Executive Summary
The proposed Integrated Assessment (the “Project”) attempts to combine two innovative methodologies/technologies (Transformative Scenario Planning \(^1\) (TSP) and enhanced visualization tools) to support stakeholders from a community (Collingwood, ON) in collaborating in the development of effective adaptive strategies for enhancing the resilience of its shoreline in the face of extreme water level events.

The key criteria for Project success which were unknown going into the Phase 1 exploratory phase of this Integrated Assessment were:

1. Relevance/appropriateness of REOS Partners’ TSP methodology as a convening/mediating process for shoreline planning in a Collingwood community context;
2. Readiness/interest of Collingwood as a community to participate in a TSP-based stakeholder engagement process targeting long-term shoreline plans;
3. Cost/feasibility of creating a shoreline-specific version of University of PEI’s “Coastal Impact Visualization Environment” (CLIVE);
4. Data availability/adequacy to support the CLIVE deployment;
5. Cost/timing considerations in carrying out the proposed Project.

The exploratory phase analysis succeeded in addressing these five issues. The results of the analysis suggests that:

- The TSP process seems very relevant for the Collingwood setting. The community representatives that the Project team met with would be interested in participating. Such a process would fit well into the context of the Town’s plan to complete a long-term shoreline planning process in the next 12-18 months (although if we cannot fit into this timeframe, potential participants may be less interested given that the Town’s formal plan might be completed prior to our getting started);
- Technical challenges associated with creation of a shoreline-specific version of CLIVE for Collingwood are addressable at reasonable time (1 month) and cost (C$30,000-C$35,000);
- Terrestrial elevation data along the shoreline is available to the Project team, but only with 1m contours, which is less than ideal. Collection of new sufficiently detailed data for the Collingwood area would be possible using an unmanned aerial vehicle owned by one of the Project partners, but it would take the summer of 2016 and cost C$35,000- C$40,000;
- Ortho-imagery and land parcel data for the shoreline is available to the Project team under reasonable conditions, timing and cost;
- Reasonable cost, timely availability of bathymetry data for the Collingwood shoreline – hoped to be sourced from a 2013-4 LiDAR project sponsored by the Canadian Hydrographic

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\(^1\) The process referred to in this report is more extensively laid out in Adam Kahane, *Transformative Scenario Planning*, (San Francisco: Berrett-Koehler Publishers, Inc., 2012).
Survey - is unlikely. Although the dataset is not yet available for direct assessment by external parties (despite promises that it would be so), early indications from government contacts that have examined it are that the quality is inadequate to support Project objectives. Floating ice apparently left significant gaps in coverage of the nearshore. Alternative means of generating this data are available, but at an extra cost of C$35,000 – C$40,000, and data acquisition and processing would likely require much of 2016;

- An overall go-forward budget for the Project (as currently conceived) of C$420,000 – C$515,000 represents a fund-raising challenge. The cost associated with REOS’ work turns out to be substantially more expensive than originally anticipated (it might be negotiable downwards somewhat if/when the prospects for Phase 2 gain momentum). While this amount could be raised given sufficient time, the fact that a Canadian federal election is in progress will make it challenging to secure this funding in the timeframe proposed for a Phase 2 RFP.

- Depending on Graham Sustainability Institute’s (“Graham’s”) willingness to consider modifications to the original Project, several substantial scope reductions could be explored to bring the Project into a more fundable format. An example might be to focus on developing CLIVE for the Collingwood shoreline, and then to partner with the Town of Collingwood to experiment with using CLIVE as a tool to engage their citizens in the Town-sponsored long-term shoreline planning process they plan to carry out in 2016.

Summary of Project Workplan
The Project team divided up the work to be completed during Phase 1 into four components that corresponded roughly to the open questions to be answered, and to the expertise of the four Project partners.

- Suitability of TSP process to Collingwood – REOS Partners (“REOS’”). Ontario Water Centre (“OWC”) worked through its local relationships to set up in-person interviews for REOS in Collingwood during several days in June, 2015 with a broad range of stakeholder representatives. The list of 16 interviewees are set forth in the body of this document and the list of questions used set forth in Appendix A. Interviewees were given an overview of the Project and partners, given a chance to ask questions, and assured that while they would be listed in any project report as having been interviewed, and quotes might be included, none of what they said would be attributed to them. The Project team would simply integrate their responses with others to derive a sense of whether a TSP-based process would be suited to the Collingwood context. All interviewees were comfortable with these assurances. Interviews lasted approximately an hour each, with the REOS consultant creating transcripts that were then used by REOS to compile a report attached at Appendix A hereto summarizing emergent themes and including unattributed verbatim quotes to provide qualitative context. Based on these interviews and discussion between REOS and OWC, REOS prepared an estimated budget and project timetable to carry out a full TSP-based engagement during Phase 2 of the Project.

- Availability of existing data – Nottawasaga Valley Conservation Authority (“NVCA”). After having been briefed by Project partners on the nature of the datasets required to support a modification of CLIVE for Collingwood, NVCA undertook a search and review of the potential sources for this data. NVCA’s report of their work and outcomes is included hereto as Appendix B. It turns out that some of the datasets required would be available to
the Project through existing relationships of NVCA or the Town of Collingwood. Team members had been led to believe that the dataset associated with the bathymetric LiDAR generated under contract to the Canadian Hydrographic Service (Federal Department of Oceans & Fisheries) would be available for scrutiny during the spring/summer of this year. However, it was never made public during the Project period. As a result, NVCA used their contacts to ascertain from scientists internal to the federal bureaucracy who were given preliminary access to the dataset that it was likely unsuitable for use by the Project. NVCA therefore explored other regional efforts that might be useful in attempting to generate bathymetry data independently for the Collingwood shoreline.

- **Options for modification of CLIVE tool for Collingwood - Centre for Climate Management, University of Prince Edward Island (“UPEI”)**. UPEI undertook an analysis of the steps required to modify its CLIVE tool for use in Collingwood. This work included a review of the software modifications to handle an environment in which both upwards and downwards fluctuations of water levels were of interest. As a result of an emerging realization that suitable bathymetric LiDAR data would not be available, UPEI included analysis of the timing and cost involved in generating completely new datasets for both above-water and below-water elevation/bathymetry data. UPEI’s final report is included as Appendix __ hereto.

- **Local engagement, project management, budgets & timeframes – Ontario Water Centre**. OWC served as facilitator and project manager for the Project. OWC’s relationships across the Collingwood community enabled a representative cross-section of stakeholders to feel comfortable participating in the interview process. Follow up discussions led to the assessment developed by the Project team that a TSP-based process exploring long-term shoreline development could succeed in Collingwood. OWC integrated partner contributions into a final report, including layout of timetable and budget. OWC also carried out initial discussions with potential funders to assess the likelihood of being able to fund Phase 2.

The following four sections summarize the findings from these work efforts, ending with a final section that lays out the conclusions the Project team arrived at concerning the viability of a Phase 2 for this Project.

1. **Community Interviews and Conclusions**

   **Process Description and Objectives**
   The TSP model that is conceived of as the Project’s process for engaging Collingwood stakeholders is initiated through a series of interviews with individuals representing the full range of anticipated perspectives on the issue in question – in this case, possible future evolution of the Collingwood shoreline.

   The initial interview is designed to develop an understanding of what community concerns have meaning for the stakeholder group, whether there is agreement on the importance of the issue that might become the subject of the TSP Project, whether there are significant differences of opinion that the parties agree do not seem easily resolvable, and whether there is a willingness among the parties to “enter the room” together in order to explore alternative ways of handling the situation.
The Project’s objectives for Phase 1 were to identify and approach a complete set of stakeholder representatives, to conduct an initial set of interviews with these representatives, and to compile responses that would provide insight into the appetite of the community to engage in an actual TSP process in Phase 2. These objectives were achieved, with interviews carried out with 16 respondents from June 17 – July 24, 2015. The questions that were used by REOS Partners in the interviews arranged by the Ontario Water Centre during Phase 1 of the Project are attached at Appendix A.

Summary of Responses and Outcomes
The report generated by REOS Partners based on the interviews in Collingwood is attached hereto at Appendix A. An alphabetical listing of interviewees and the stakeholder group each represents is as follows:

- Ian Adams, Reporter at the Wasaga Sun and Commodore, Collingwood Dragon Boat & Canoe Club;
- Richard Bowering, Owner, Eagle Adventure Experiences and Director, Regional Tourism Organization 7;
- Fred Dobbs, Manager, Stewardship Services at Nottawasaga Valley Conservation Authority;
- Larry Dunn, Chairman & CEO, HarbourEdge Capital and The Landex Group (developer);
- Nancy Farrer, Director, Planning Services, Town of Collingwood
- Andrew Hill, President, Georgian Triangle Development Institute
- Kathy Jeffery, Councillor, Town of Collingwood
- Wendy Martin, Manager, Parks, Recreation & Culture at Town of Collingwood
- John Megarry, President, Collingwood Rowing Club
- Tim Morris, Member, Condo Board at Lighthouse Point and Principal, Tim Morris Consulting
- George Powell, Vice Chair, Watershed Action Group
- Michele Rich, Executive Director, Environment Network
- Brian Saunderson, Deputy Mayor, Town of Collingwood
- Philip Tarlo, Owner, Collingwood Cooking Academy and Willow Trace B&B, and Director Regional Tourism Organization 7
- Norm Wingrove, President, Blue Mountain Watershed Trust
- Gayle Woods, CAO, Nottawasaga Valley Conservation Authority

As described much more fully in the REOS report, the following insights emerged from this interviewing exercise:

- Stakeholders are attached to the area, the community, and the waterfront. Everyone involved spoke about the importance of working towards a healthy future for the Town, and agreed that the waterfront was key to this future
- Choices being made now will have a significant impact on the future of the waterfront, which will in turn impact the community
- Stakeholders felt that the community was still small enough that they could have an impact on outcomes, but there was significant displeasure with the way the decisions are being made about use and development of the waterfront
• Deep divides exist around issues such as the importance of shoreline access vs. economic health of the community; how to govern shared shoreline resources such as parks, the harbour, etc.; how beholden ‘the system’ was to special interest groups (ie. developers, marina operators, etc.)

