Geopark requires a vast wealth of scientific knowledge that can be successfully compiled, organized, and managed using a Geographical Information System (GIS). A pragmatic GIS database is essential to fostering the suitable governance of the 49,242 km^2 Georgian Bay Geopark (and the 85,987 km^2 Georgian Bay Geopark including the "Georgian Bay Geopark Zone of Influence"). The geospatial database is currently structured with over 100 thematic "layers" (coverages) compiled from public sources and previous works or produced through traditional mapping (interpretation of satellite imagery) and GIS tools.

The existing thematic maps in the geodatabase illustrate the broad range of geographic information already in the GIS database. Among them, 60 basic maps provide an overview of the Geopark (what's there), and 40 new maps focus on crosscutting and technical issues. All maps illustrate the potential of GIS to create new insights and issues by combining coverages and adapting to their purpose and audience. The geospatial and non-spatial database facilitates the suitable publishing of consistent outputs (e.g., online dashboards, brochures, books, panels, webpages, posters, postcards, web servers) and the elaboration of technical data to assist in the Geopark's long-term planning and management.

The database furnishes information to support the analysis and design of education actions, touristic routes, activities, and Geopark facilities. The GIS database is also a supportive tool for scientific research and provides the necessary knowledge to conduct geo-conservation actions based on land use and watershed health indicators, identifying environmentally sensitive areas, identify headwaters (water sources) of the Geopark, important areas to protect carbon stock, areas impacted by climate change, geological hazards, water availability, and the occurrence of natural and cultural heritages. Altogether, the GIS database constitutes a powerful dynamic instrument for policymaking and ecoregional planning, facilitating the identification and evaluation of alternative strategy plans for the Geopark and all the stakeholders in the Georgian Bay Geopark Region.

Empower national, provincial, and local governments, First Nation Governments, conservation organizations, and businesses with knowledge and tools for proactive planning for the sustainable and resilient future of the Georgian Bay Geopark Region.

Annex 3: Existing Georgian Bay Geopark Geospatial Database

The existing Georgian Bay Geospatial Database has approximately 100 thematic "layers" of geospatial data in Esri Arc GIS formats organized in similar format as those of the National Oceanic and Atmospheric Administration's (NOAA) strategic coastal and ocean assessments for all the U.S. Exclusive Economic Zones and coastal counties prepared by Dobbin International for NOAA (references available).

1. Administrative Boundaries
   - First Nations Treaties
   - First Nations Reserves
   - International, provincial, municipal
   - Urban towns
   - Ontario Conservation Authority Boundaries, watersheds

2. Base Maps
   - Ontario
   - Niagara Falls to Manitoulin Island
   - Georgian Bay including North Channel
   - Georgian Bay not including North Channel
   - Manitoulin Island and North Channel (Zoom)

3. Biophysical Boundaries
   - Ministry of Natural Resources and Forestry (MNRF), Catchments 1, 2, 3, 4
   - MNRF, Aquatic Ecosystems
   - MNRF, Ontario Conservation Authorities, Watersheds
   - Nature Conservancy Canada (NCC) Coastal Environmental Index Regions
   - NCC, Georgian Bay Islands
   - Parks Canada, Terrestrial Regions
   - Parks Canada, Marine Regions

4. Environmentally Sensitive Areas
   - MNRF, Areas of Natural and Scientific Interest (ANSIs)
   - MNRF, Cold Water Fisheries
   - Niagara Escarpment Commission (NEC), Niagara Escarpment
   - NCC, Critical Bird Habitats
   - NCC, Coastal Type
   - ANSIs

5. Geology and Geomorphology
   - Basic Geology
   - University of Toronto Geosites/Geoplaces (Georgian Bay Geopark Places)
   - Geomorphology: Niagara Escarpment
   - Georgian Bay Islands
   - NCC, Shallow Water Habitats

6. Cultural Heritage
   - First Nation Treaties
   - Metis Treaties

- Indigenous Cultural Heritage Sites
- Non-Indigenous Cultural Heritage Sites
- Metis Cultural Heritage Sites
- Colonial Cultural Heritage Sites
- Historic Sites

7. Infrastructure
   - Airports: 1, 2, 3
   - Shipping Routes
   - Lighthouses
   - Ports: Commercial and Fishing
   - Railroads
   - Roads: 1, 2, 3

8. Protected Areas
   - National
   - Provincial
   - Provincial Crown Lands
   - Areas Considered for Protective Status

9. Rivers and Waterbodies
   - Main Rivers (first order)
   - Secondary Rivers (second order)
   - Tertiary (third order)
   - Lakes, Bays, Channels, and Rivers
   - Water Flows