It is important to note that while all participants were very interested in the future of their waterfront, none of them viewed water levels per se as a significant influencer of any shoreline planning process. It is the Project team’s view that appreciation of the potential impacts of variable water levels would come through use of the proposed enhanced visualization tools in the course of a TSP process that focused more generally on the future of the Collingwood waterfront. An attempt to engage participants in a process narrowly conceived around the impact of water levels on the future of the community’s shoreline would be less likely to garner the support to succeed.

Likelihood of being able to build a “convening” group
Following completion of initial interviews, the next step in a TSP process – which would be the first stage of Phase 2 of this Project – is to identify and assemble a group of 5–8 community leaders who believe in the importance and potential of carrying out a TSP exercise. This “convening group’s” main role is to help persuade a larger group of participants that participating in this process will be “worthwhile and safe.” Ideally, these leaders are highly regarded and come from different backgrounds and perspectives so that their confidence in the potential of the process, and their trust in the integrity of the process, help convince a broader population to consider participating when they might not otherwise do so.

The Project team believes that, given the information gleaned through the initial interview process, there is a good likelihood that a convening group could be assembled. If funding is secured to pursue a Phase 2, the interview summary document attached as Appendix A would be a key tool used in discussions with potential candidates. The Ontario Water Centre lead on this Project has the breadth of relationships in the Collingwood community to conduct this recruiting process.

Potential challenges to success of convening a “full stakeholder” group
The next stage in the TSP process is to work with the “convening” group to assemble a Scenario Team (a full stakeholder group) of 25-35 members representing the main interests at play in any future plans concerning the Collingwood waterfront. The Scenario Team members agree to spend 4-6 days together stretched out in 2-3 sessions over 4-8 months to explore alternative approaches to addressing the future of the waterfront. While there can be no certainty about the success of any effort to convene such a group, the Project team members involved in the initial interviews felt that current levels of interest in the future of the Town’s shoreline provide fertile ground. Nevertheless, there are several specific challenges that would need to be overcome:

• **Timing** – Collingwood has conducted a strategic planning process during 2015, the final report from which is due in September. The report is expected to recommend that a

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2 Ibid. Location 478 out of 2143 (e-book).
3 Ibid. Location 605 out of 2143 (e-book).
4 Ibid. Location 486 of 2143 (e-book).
subsequent process be initiated immediately to complete a long-term plan for the Town’s waterfront. Several interviewees pointed out that a TSP process carried out in the next 12 months could dovetail effectively with this anticipated shoreline planning process, providing an alternative source of insight. However, it was also pointed out that, unless the processes were coordinated, the parallel nature of these efforts could be confusing and hamper efforts to convene a TSP process that was not “officially sanctioned” by the Town.

- **Stakeholder dynamics** – “Developers” appear to be a particularly controversial group for many stakeholders in Collingwood, evoking strong emotions both positive and negative. Convening a Scenario Team would require careful orchestration to ensure that developers did not come to view the TSP process as a chance for others to “dump on them”, thereby leading them to bow out. Conversely, other stakeholders would need to see that the TSP process was not going to be controlled by developer interests.

- **Funding** – Raising the significant amounts of money required to facilitate a TSP process would require participation by multiple levels of government, as well as local corporations and moneyed individuals. The terms under which this funding was secured would have to be carefully controlled in order not to inflame the dynamics and concerns described above. Also, given the fact that a federal election is in process in Canada, the outcome of which is very much up in the air, the fund-raising environment may take some time to re-stabilize.

In spite of these challenges, the Project team believes that there is a good likelihood that convening a suitable Scenario Team could be achieved. Success at this level would be sufficient to enable completion of a TSP process during 2016 – which is the objective of the proposed Phase 2 of this Project. The impact of any outcomes of such a Phase 2 process cannot be anticipated at this time.

2. Analysis of Data Availability

**Description of required data for the Collingwood shoreline**

In order to support the proposed Phase 2 of this Project, two general types of data would be required:

- Information about a full range of change options pursued by shoreline communities to expand the context in which the Scenario Team considers alternatives;

- Digitized datasets and imagery representing the profile of the Collingwood shoreline from 2m above to 2m below long-term average water levels. More specifically, these datasets would ideally include:
  - An above-water terrestrial elevation dataset
  - Above-water ortho-corrected overhead imagery
  - A shoreline property parcel dataset
  - A below-water bathymetry dataset (i.e. underwater ‘elevation’ data)

Whereas collecting and organizing the first type of data would not be a simple task, the Project team felt confident that such data would be available through publicly accessible sources. Part of this process would be consciously accommodated by setting up learning visits by Scenario
Team members to communities around the Great Lakes (TSP incorporate learning visits by Scenario Teams as part of the process). As a result, primary attention during this exploratory Phase 1 of the Project was paid to assessing the availability/cost of the digitized datasets without which development of the enhanced visualization tools would be challenging to impossible.

**Potential sources examined**
Appendix B contains a report from the NVCA, the Project team’s partner tasked with exploring dataset availability. Their primary conclusions are that:

- Several above-water terrestrial elevation datasets are available covering the required stretch of shoreline. These could be accessed by NVCA at very reasonable cost. As discussed elsewhere in this document, a decision might be made to supplement this data with additional data generated as part of the Phase 2 exercise using an unmanned aerial vehicle.
- Ortho-corrected overhead imagery for the shoreline in question is available at reasonable cost to NVCA from 2012 and 2013 projects. As discussed elsewhere in this document, a decision might be made to supplement this data with additional data generated as part of the Phase 2 exercise.
- A shoreline property parcel dataset is available via NVCA at low cost, provided that permission can be secured from Town to use this data for the Project.
- The below-water bathymetry dataset (ie. underwater ‘elevation’ data) that had been hoped would be available through a bathymetric LiDAR project sponsored by the Canadian Hydrographic Service in 2013-4 was unavailable for review by the Project team. However, early reports from staff at Environment Canada who were given access to the dataset suggest that it contains too many gaps in the nearshore area (primarily from floating ice) to be suitable for use with the proposed visualization models. As discussed elsewhere in this document, a decision might be made to supplement this data with additional data generated as part of the Phase 2 exercise.

3. **Analysis of Work Required to Develop CLIVE Version for Collingwood**
 Appendix C contains a report from the Centre for Climate Management at the University of Prince Edward Island (UPEI), the Project partner responsible for investigating the practicality of developing version of its “Coastal Impacts Visualization Environment” (CLIVE) tool as an enhanced visualization support for the Scenario Team members as they consider potential future scenarios for the Collingwood shoreline. UPEI’s report covers i) the importance of visualizing environmental change in enabling communities to discuss future possibilities, ii) a description of CLIVE, iii) an assessment of how elevation and bathymetry data – if it is not already available (see earlier discussion) – could be generated in order to provide the necessary inputs to a CLIVE system covering the Collingwood shoreline, and iv) the likely budget needed to carry out such efforts and complete such a CLIVE system.

**Description of desired product**
As further described in Appendix C, “(CLIVE) is both a geo-visual interface and an analytical information visualization workflow. It combines available coastal data, historical records and predictive climate change models and translates them into a 3D geo-visual information tool that
can be explored and queried by non-scientist stakeholders. It allows citizens ... to explore past environmental change, and how future environmental changes may impact coastal communities ... at various scales.

![Figure 1: CLIVE Coastal Impact Visualization Environment.](image)

CLIVE enables citizens to interactively navigate and view a 3-D virtual environment of (the target shoreline) constructed from accurate historical spatial data and recent ... surveys of topography. Users can view this 3-D environment from distance, by flying around it overhead for an overview. They can also explore the data and virtual landscape from first-person on-the-ground perspectives, to inspect detailed local-scale historical environmental change, and projected impacts. While navigating CLIVE PEI from any perspective, at any scale, users are able to select and manipulate multivariate overlays of historical data and projected models through time.”

The objective of a Phase 2 development process would be to generate/assemble the datasets required to support a CLIVE model of the Collingwood shoreline (“CLIVE Collingwood”), one which could then be used by a Scenario Team to investigate – individually or together, in as much detail as desired – future possible scenarios. While the system is most readily adaptable to model variable water level impacts, the Project team has considered further extensions of the model to enable different forms of visualization.

**Likely technical challenges/risks to successful completion of CLIVE Collingwood**

As described above, the only significant challenge that the Project team has discovered during Phase 1 to completing at least an initial version of CLIVE Collingwood is the apparent lack of digital bathymetry data for the shoreline of sufficient resolution or completeness. This lack dictates that any model could only show the impacts of water level rise (not fall), which could prove a significant limitation. Beyond this, it is possible that different datasets from which terrestrial elevation and other above-water imagery would be generated might require in-field validation in order to combine them into a unified visualization.

Given that some degree of in-field measurement seems unavoidable, the UPEI team has laid out two work programs (including budgets) to compile new sets of both terrestrial and bathymetric data for the 15km Collingwood shoreline using: i) an unmanned aerial vehicle already owned by UPEI, and ii) the Bathymetric Automated Survey System (BASS) developed by the Ontario Ministry of Natural Resources. If a Phase 2 is funded for this Project, this data collection process
would likely require a full season (spring/summer/fall of 2016), which provides unavoidable time constraints.

4. Analysis of Overall Project Cost and Timetable
This report lays out evidence that identify several considerations that influence the likely timetable for a Phase 2 of this Project. It also suggests a range of likely budget scenarios.

<table>
<thead>
<tr>
<th>Project Component</th>
<th>Likely Duration</th>
<th>Likely Date Range</th>
<th>Budget Estimate (C$)</th>
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<td>Data Acquisition</td>
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<td>Ortho-imagery (NVCA)</td>
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Conclusion
The Project team believes that the community of Collingwood would benefit significantly from this Project. Utilization of the proposed TSP approach (supplemented by enhanced visualization tools) would be a first, bringing an innovative perspective to traditional shoreline planning paradigms. Anticipated learning would be applicable to other shoreline communities around the Great Lakes.

Our cost estimate of a full TSP process, including facilitation, incidental expenses, project management, report generation, etc. falls in the $300,000 to $375,000 range. This cost could likely be brought down in future uses of the process, as techniques and practices emerge suited to the smaller scale associated with shoreline communities (as opposed to the larger scale on which TSP has been used to date).

CLIVE as a visualization tool to support the TSP process is economically adaptable by UPEI from a sea-level rise environment (it’s current format) to a fluctuating lake level environment. It would assist in helping residents to visualize shoreline impacts of water level variation, and likely of
additional potential impacts of climate change and development choices. Our estimate of the cost of adapting the CLIVE system to be used in Collingwood (assuming availability of required data) is $30,000 - $35,000.

The above-water shoreline digital elevation data required for the Project could be generated over a 1-2 months in the summer of 2016, probably using unmanned aerial vehicle technology already owned by UPEI, at a cost of $30,000 - $35,000. Land parcel data and ortho-imagery inputs are also available through the Project’s relationship with NVCA – we assume a cost of $5,000 - $10,000 to gain access.

Availability of the required bathymetry dataset for the Collingwood area – and indeed for all Canadian shorelines along Great Lakes – is poor to non-existent (this study did not have time to analyze whether LIDAR data available for US shorelines would be adequate for our purposes). Currently available technology could likely produce underwater profiles of the relevant Collingwood shoreline at a cost of $35,000 to $40,000, and would be collected in spring/early summer 2016.

It is assumed that compilation and integration of the various datasets would take a month and cost $5,000 - $10,000.

Overall projected costs (as the Project is currently defined) – at $420,000 to $515,000 – could likely be funded given sufficient time. The novelty of the approach and many stakeholders (local, county, provincial and federal) interested in exploring novel alternatives to current models of shoreline planning would help this effort. The Project team has identified and opened dialogue with several of the players who would be involved in such a fund-raising effort.

The challenge, however, in fitting the Project into Graham’s timetable is that multiple uncertainties – primarily in timing and funding – combine to make the risk of failure higher than might otherwise be desirable. Given the planning processes going on within Collingwood, the ideal timing for conducting a TSP process is within the next 12 months, in conjunction with the Town’s upcoming shoreline planning process. If the Project is unable to accommodate this timing, potential participants may be more likely to question the value of participation when an officially sanctioned planning process will conclude prior to the TSP getting underway. This timetable can only be accommodated if fundraising could be carried out with a high probability of success in a six-month period from October, 2015 to March, 2016. However, the uncertainty inherent in the current Canadian federal election, with an unclear outcome and the possibility of government change, makes for a very unstable fundraising environment during this period.

If Graham would consider a modification to the current Project design, one promising possibility would be to approach the Town of Collingwood with an offer to collaborate in the Town’s own upcoming shoreline planning process. If the Project refocused only on development of a version of CLIVE for Collingwood (perhaps with additional visualization features), this tool could be incorporated into the Town’s citizen engagement exercises to experiment with its ability to help citizens better understand potential futures for their shoreline. Project costs would be a more affordable C$125,000 (requiring the team to raise only ~C$75,000 above Graham funding). We would replace REOS with a local university-based research partner who would design the experimental framework to test CLIVE’s efficacy in enhancing the scope of shoreline community engagement processes.
Synthesis of Dialogue Interviews:
Transformative Scenarios for Collingwood’s Waterfront

Edited by: Elizabeth Pinnington

July 2015
Introduction

This synthesis presents the ideas shared by a variety of stakeholders in conversation about the future of the Collingwood waterfront. The 15 one-on-one interviews were conducted in person, on the phone, and via Skype by Reos Partners and Ontario Water Centre staff between June 17 and July 9, 2015.

The purpose of these dialogue interviews and synthesis is to explore whether there is an urgent question, or a group of questions that a significant group of actors would be interested in working on together in order to move forward. They key is that not just friends and colleagues show interest, but whether people who have historically considered themselves opponents say, “If we are working on these questions, it is worth it for us to be there.”

This synthesis is organized according to a series of questions raised by interviewees. Reos Partners wrote and arranged the questions and subheadings based on the ideas interviewees expressed. Apart from questions and subheadings, the text is directly quoted from interviewees. The interview questions are listed in Appendix I. The list of interviewees appears in Appendix II.

Stakeholders indicated that when discussing the waterfront, several other issues are interrelated. The key questions they raised are:

1. What will happen with quality of life in Collingwood?
2. How will decisions get made about Collingwood’s waterfront?
3. What relationships will regional stakeholders have with Collingwood and its waterfront?
4. How will people use Collingwood’s waterfront in the future?
5. How will the waterfront connect with infrastructure, economic and social development in Collingwood?

How to read this document

Transformative Scenarios were developed in the private sector as a way of understanding how possible futures could influence an organization’s business. Transformative Scenarios are 3-4 narratives about futures that could happen, rather than stories about what we desire. For example, in the 1980’s Shell Oil developed a scenario about a future in which carbon could be taxed. While many in the Shell leadership thought this future was unlikely, they agreed it was plausible. The scenario led the organization to make strategic decisions to prepare for carbon taxation.

Scenarios are a useful first step in collective work. While visioning requires participants to debate and concede to a commonly defined future, Transformative Scenarios allow differing perspectives to be reflected in the final product.

Scenarios provide a shared framework and language for strategic conversations among actors from across a social system about the situation they are part of and what actions they can, must, and will take to address it. Transformative scenario planning thereby offers a way for systems to get unstuck and to move forward. Visioning and strategic planning are logical next steps after Transformative Scenarios, as actors typically have built more capacity to work across differences in the process, and also better understand the implications of not acting together for the future.
Reos Partners has facilitated Transformative Scenarios to discuss the future of South Africa post-apartheid, new ways of thinking about drugs in the Americas, and urban planning in Bogotá. To see examples, visit reospartners.com.

One of the things we ask teams to engage in during scenario work is to see the "meaningful whole" that is being expressed by the various participants in the process. The first step in a Transformative Scenarios process is dialogue interviews, which are presented in this document. When reading this document, rather than trying to determine how you would rebut a particular statement, ask yourself the following questions:

1. What are stakeholders trying to say in the ensemble of these statements? What is the "meaningful whole"?

2. If people who have traditionally been opponents worked together to answer the 5 key questions in this synthesis, what would we have at the end of the process that we do not have now?

If there is a desire to work together on answering the 5 key questions, the next step is to convene a Transformative Scenarios process.

A Transformative Scenario process involves 25-30 stakeholders who have the capacity to influence a system and are willing to work as a team with others who have historically been both allies and opponents. The Scenario Team and its supporters understand that to avoid recreating the challenges they are trying to address, they must find answers together, as no single stakeholder or organization has been able to respond to the issues unilaterally. This Scenario Team dedicates 4-5 days of their time, over a period of 2-3 months, to working together to understand what is happening in the world, and how that influences futures that could happen in Collingwood.

At the end of the process the Scenario Team has collectively written 3-4 nuanced stories about what could happen in Collingwood and with its waterfront. These 3-4 stories reflect the thinking of all participants, and the input from Learning Journeys and Resource Persons involved in the process. The narratives reveal what can and must be done. Scenario Team members use these narratives to inform strategic plans and decisions moving forward.

Past Transformative Scenario team members have used the narratives they created to inform: South Africa’s economic policies under the Mandela government, President Santos’ approach to peace talks in Colombia, and nation-building following the end of the civil war in Guatemala.¹

Leaders are realizing the potential of Transformative Scenarios in municipal planning. For example, in a 2014-15 Scenarios process in Bogotá, municipal stakeholders came to see that leadership was a key aspect of creating desirable futures. A member of the Bogotá Chamber of Commerce said: "We had no idea that our style of leadership would make such a big difference in our city. Without the Scenarios process, we would all have continued organizing and developing Bogotá the same way: the status quo."