10. Topography and Elevation
    - Bathymetry: Marine
    - Topography: Terrestrial

11. Tourism and Ecotourism
    - Regional Touirsm Organizations
    - Bruce Trail
    - Ganaraska Trail
    - Sailing Routes, Kayak Routes
    - Marinas
    - Public Access to Georgian Bay

12. UNESCO Sites
    - Georgian Bay Biosphere Reserve
    - Niagara Escarpment Biosphere Reserve

13. Canadian Census: 2023

Annex 4: Phase 2: Permanent Water Quality Monitoring System and Assessment for the Georgian Bay Geopark

Highlights of the Waters of the Georgian Bay Geopark

Georgian Bay (and the North Channel) is known as the 6th Great Lake (18,477 km^2), equivalent to the size of Lake Ontario (18,960 km^2), and the 14th largest freshwater lake in the world, with a coastline of 3,005 km. It is surrounded to the north and east by crystalline Precambrian rocks of the Canadian Shield and to the west by Paleozoic cover rocks, principally limestones, which along its southern margins are covered by thick glacial sediments left by the last ice sheet. This geodiversity gives rise to a very wide range of landscapes, watershed types, and ecosystems. The latter have been long studied on the scale of individual watersheds or lakes, some of which are pristine, others heavily urbanized or occupied by resorts and cottages (e.g., Seguin, Muskoka, Silver Creek, Beaver, Nottawasaga rivers). All this development contributes urban-impacted waters to the Bay.

The open water conditions along the western and southern coastal margins of the Bay contrast with the many enclosed bays and inlets of the island archipelago of its eastern shore with its many wetlands. In total, Georgian Bay contains 30,000–90,000 islands and shoals, making it the largest freshwater archipelago in the world. The Bay also boasts the longest freshwater beach in the world (Wasaga Beach) and the world's largest freshwater island (Manitoulin Island). The large-scale circulation patterns in the Bay and the role of islands in heating inflowing waters from Lake Huron are superficially known. Variation in temperatures with depth are key to aquatic ecosystems in the Bay but have not been studied Bay-wide.

Envision 2030 - Phase 2: Permanent Water Quality Monitoring System and Assessment for the Georgian Bay Geopark

Leading Ministries and NGOs have conducted essential research on Georgian Bay and its waters and continue to do so. Such organizations include Fisheries and Oceans, Environment Canada, the Ontario Ministry of Natural Resources and Forestry, First Nation communities and Metis Councils, the Georgian Bay Land Trust, Severn Sound Environmental Association, Georgian Bay Forever, and the Nature Conservancy Canada. The intention of this initiative is to collaborate with these organizations and together establish an enhanced, integrated, and comprehensive science-based water quality monitoring framework for all Georgian Bay.

Regional-scale characterization of water quality and seasonal changes in flow, temperature, and quality in all these onshore and offshore settings can be achieved by installation of permanent monitoring stations to measure short-term events (e.g., storms) and seasonal and long-term geochemical fluctuations. The role that fractured rocks play in contributing groundwater to Georgian Bay is poorly known but likely very important in areas of Shield terrain along the north and eastern coast, and from fractured limestones to the west. In this regard, the nature of groundwater flows from the thick glacial sediments that plug the southern end of the Bay are also not well known, but the information is fundamental to understanding water quality in the Bay, especially from urbanized catchments or from agricultural lands.

Regional-scale water circulation patterns in Georgian Bay (the open bay and among the eastern archipelago) and measurement of water quality at various depths in the water column can be monitored

from fixed buoys or free-floating monitors as used for autonomous observations in ocean waters, such as NOAA's Argo program.

Much remains to be learned of the offshore bathymetry of the Bay and its lake floor geology, especially the postglacial history of environmental changes over the last 10,000 years contained in pollen and micro-organisms preserved in sediments below its floor. Work to date has revealed a phase of low water level around 7,000 years ago, when much of the Bay floor was exposed (the Lake Hough phase) because of regional climate warming and much-reduced seasonal runoff. It is possibly a guide to future water levels in the face of ongoing climate warming across the Great Lakes.

The Bay-wide impact of this major event can be achieved through a comprehensive geophysical program of sub-bottom profiling using magnetic and high-resolution seismic reflection techniques and side-scan sonar. This would identify the environmental history of the Bay since deglaciation 10,000 years ago and key areas for follow-up retrieval of sediments by coring. In turn, this information is key to better understanding of the history of Indigenous cultures that have occupied Georgian Bay over the past 11,000 years.

Available mapping, using emerging LiDAR (Light Detection and Ranging) techniques by drones and satellites, combined with other multispectral remote sending imagery such as Sentinel II (10m resolution) satellite imagery, can be expanded around the landward margins and catchments of the Bay to map, classify landscape, and assess the compositional structure of forest and other habitats, and assess changes in above ground biomass, carbon storage on different timescales.

These same geophysical techniques will expand knowledge of existing archaeological sites, aid the search for others, and illuminate the changing history of environmental use by Indigenous cultures. The information will be combined with data regarding offshore aquatic ecosystems and physical processes of Georgian Bay and the North Channel (currents, upwellings, water temperatures, ice coverage, etc.), living aquatic resources, (invertebrates, fishes, reptiles, mammals), economic activity, environmental quality (including pollution sources, discharges, nutrient loading, heavy metal discharges, organic discharges, etc.) to identify critical sites, areas, and watersheds and river basins for water quality control and management.

Objectives of Phase 2: Permanent Water Quality Monitoring System and Assessment for the Georgian Bay Geopark

The Board of the Georgian Bay Geopark seeks substantial funding to permit a comprehensive evaluation, using current and emerging environmental technologies, to develop Phase 2 of the Envision Project: This innovative and ambitious project would have the following objectives:

1. Establish a comprehensive and permanent surface water monitoring system in principal catchments and rivers (river basins) flowing into Georgian Bay from watersheds underlain by (a) Shield, (b) limestone, and (c) glacial sediments. Monitoring sites would be in headwaters and downstream to capture the impact of urbanization, farming, and agriculture on water quality and assess the effects of extreme weather events and climate warming.
2. Establish a comprehensive monitoring system for assessing seasonal variation in water quality in the inshore waters of Georgian Bay close to the mouths of major rivers assessed in Objective 1 above. This work would also include assessment of waters entering and leaving the Bay from Lake Huron principally through the Main Channel.
3. Complete a comprehensive assessment of the offshore geology of the Bay using boat-based geophysics (seismic reflection, side scan sonar, etc.). This effort would be complemented by a program of coring of offshore sediments and laboratory investigations to understand postglacial climate history.
4. As part of this process, an Environmental Sensitivity Index prepared in Phase 1 at a detailed catchment level could be created using the variables listed above (and more) to understand (1) the relationships among different factors and water quality and (2) which areas are most important for protecting or improving the water quality of the Bay. This work should help planners prioritize geographically and understand which interventions will achieve the most "return on investment."
5. Establish a network of coastal guardians and "river keepers" from First Nation communities and others in identified catchments supported by training programs. With an Environment Sensitivity index for watersheds, there is an opportunity to include First Nation communities as stakeholders and build cultural value of different sites and areas into the index/prioritization as much as possible.
6. Establish a comprehensive "open access" geo-biophysical (environmental) GIS geospatial database and pollution monitoring data for acquisition, processing, mapping, analysis, spatial planning, and visualization of all data and findings on the digital platform developed in Phase 1.
7. Recommend an action plan for watershed and coastal pollution monitoring network and management strategies for critical sites and catchments. There are some opportunities to make use of ArcGIS Online technology to support ongoing monitoring efforts, helping track progress toward the water quality goals. For example, see building interactive maps/dashboard that help track progress (https://experience.arcgis.com/experience/7de6d4040ce1435e9994cff1800970f7/).
8. We will draw on the intellectual wealth of the First Nations Knowledge Keepers and the University of Toronto scientists seeking transdisciplinary expertise from such disciplines as environmental science, earth science, physical geography, urban and regional planning, landscape architecture, water studies, social sciences, computer and environmental engineering, biology and ecology, forestry, physics, and others. We see the training of a new generation of environmental scientists and planners as a priority, drawing on and collaborating with the various communities around the Bay, settler, Francophone, Metis, and First Nations. We are especially interested in adopting a "two-eyed seeing" approach with Indigenous partners to incorporate and benefit from Indigenous knowledge keepers' knowledge, experience, and insights.

Who Are the Implementation Partners?

Phase 2 of the Envision Project will be led by Dobbin International in collaboration with leading geologists from the University of Toronto, in association with the following potential organizations:

- Parks Canada, Ontario MNRF, Environment and Climate Change Canada, Great Lakes Ecosystem Management, the International Joint Commission, the Council of the Great Lakes Region, and others.
- Anishinabek Nation, Huron-Wendat Nation and other Indigenous Organizations/Institutions
- NASA GEDI Program (Satellite-based LiDAR ecosystems research. In discussions regarding access to forest height, canopy cover, and carbon products data for the Zone of Influence regions of Georgian Bay), Canadian Space Agency, and Royal Canadian Geographic Society
- Esri USA and Canada with possible access and integration of their geospatial datasets into the Georgian Bay Geopark's existing and developing geospatial database for planning and analysis, including their (1) Globalization Action Model, Esri's ArcGIS Living Atlas of the World; (2) Esri's Global Carbon Assessment; and (3) USGS and Esri's "Probability of Ecological and Land Use Change by 2050."

The core working group will also include the Georgian Bay Geopark's Geological Working Group, Indigenous Working Group, and the Spatial Planning and Analytics Working Group:

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