What will happen with quality of life in Collingwood?

**Lifestyle**

I'm here in Collingwood because of lifestyle.

Lifestyle and recreation bring me to the water.

We're a town that thrives on it's natural amenities, the escarpment for skiing, Wasaga, a trail system through town.

I moved here for lifestyle from Toronto. I found a way to make my professional life work here.

I came to Collingwood when I retired. It has a cottagey feel but is also close to doctors, hospitals, and stores.

I really like the community. I live on the waterfront.

I live a few streets from the water. I hardly ever go. But if I were to ever move away, I would really miss the water. It's important to know it's there.

I would like to be able to protect this area for future generations. It's a nice area to live in, and to visit.

**Interrelationships**

One of the challenges is that people just come up on weekends or summer. They are trying to get away and enjoy the playground, rather than thinking about the community and how it plans for the future.

When people see what's happening with the issue and it's personal, it sort of hits them. This happened with the water levels. When it was dry, people were concerned and wanted something to happen.

Who calls themselves “we” in Collingwood? Who considers themselves “home” in Collingwood? Do the weekenders feel part of the community? They're getting benefits, but what are they giving back? Where do private interests fit in the community? Are they doing things because it's beneficial to the community, or is it private interest?

When I first came to town there was a divide between the weekenders and the so-called “townies.” That divide is less now. There are still some people who think that because they've been here five generations they can do what they want. But there are enough new people now that there's pride in being from Collingwood, no matter how long you've been here.

The national Truth and Reconciliation Commission really brought some things home that many Canadians didn't understand, dating back eleven thousand years.

We have a very rich culture and history of the Underground Railroad in Collingwood and Owen Sound. But how many people in Collingwood would know that?
Sense of community

I really like the fact that we're trying to be a cohesive community. There are some residents that want to live in gated communities. That sends the wrong message on every level. We want everyone to be part of this community.

You see more and more “no trespassing” and “private property” signs. It's just growing.

In fifteen years I would love to see no homelessness. People can come here and there would be housing and food. We don't all have to have mansions, but some form of safety and security.

We want our kids to be able to afford houses here when they grow up. Real estate is really going up here. Three quarters of million dollars for a waterfront property is a lot.

Wasaga doesn’t really have a downtown core. Collingwood's downtown provides sense of community. It’s an effort, but we need to maintain it.

I have a mother that is thinking about moving up here. She thinks she would be less isolated here with the downtown because it's walkable.

People are drawn to the water. It can be a real gemstone or cornerstone in our downtown if we make it accessible to the public.
How will decisions get made about the waterfront?

**Municipal planning**

Our voice still means something. We’re still small enough that people listen.

Our council tends to be reactive and not long-term thinking.

There is a lack of planning in the town. That’s particularly true about our harbour and waterfront. We’re kind of just waking up to the fact that we don’t really have access to the water.

Lack of transparency and public input in the process is a big problem.

We’ve had the tail wagging the dog. A lot of councillors used to come with their own agendas and say, “I grew up here. I’m from Collingwood. I know what’s best for the area.” But that is changing.

We had a change around the local council table. We now have more political will to see a change in the vision for the harbour coming forward.

In terms of the actual development across the waterfront, the municipality doesn’t have a lot of control over it.

**Engagement**

We need an approach that reflects the right blend of leading by example and some stewardship, as opposed to just using a regulatory approach. Customizing that approach is really part of the success. For certain big developers it’s less expensive to fight a prosecution.

From a Collingwood perspective, how do decisions get made? How do certain developments get made? What planning is in place? What is the long-term plan for Collingwood? Is there one? Is it ecologically sensitive? Is it just continual growth?

If it were better, you’d have a more engaged community. There would be more people in the community involved in discussions with political groups, or regular ongoing public forums about planning, which I hope is going to happen.

There has been a lot of talk about what needs to occur on the waterfront. We’ve already looked at this. We understand what the objectives are and what he priorities are, let’s get on with it. The opportunities are now. There already are criteria for development down there. It can be implemented within current policies that are in place.

There are a lot of interest groups right now, when someone puts in a an application, all these interest groups say “What about me?” And politicians get afraid.

It would be good to get more people to the harbour and have them understand what is going on.

Engagement at the local level helps to release the energy and expertise in communities which top down governments and agencies find more challenging because they are bureaucratic. Instead of top down, you support the local energy to find interesting and innovative approaches to fit that local context.
Sharing a resource

I treasure this area. I've been all over the world. I'm passionate about seeing something constructive done with a long term plan. We need a blueprint so people have confidence and they know where they are going.

We need some sort of plan on development for the waterfront. A strategy. I'd put a moratorium on the waterfront development until we come up with that plan.

We have a great resource that would attract international travelers. But we don't have a plan.

In communities like Collingwood, there should be a tourism component in decision-making.

It seems that somehow over the years public works, sewer, and hydro, have gotten a lot more clout compared to green space.

The public process for the former shipyard worked well. If you ever wanted to replicate something like that, it would be perfect. It said to the public, "Okay, this is private property but we recognize that this is also waterfront and there should be public access. What sort of things do you want to see there in terms of public access? The community is going to have to live with it." They probably didn't have to do that, but they took that step. For the most part what they've been able to develop has met with that vision.

The shipyards had what I would suggest a good master plan and its stalling for various reasons. That needs to be a number one priority. It's good because it's mixed use. It has opportunity for commercial use that creates places for people, too.

If we destroy our waterfront, I'd hate to think that in thirty years time somebody says, "I wish they hadn't build that".
What relationships will regional stakeholders have with Collingwood and its waterfront?

Connections between different decision-makers

Municipalities in South Georgian Bay don’t think regionally. There could be more shared services, more economic development strategies, planning policies affecting the waterfront, and infrastructure.

The lack of communication between the municipality and the South Georgian Bay region has been a problem over the last number of decades. It is starting to improve and needs to continue.

We have common interests and challenges in South Georgian Bay. The way that those things are going to be leveraged and resolved are by improved communication and collaboration.

The county has to approve all of Collingwood’s official city plans. We are also connected for transit and trail links. They didn’t start life as a regional government but they’re heading that way.

The County doesn’t provide any role with the waterfront.

If you think about water levels, it’s much bigger than Collingwood. Adaptation is more of a local approach. Mitigation is bigger, more global.

I’m a firm believer in collaboration. Collingwood is also connected to Meaford, Wasaga, and Thornbury. How do we connect our waterfronts so there’s a theme so people can feel that we’ve done something important?

The Georgian Bay coastal route was an example of good regional collaboration. It took about fifteen years. It was one or two people who started and plugged away and now it’s a properly signed route. When we talk about waterfront that would be a good model because it involves quite a few communities around a body of water.

Someone’s done it right somewhere. Go and study it. Don’t try and make it up. Go and see similar communities. Don’t make those mistakes but take the best of those communities. A lot of municipal governments don’t always travel to different communities that might have similar challenges. There’s a need for collaboration around Georgian Bay. It’s not just one persons’ issue.

Wasaga has the longest sandy beach freshwater in the world. How can we leverage that? How can we leverage each other’s communities for the benefit of our communities?

The higher ups at Blue Mountain know they have to introduce other experiences - like spa, boat cruises, and cooking classes to remain viable. They need to connect with the rest of the region for those things.

Being a regional service centre

According to the provincial “Places To Grow” legislation we have to have growth targets and density targets. We are required to have intensification, a certain population per hectare. Blue Mountains are not in that. Wasaga is included but has lower targets than Collingwood.

We interact a lot with Wasaga and Blue Mountain because we’re the service centre. Most of Blue Mountain’s employees live here.

If you look at other resort areas like Whistler, Tremblant, and Vancouver, people who are waiting tables and working at Shoppers Drug Mart can’t find accommodation that’s affordable. It’s
important for sustainable development to occur here so that it's a healthy community. It's not just a community for the wealthy.

Collingwood is a primary settlement, meaning we are supposed to be the primary place for growth, according to “Places to Grow”. But if you look at the town of Blue Mountains they're not in the growth plan. Collingwood is supposed to service a population that lives in a different county, and different municipalities. That is a challenge.
How will people Collingwood’s waterfront in the future?

Vision

What is the vision? Is it the same as everywhere else? Should it be?

We have unique attributes in Collingwood. This is an area of unique opportunity. You go from town to small town in Canada. It’s virtually the same kind of development. Do we need the same kind of density of residential development? Commercial? I would suggest no.

I would like to see Collingwood consider an intentional waterfront, like Thunder Bay. They have highlighted the area’s aboriginal heritage, and have flowing landscapes so that people can enjoy the view and access the waterfront. It draws people and business.

We should be thinking about clean, healthy, accessible connections to the water. A place of vibrancy, open space, and accessibility.

If things went wrong, the harbour would look like it does now. No money being put into it - piecemeal, with no investment.

Chicago has done a magnificent job on some of their waterfront. There are all kinds of great examples of waterfronts in the Caribbean but we’ll never achieve that. Going around the Great Lakes we saw all kinds of examples of other communities who also have to deal with winter.

Look at Copenhagen and Oslo; they have all those wonderful bike trails. When we arrived in port, it was easy to get around. There were gardens. They’re dealing with similar climates. Whereas when you arrive in Collingwood on the water, it’s a walk to downtown.

A major image for me of the waterfront not being healthy down the road is garbage, plastics, garbage disposal in the water and general inaccessibility. St. Catherine’s has kept a good buffer.

I’m sure there’s going to be development on Collingwood’s waterfront, but what is it going to be? If it fits into the town plan now, it might not fit into the long-term vision for the waterfront. Short-term gains might not be long-term gains for everybody.

A lot of people are waking up to this being a great place. This is the only four season recreational destination in Ontario. It’s the single determining factor for this region. So with all that, why don’t we have a great waterfront?

It’s one thing to put in a couple hundred houses in a field on the south end of town. It’s another to put something in the heart of the community.

Accessibility to multiple residents and users

The waterfront will become more accessible to the population through development. People can live there. People can have activities. People can spend time there.

Currently, most of the harbour is cut off from the main population. You have to cut across a 4-lane highway to get to it. If you were to drive through town on highway 26 going towards Blue, you may not even know there is water to your right because it’s blocked off.

I hate box stores, which is what we now have between the main street and the waterfront.

Nobody wants high-rise development here.
People have suddenly woken up to the fact that the last remaining commercial space along the waterfront is getting built up.

There needs to be a reason for people to walk the promenade. “I want to eat there.” “I want to shop there.”

You need to animate the waterfront. There need to be places for boats to be moored, stored. Places to row and swim. There should be protected area, as well, including marshland.

I would like to see more accessibility to the waterfront for the public. I agree with creating a restaurant community on the water, but also down the way a beachfront that people can use.

I think making the waterfront a really attractive and accessible place for everyone is a top priority. Not just for those who can afford the condo that’s down there.

We have one restaurant on the waterfront in the region, and that’s in Thornbury. The number one thing tourists want with waterfront is to be able to look at the waterfront. I’m talking about tourists from Meaford and Thornbury.

The marina coalition has about 900 people who want to be able to walk down to the waterfront and enjoy a coffee or a nice meal in the evening.

If there is a marina, I would like it to be a respectful sharing of the waterfront. We don’t need a parking lot that runs over the paddlers and rowers that use the inner bay.

There is potential for conflicting use between those who would use the harbour in a passive recreational way, and power boaters. We’re talking about access and shared use of resources in a very finite space. If the harbour is developed in one particular way, that could severely limit use for some people.

This is not going to become a destination for cruisers. It’s not the 30,000 islands. It’s a lot of fuel and time to get out into the bay.

It will be like Toronto’s waterfront where you can’t see the waterfront due to condos and the expressway. And you have to pay twenty or thirty dollars to get to it. Really it’s just the benefit of just a few people.

I know we have to have space for everyone. It’s just a matter of trying to determine where different user groups can go.

**Maintaining a healthy environment**

To me a vibrant waterfront is going to have many aspects to it. One would be protecting the natural wildlife. Eagles are back. There are beaver living in the shipyards. These are wonderful things that have not been around for eons.

We hope the public understands that this doesn’t have to look like the Toronto shoreline. We’re not that far along on the decline curve.

A lot of people looked at Lake Simcoe with zebra mussels and would say, “it’s clear, therefore it’s healthy”. It’s not.

In the context of shoreline many people would say clean means no garbage. But from an environmental perspective clean might mean a variety of animals using it as habitat.
Wasaga beach just lost its blue flag status.\(^2\)

We were a hotspot in the 1990s, it was all contaminated soil dredged out of the harbour. We’ve now restored the natural ecology. The perch are back.

Cleaning up the harbour was a great thing. We got ourselves delisted. And we also cleaned up the space behind the grain elevators. As a process it helped make people aware of what was going on with the water. There was a big push around use of phosphorus – sewage treatment and the one stream that flows directly into the harbour.

There are large parts of the waterfront going west that are underutilized for recreation purposes.

We’ve got about four miles of virgin beach that, and that’s not going to last.

You can drink our water right out of the bay; it’s mostly limestone and shale. We have a great resource that should be for the benefit of everybody.

It’s not about solving water levels going up and down. It’s about people meaningfully engaging in trying to understand how they can live in tune with Georgian Bay.

One of the aspects of the inner basin is that it doesn’t have any circulation. So on the East side of the spit you have wonderful fresh water, but on the west side it can become very stagnant and the sewage treatment plant is on that side, too. My fear would be that we don’t consider the environment. We jump on an economic opportunity that is unproven, for the marina.

You can see the challenge that Toledo, Ohio had last summer with blue-green algae potentially happening in Collingwood. The urban growth projections for the watershed are very high.

\(^2\) [http://www.blueflag.org](http://www.blueflag.org)
How will the waterfront connect with infrastructure, economic and social development in Collingwood?

Infrastructure

It's like every other town in South Ontario. Big box retail. Dense subdivisions.

I'm not against development. I'm against bad development. Expect development and plan for it.

I don’t want to see the downtown expand out much more. We should be increasing densities and still have all the accessibility of the trails.

There's an opportunity for good development, meaning: a variety of housing types, a variety of commercial businesses, and development of small business.

From shipyards all the way to western boundary, you have a naturalized pathway through the woods, with wildlife. If people want to start doing fast projects through there that would be undesirable.

Provincial legislation dictates that we need to have more density. People don’t like that but that’s the way of the future. We need to become more urban. We can’t keep taking up land. That's not reality.

Fifteen years from now I’d like to see that development has occurred in a rational pace, meaning it isn't occurring so fast and at such a high cost that there are peaks and valleys, that there’s a recession. Recessions occur in development because markets become overinflated. We have that risk in Collingwood. That means that it’s not accessible to all income brackets.

Economic growth

Help change Collingwood from an industrial town to a place that people want to come to.

This is a small community. Big business is not sustainable. Economies change. It takes a lot longer to adjust when things change. We've learned that. We've lost the shipyards and other major businesses that you can’t replace quickly. But if you have a diverse set of small businesses, they can adjust.

Collingwood is an interesting opportunity. It’s always seen its waterfront as an industrial/commercial facility with the shipyards that were here until the 1980s. It’s been a difficult change. The harbour has been almost a wound that has been healing over.

The town has been very land-out centric. When you look at the town from the water-in, it’s a different view and the possibilities are different.

To do business well you have to have a level playing field for everyone—whether a large developer, small mom and pop, or local interest group.

We have many little quaint, artistic communities with nice restaurants in the area. I see that all being displaced by big business interests.

It always frightens me when we talk about the harbour front and economic development. It makes me think everything needs a dollar sign. How can we put a dollar sign on having access to a passive recreational use?
Fiscal constraints

We have an extremely high level of taxation. We have high tax per capita. Most of our constraints are fiscal. So our ability to start to move forward in realizing something like the harbour front plan is limited. But in some respects that may not be a bad thing – 5 years to develop the harbour may not be a bad thing.

Municipalities are feeling the crunch. Municipalities are small. They are not York Region. They’re not the city of Barrie. Fiscal constraints are prohibiting them from doing investment in research and local development. It’s happening in all the government sectors.

We’ve experienced a continual loss of employment from the shipyards, and other big manufacturing. That’s now giving us a real imbalance in the property tax base. There’s more in residential and less commercial industrial.

We’re not seeing an emergence in this sector of public private partnerships. It’s possible to have that happen here, but it hasn’t happened yet.

Developing tourism

Tourism has changed. You don’t just go to Niagara Falls to see the falls. “Experiences” are also part of it now. So, you also go to a winery. If every main street looks like every other main street in Ontario, that’s a problem. If you want to be a community of unique experiences, you need to preserve and maintain what’s unique.

What role does tourism play? Are they one interest? Multiple? The bulk of the tourism is technically not in Collingwood; it’s in Blue Mountain. But there’s obviously a significant economic influx to Collingwood for people who are up for summer and winter activities at Blue. In terms of harbour use, I’m not sure how much there is.

So we could do a kayak route around the bay. Other countries that I visited have that. No one has done it from a tourist point of view in Collingwood. This is a world-class bay, the largest freshwater bay in the world. We could have a routing with accommodations along the way.

If you were going to the beach in Collingwood, where would you go? There isn’t much. So we’re not going to get the beach crowd. We’re going to get the mature crowd. Wasaga can have the families.

People don’t realize we’re all involved in tourism in this area. If you’re a gas station, you have visitors.

Demographics

We would have a community that has experienced moderate growth. Increased employment. Other than just growth by retired folks.

I don’t see how we are going to attract employment. A lot of our growth is coming from retirement. It’s a pretty ideal community to retire to from the city. It’s financially a problem for the town. It’s going to get worse; with an aging population comes more demands on health and social services.

I would love to see Collingwood be a balance between a green community that situates itself as an innovative and modern community that’s developed interesting economies from high tech. I would also like to see a balance of the different demographics – retirees, weekenders, and locals.
Appendix I: Interview Questions

1. Please tell us your story: How did you end up doing what you are doing now? How does your history explain what you are focussing on these days?
2. What are your main concerns and uncertainties related to the future?
3. If the future turns out as you would like it to be, what will have happened 15 years from now?
4. If the future is undesirable, what will have happened 15 years from now?
5. What pivotal experiences from the past, good or bad, are important lessons for the future?
6. What major decisions with long-term implications does Collingwood currently face, that need to be tackled within the coming year?
7. What major constraints are you experiencing, inside or outside Collingwood that limit what you can achieve?
8. When you have moved on from your current position, to another position or to retirement, what do you hope to leave behind? What do you want to be remembered for?
9. Who do you think needs to be involved in this project?
10. Anything else you want to say?
Appendix II: List of Interviewees (alphabetical by last name)

1. Ian Adams - Reporter, Wasaga Sun and Commodore, Collingwood Dragon Boat & Canoe Club
2. Richard Bowering - Owner, Eagle Adventure Experiences and Director, RTO7
3. Fred Dobbs - Manager, Stewardship Services at Nottawasaga Valley Conservation Authority
4. Larry Dunn - Chairman and CEO, Harbouredge Capital Corporation
5. Nancy Farrer - Director, Planning Services at the Town of Collingwood
6. Andrew Hill - President, Georgian Triangle Development Institute
7. Kathy Jeffery - Councillor, Town of Collingwood
8. Wendy Martin - Manager, Parks, Recreation and Culture at the Town of Collingwood
9. John Megarry - President, Collingwood Rowing Club
10. Tim Morris - Member, Condominium Board at Lighthouse Point and Principal, Tim Morris Consulting
11. George Powell - Vice-Chair, Watershed Action Group
12. Michele Rich - Executive Director, Environment Network
13. Brian Saunderson - Deputy Mayor, Town of Collingwood
14. Philip Tarlo - Owner, Collingwood Cooking Academy and Willow Trace B&B and Director, RTO7
15. Norm Wingrove - President, Blue Mountain Watershed Trust
16. Gayle Woods - CAO, Nottawasaga Valley Conservation Authority
Analysis of Availability of Datasets Required to Support Proposed Visualization Tools Covering Collingwood Shoreline of Georgian Bay

Completed by Hendrik Amo, Manager GIS/IT, Nottawasaga Valley Conservation Authority

Scope of Analysis

Nottawasaga Valley Conservation Authority (NVCA), as a partner in the project entitled “Transformative scenario planning in Collingwood using enhanced visualization tools” (the “Project”), was tasked with analysis of the availability, adequacy and approximate cost of several datasets required to support the visualization tools contemplated by the Project. The desired datasets included:

- Ortho-corrected aerial imagery covering the Collingwood shoreline;
- Bathymetry data covering the nearshore (out to 2m of depth) along the Collingwood shoreline, at a resolution of 15cm-20cm;
- Terrestrial digital elevation models for the Collingwood shoreline within 50-100m of the shore.
- Land parcel data along Collingwood shoreline.

Summary of Findings

Ortho Imagery

As the Project would benefit NVCA’s business, 2012 Ortho Imagery could be made available. NVCA owns this dataset and has distribution rights. If the more recent 2013 product is desired, a formal request must be made to Simcoe County / Town of Collingwood for permission to use the data (which would likely be granted). To secure more recent images, covering the higher water levels from 2014-5, newer imagery could be captured at high-resolution, but there would be additional costs and time delays:

- $30,000 - $50,000 to purchase an Unmanned Aerial Vehicle and sensor equipment and training
- $6,000 simulation software
- Contract consultant to carry out survey, up to $25,000
- Permits to conduct aerial survey data capture (which can take months to secure)

Bathymetry

The dataset which it had been hoped could provide bathymetry data for the desired shoreline at the desired resolution – using LIDAR flight data generated by the Canadian Hydrographic Services (CHS) in 2013 – is not yet available for us to look at. However, my informal investigation has led to the conclusion that this data set, when available, may contain substantial holes. I’ve contacted other agencies who have also inquired about this data set’s availability (MNRF, Env Canada, and Severn Sound Env.), and they all confirmed this conclusion:

Quote: “We actually thought it would be possible after LiDAR was captured for the Nottawasaga Bay in 2013-4. Unfortunately, there was ice cover in the nearshore area so we do not have data for the 0-3 metre zone. Another complication is that the Canadian Hydrographic Service is the owner of the data and it is not shared widely. In fact, EC had to write a special agreement to gain access and we are not permitted to share… not that it matters given that the important zone was not captured.”
This data could be generated using a combination of a RTK GPS and a water surface vessel (with the appropriate sensors) – it would cost $50,000-$100,000 and could require a full season to gather. If time is available, data collection partnerships could reduce this cost substantially (Georgian Bay bathymetry data is desired by several entities). If the Project was satisfied with a “proof of concept” effort, we might combine the best available bathymetry data to create a “representative” sub-surface, but the accuracy and resolution would not approach the specified levels.

**Terrestrial Digital Elevation Model (DEM)**
NVCA could provide a DEM for the study area at 1 metre contour resolution. Utilizing unmanned aerial vehicles could support capture of higher resolution data – with costs as mentioned above. If the Project chooses to capture Bathymetry though RTK GPS and sensors, terrestrial data could be included in the scope of the work.

**Parcel Fabric**
This data is available and NVCA has access to it, but its use is restricted. If NVCA is to provide this data, we would need to confirm we are not in any violation of our access agreement. I do not believe providing the OPA parcel data set would be a concern. Parcel data could also be provided by Town of Collingwood.

**Ortho Imagery**

**Description:**

- An **orthophoto, orthophotograph or orthoimage** is an aerial photograph geometrically corrected ("ortho-rectified") such that the scale and overhead perspective is uniform.
- Orthophotos can be used just like a map to measure true direction and distances, because they are an accurate representation of the Earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt.
- Imagery resolution can vary, with some imagery collected better than 10 cm.
- File formats include MrSID, GeoTIFF, JPEG2000, JPEG, ECW.

Sample Data:
**Availability:**

Older Data: **2002; 2008; 2010**

Current Data:

**2012** – Simcoe County

- Available through NVCA and/or Simcoe County
- 10 cm and 20 cm resolution

**2013** - South Central Ontario Orthophotography Project - 2013 (SCOOP 2013)

- This image data is the result of over 40 private and government entities working together under the guidance of the Ontario Ministry of Natural Resources (OMNR), Land Information Ontario program
- Available through LIO (Land Information Ontario) or Simcoe County
- 20 cm Resolution

**Data (New) Acquisition:**

The MNRF does not plan to obtain orthoimagery for the study area in the near future. Simcoe County has had some preliminary discussion (internally) regarding a 2016 flight, however at this point there is no set plan for acquisition. Partnerships, budget, and counsel approval have yet to be established.

While there are survey companies such as First Base Solutions or Northway mapping who have the equipment to collect ortho imagery, their methods can be expensive (eg Pilot/fuel)

**UAV / UAS – Unmanned Arial System**

- An **unmanned aerial vehicle** (UAV), commonly known as a **drone**, and also referred to as an **unmanned aerial vehicle** and a **remotely piloted aircraft** (RPA); rebranded commercially as an UAS
- Utilizing UAS technologies, ortho imagery can be collected on a site specific basis. There are two types of commercially available, **Fixed Wing** and **Rotary**. Each has their advantage points and limitations. Both options require specialized training and a series of permissions/rules to follow in order to operate in public open space; however are economical viable options to collect Imagery at the site specific level.
- Specialized camera equipment and sensors are mounted on the UAS to capture the desired information, post processed on the PC.
- This technology can be used to collect elevation / survey data

Local companies that offer Ortho-Imagery data capture services:

SANI-ITA:  [www.sani-ita.com](http://www.sani-ita.com)
JD Barnes / First Base Solutions:  [www.jdbarnes.com](http://www.jdbarnes.com) / [www.firstbasesolutions.com](http://www.firstbasesolutions.com)
Northway:  [www.northway-photomap.com](http://www.northway-photomap.com)
Cansel:  [www.cansel.ca](http://www.cansel.ca)
Infinitejib:  [www.infinitejib.com](http://www.infinitejib.com)
Options for acquiring UAV - UAS technology:

- Purchase system
- Lease equipment
- Contract the work out to a third party
- Partnerships

**Bathymetry**

**Description:**

- "Bathymetry" originally referred to the ocean's depth relative to sea level, although it has come to mean “submarine topography,” or the depths and shapes of underwater terrain.
- In the same way that topographic maps represent the three-dimensional features (or relief) of overland terrain, bathymetric maps illustrate the land that lies underwater. Variations in sea-floor relief may be depicted by color and contour lines called depth contours or isobaths.
- Bathymetry is the foundation of the science of hydrography, which measures the physical features of a water body. Hydrography includes not only bathymetry, but also the shape and features of the shoreline; the characteristics of tides, currents, and waves; and the physical and chemical properties of the water itself.

Sample Images:

*Bathymetric Survey mass points, interpolated contours, and derived sub-surface model*

*Lake bed surface*
Bathymetry of Lake Huron

Bathymetry of Lake Huron has been compiled as a component of a NOAA project to rescue Great Lakes lake floor geological and geophysical data and make it more accessible. This project is a cooperative effort between investigators at the NOAA National Geophysical Data Center's Marine Geology and Geophysics Division (NGDC/MGG), the NOAA Great Lakes Environmental Research Laboratory (GLERL) and the Canadian Hydrographic Service (CHS). Through NOAA and CHS, a spatial data set is available (contours 5m intervals) or as an Imagery Grid). While this data set is available, it is too coarse for the Project’s purposes.

- There would be an opportunity to interpolate contours from this product (with DEM 3D shoreline) to provide representative depths for a “proof of concept”. Here is a simplified version that NVCA makes available.
Bathymetry through Third Party “Navigation” Charts

Navionics:

- Navionics integrates the sonar logs from individual users with existing data to ensure the SonarChart becomes more and more precise, even in the ever-changing conditions of sea, lake and river bottoms. Navionics accepts sonar logs from all major plotter/sounder brands and mobile devices.
- Bathymetry maps featuring extraordinary bottom contour detail are used to increase awareness of shallow waters.

DFO / CHS – CHS has another product (flown circa 2014), generated using bathymetric LiDAR along certain stretches of Georgian Bay shoreline. However, this data set has not been made available for licensing through CHS.

LiDAR (Light Detection and Ranging)

- **LiDAR** systems can gather digital elevation data to be used in mass point data sets, and in DEMs. LiDAR is composed of an airborne GPS with a GPS base station, an Inertial Measurement Unit (IMU), and light-emitting scanning laser. The airborne GPS determines the in-flight three-dimensional position of the sensor, and the IMU determines the attitude of the sensor, i.e., the roll, pitch and heading.
- Topographic LiDAR can measure elevations on land using the travel time of a red laser pulse. **Airborne LiDAR mapping (ALM)** uses a large number of near-vertical laser pulses to develop a digital elevation model (DEM) of the terrain. As topographic LiDAR also uses backscattered energy to determine distance, multiple travel times are possible for each beam in areas with tree cover. Many LiDAR applications require “bare-earth” DEM to be developed, so one task of LiDAR analysis involves identifying and removing the objects that sit on the ground, such as trees and buildings.
- Bathymetric LiDAR uses a blue-green laser, which penetrates clear water easily. **Airborne Bathymetric LiDAR (ABL)** deploys two lasers from the aircraft: the red laser measures the height of the sea surface since it does not penetrate the water; and the blue-green laser measures the distance to the seabed (provided enough backscatter energy returns to the aircraft). The time difference between the two laser returns gives the depth of water.
- Bathymetric LiDAR works very well in depths up to about 50 metres, when the water is clear and the seabed is light-coloured. It is not suitable for measuring depth if the
water is turbid or if there are suspended materials in the water column, such as air bubbles, fish or kelp.

I’ve contacted various other agencies (MNRF, EC - Great Lakes Issue Management and Reporting Section, Severn Sound Environmental Association) regarding this data, comments include:

- Data captured near shore is not reliable or available as ice formations existed during time
- Product is not ready for release
- “We’ve filled out the data Application Form in April 2014, have yet to receive the data”.

**Data (New) Acquisition:**

The scope of this Project would require collection of nearshore bathymetric data - up to 2 metres in depth. Retaining a vendor to collect ABL using large airborne equipment (planes / helicopters) is not feasible for this exercise – time or money.

With the advancement in technology, bathymetric data collection sensors have become available that might be cost effective for our purposes. Sensors can be attached to small boats, remote controlled vessels, flotation devices, to capture the information.

- Can run very shallow
- Single and multiple-beam depth sounding and acoustic bottom tracking
- Water sound speed corrections are interpolated in both space and time
- Water column velocity (currents) mapping can be captured
- Can be coupled with RTK (Real Time Kinematic) GPS for position accuracy

**Sample Products:**

*The HyDrone™ RCV is a hand-portable, remote controlled hydrographic survey platform. HyDrone RCV conducts bathymetric surveys in ponds, lakes, rivers, and streams. It accomplishes the same results as much more expensive RC survey systems, has a wide profile to avoid tipping, and watertight construction. It's rugged, lightweight, and is manufactured from high quality marine components. The system is easily disassembled for transport and shipping. Work environments include mines, sewage treatment plants, contaminated lakes, harbors, and rivers.*
The **HydroSurveyor™** is a system designed to collect bathymetric, water column velocity profile, and acoustic bottom tracking data as part of a hydrographic survey. The two key components of the system are the HydroSurveyor Acoustic Doppler Profiler platform, and the data collection software.

**NVCA** has equipment that captures depth data through similar technology:

- RiverSurveyor S5. - Portable five-beam 3.0 MHz/1.0 MHz acoustic Doppler current profiler/discharge measurement system intended for use from moving boats and other floating platforms in shallow channels. System is provided in a 5 inch (13 cm) diameter Delrin housing and consists of 3.0 MHz velocity measurement transducers in a 4-beam Janus configuration, 1.0 MHz vertical acoustic beam for **depth measurement**, temperature sensor, and 8 GB recorder. Features bottom tracking, internal discharge calculation, RiverSurveyor Live! Windows software for real-time display of current profiles, **bathymetry** and computed discharge measurements.

NVCA is currently is testing the RiverSurveyor’s capabilities, in an open water scenario, as the organization looks to this technology to support their programs.

**TRCA** (Toronto and Region Conservation) has been contacted to inquire what services they may be able to provide.

- TRCA has the equipment, expertise, and resources to collect the desired data. Along Toronto’s waterfront (and other water bodies in their Jurisdiction) their survey dept. provides this service to TRCA’s programs.
- With a scheduled work plan and compensation, TRCA staff could be made available to collect bathymetry along the Collingwood shoreline.

Options:
- Purchase / Lease Equipment

**Suppliers (Not limited to):**
- SonTek:  [www.sontek.com](http://www.sontek.com)
- Cansel:  [www.cansel.ca](http://www.cansel.ca)

- Contract the work out to a third party

FURGO:  [www.fugro-pelagos.com](http://www.fugro-pelagos.com)  (ABL Services)

**Partnerships** - I’ve been asked if we would be willing to acquire data via a partnership, not to create duplicate efforts. There are current data collection exercises going on in other parts of Georgian Bay, along the Severn Sound section.
Terrestrial DEM

Several elevation products could be derived from already collected terrain data. The elevation products could include a Triangular Irregular Network (TIN), contour lines, and Digital Elevation Models (DEM). The elevation products would be generated from a Digital Terrain Model (DTM) that is a combination of mass points and breaklines. There are many ways to create the contours and DEMs that would be required as input to the Project’s hydraulic models. Each product will have its own level of accuracy.

DEM’s represent the elevation of bare earth at regularly spaced intervals in eastings and northings. DEM’s are usually displayed as uniformly spaced grids. DEM data is suitable for automated analyses where breakline information is not important. DEMs may neglect breakline information as the DEM is grid based. DEMs are slightly less accurate than TINs, or mass points from which they are averaged or interpolated. DEMs can be produced by a variety of methods:

Breaklines - are linear features that describe a change in the slope, smoothness, or continuity of a surface. Breaklines are produced using either stereo photogrammetric procedures or digital ortho-photography. Breakline features are digitized as two-dimensional features. Breaklines are generally created for stream centerlines, drainage ditches, tops and bottoms of streambanks, ridge lines, road crowns, levees, bulkheads, seawalls, road/highway embankments, and features that constrict the flow of water.

DTM (Digital Terrain Model) - is the combination of mass points and breaklines that can be used to generate a TIN.

TIN (Triangulated Irregular Networks) - a TIN is a set of adjacent, non-overlapping triangles computed from point, line, and polygon data interpreted from mass points and breaklines. The TIN model stores the topological relationship between triangles and their adjacent neighbors. A TIN allows for the efficient generation of surface models for the analysis and display of terrain surfaces. A TIN model can be used to generate contour lines and DEMs.
TIN generation from mass points and breaklines with generated contours

Data Availability:

2002: First Base Solution product, NVCA owns this data set

- 1m Metre contours
- Mass Points (x,y,z) and 3D Breaklines +/- 80cm accuracy

2012: Update to the 2002 product, same specs. Data was collected during low water conditions, adding value to the near offshore elevations.

2013: From the SCOOP project (see orthoimagery section) an unclassified point cloud was delivered with the acquisition; can produce bare earth DEM data. Specialized software is required, Inpho, and a multi-step process to go from unclassified point cloud to reliable bare earth DEM. $70K (plus labour) required to process the information.

New Data New Acquisition:

Following options outlined in the orthoimagery section, sensors could be attached to UAVs to collect LiDAR or Photogrammetry elevations. This data could be spec’d at a higher resolution than the currently available data.
**Parcel Fabric**

**Municipal Parcel data**

Source: Ontario Parcel Alliance (OPA), Available as an ODGE member with some restrictions, only access to address information

- The Ontario Parcel is one of Land Information Ontario's (LIO) key data sets. LIO provides assessment and Crown parcel data to municipalities, government ministries, conservation authorities, and other users. Please note that municipalities must access the ownership data from Teranet Enterprises Inc. Eligible organizations must enter into the appropriate Ontario Parcel licenses and become members of the Ontario Geospatial Data Exchange to access the Ontario Parcel data. With these agreements in place, Ontario Parcel data is available at no cost.
- The Ontario Parcel database was developed through a partnership between Teranet Enterprises Inc., the Municipal Property Assessment Corporation and the Ministry of Natural Resources.
- Through NVCA membership of OGDE (Ontario Geospatial Data Exchange) parcel data (Parcel boundaries with ARN and Address) can be acquired from LIO for the purpose of NVCA business.
  - This includes watershed planning; municipal address information for public inquiries and planning / regulation applications; and Source Water Planning

County of Simcoe/Town of Collingwood – Data available through Collingwood as a sub-licensee, if work carried out is for the Township planning purposes.
Developing an Environmental Change Visualization for Community Consultations and Development

by Adam Fenech and Andrew Clark
Centre for Climate Management, University of Prince Edward Island

1. The Importance of Visualizing Environmental Change

The application of 3D visualization offers a unique learning opportunity by providing the potential to enhance the capacity of communities to strengthen their planning practices (Burch, 2010). An emerging approach to enhancing participation and awareness-building at the local level is the use of 3D landscape visualisation to depict past and future community scenarios. Various forms of imagery including GIS-based tools, 3D modeling and photo-manipulation have been explored to investigate landscape change and management (Al-Kodmany, Using visualization techniques for enhancing public participation in planning and design: process, implementation, and evaluation, 1999) (Tress, 2003) (Lewis, 2006) including some early research on the potential to visualize climate change futures (Dockerty, 2005) (Nicholson-Cole, 2005) (Sheppard S. &., 2007). These highlight the potential for visualization to influence an individuals’ perceptions of landscapes, floods, and a changing environment, which in turn may influence cognitive and affective (or emotive) understanding and influence individual and collective behaviour to respond appropriately to risks. (Sheppard S. , Landscape visualization and climate change: the potential for influencing perceptions and behaviour, 2005) has summarized how visualization may contribute as an effective tool for communities in building their capacity to address the impacts of environmental change.

These include:

1. By integrating the analytical (including predictive) capabilities of GIS-based software with the emotionally-rich and intuitive media of photo-realistic software;

2. By representing recognizable places and local information in a realistic manner (as opposed to more abstract representation) that increases personal relevance (Daniel, 2001) (Sheppard S. , Landscape visualization and climate change: the potential for influencing perceptions and behaviour, 2005);

3. By presenting both past and alternative futures (allowing for choice) to assist with decision making (Al-Kodmany, GIS in the urban landscape: Reconfiguring neighbourhood planning and design processes, 2000) (Appleton, 2003) (Steinitz, 2003) (Sheppard S. , Landscape visualization and climate change: the potential for influencing perceptions and behaviour, 2005); and

4. By using computer visualization techniques that allow for modification and user-feedback in a participatory manner for refinement and analysis (Sheppard S. , Validity, reliability, and ethics in visualization, 2005).
The goal is to give citizens of communities a new way to explore their surroundings and the future changes due to environmental change through an interactive geospatial visioning tool for stakeholders that visually displays the potential effects of environmental change (Schroth, Pond, Shappard, & Paar, 2010). By using 3-Dimensional (3-D) geo-visualization on 2-Dimensional (2-D) displays, this approach allows the creation of depth cues and high levels of detail not seen by 2-D maps. In addition, by using 3-D visualization techniques that are closest to the normal human perspective (Meng, 2002), more geographic variables are able to be shown and understood while keeping the cognitive load low to the user.

Using this 3-D geo-visualization platform, this approach can communicate the future outcomes of environmental change due to changing lake levels or climate changes derived from the projections in a visual setting. It can also incorporate the current strategies for adapting to these changes, as well as show future possible adaptation efforts. This platform uses augmented reality and virtual reality to allow for a contrast in photo-realism and carto-realism (Meng, 2002), as both have been shown to be important for users (Haller, 2004). The platform can also be used in the mobile environment whereby GPS capabilities of mobile phones can be used to give a visualization of the past, present and future environment from where you stand (in situ).

This approach for showing environmental changes is presently being used on Prince Edward Island where the threat of coastal environmental change is evident. It is being developed as an interactive tool known as CLIVE.

2. CLIVE: a Science-Based Interactive Visualization Tool for Communities

The Coastal Impacts Visualization Environment (CLIVE) is an analytical geo-visualization tool created by researchers at the University of Prince Edward Island (UPEI) Climate Lab and Simon Fraser University’s (SFU) Spatial Interface Research Lab. CLIVE is both a geo-visual interface and an analytical information visualization workflow. It combines available coastal data, historical records and predictive climate change models and translates them into a 3D geo-visual information tool that can be explored and queried by non-scientist stakeholders. It allows citizens of an entire province to explore past environmental change, and how future environmental changes may impact coastal communities due to sea-level rise at various scales.

CLIVE combines data from numerous sources, including an extensive province-wide archive of aerial photographs documenting coastline erosion as far back historically as 1968, and the latest high-resolution digital elevation data derived from laser surveys known as LiDAR, a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light. These historical data and model projections of future sea-level rise are used to develop analytical visualizations of coastal erosion regimes and potential future sea-level rise scenarios. These geo-visual outputs are then delivered using a 3D game engine technology adapted to serious scientific communication.
CLIVE enables citizens to interactively navigate and view a 3D virtual environment of the province of Prince Edward Island (PEI) constructed from accurate historical spatial data and recent LiDAR surveys of topography. Users can view this 3D environment from distance, by flying around it overhead for an overview. They can also explore the data and virtual landscape from first-person on-the-ground perspectives, to inspect detailed local-scale historical environmental change, and projected impacts. While navigating CLIVE PEI from any perspective, at any scale, users are able to select and manipulate multivariate overlays of historical data and projected models through time.
By allowing citizens to view scientific data and explore climate change projections at any scale in their own neighborhood, the aim is to help them understand these often abstract phenomena at local, human scales. By delivering this science and its implications for real coastal communities using agile non-technical game engine technology (rather than specialized and expensive geographical information systems) closes the gap between expert science and citizens. Reconnecting abstract expert science to geographic spaces at risk, with a public information tool, using an inclusive public engagement approach, is a way to connect all stakeholders to this mutual problem. By educating citizens and raising awareness, CLIVE aims to encourage engagement, support dialogue and collaborative problem-solving at all scales of society and government.

Before CLIVE was introduced to the public on Prince Edward Island, it was deemed it necessary to consult with professional associations such as the planners, engineers, insurance brokers, real estate agents, watershed groups as well as elected government officials as a courtesy so that they could be prepared for the public response. This courtesy turned into a legitimizing step in the process as each professional association greeted CLIVE with an acceptance and response that raised CLIVE’s profile and importance. For example, on 21 January 2014, CLIVE was introduced to the Honourable Janice Sherry, Prince Edward Island Minister of Environment, Labour and Justice and her staff. She reacted strongly to the vulnerability of Prince Edward Island coastlines and arranged for the full Prince Edward Island Government Caucus to visit the Climate Research Lab at the University of Prince Edward Island on 7 February 2014. Twenty-six members including the full provincial Cabinet were present to view CLIVE target the home of the Honourable Wes Sheridan, the PEI Finance Minister, under conditions of future sea level rise and coastal erosion. The Prince Edward Island Association of Planners, a branch of the Atlantic Planners Institute, was introduced to CLIVE on 20 January 2014 and commented that the “set-back regulations”, those permits for building homes or cottages close to the coast, may have to be revisited. Over 100 members of the Prince Edward Island Real Estate Association attended a public lecture on CLIVE on 11 February 2014 as a requirement of continuing professional development. And the Prince Edward Island Watershed Alliance, a non-profit cooperative association of watershed management groups on Prince Edward Island whose overall goal is “to improve and protect the environmental quality of Prince Edward Island watersheds for the benefit of all Island residents,” was introduced to CLIVE on 29 January 2014, and showed no surprise at the vulnerability of PEI coasts to sea level rise and coastal erosion.

![Figure 3: Public consultation, presentation and engagement with CLIVE](image-url)
Over three hundred members of the Prince Edward Island public attended a public lecture on CLIVE on 11 February 2014. This, coupled with extensive national print media coverage (Globe and Mail) and national radio media coverage (Canadian Broadcasting Corporation’s World Report), prompted many provincial, national and international coastal home or cottage owners to contact the Climate Research Lab at the University of Prince Edward Island in an attempt to examine CLIVE more closely. To meet this demand, the provincial government sponsored the Climate Research Lab to conduct community consultation sessions across Prince Edward Island in 2014 including Victoria (July 8), Souris (July 9), Abram Village (July 15), Montague (July 17), North Rustico (July 22), Charlottetown (July 23), Summerside (July 24) and Alberton (July 30). Each session was hosted by Dr. Adam Fenech who presented an introduction to PEI’s vulnerability to coastal erosion and sea level rise, introduced CLIVE, examined the vulnerability of local communities and answered questions. Each session was also preceded and concluded with a written survey to gauge attendee’s knowledge, concern and willingness to adapt to coastal erosion and sea level rise. The concern for coastal erosion of each participant was high (presumably that was the motivation for attending the session), and increased after being introduced to CLIVE. One notable exception where the concern dropped considerably was likely because their property was not affected by the CLIVE visualizations of future sea level rise and coastal erosion. Most importantly, these sessions motivated coastal home or cottage owners to respond to their vulnerability by increasing their resilience to the anticipated sea level rise and coastal erosion.

The sessions that introduced CLIVE to the Prince Edward Island public focused discussions on community action in response to such a significant vulnerability to anticipated future coastal erosion. CLIVE presented visually an anticipated threat to coastal homes and cottages that was quantitative and targeted individual coastal structures motivating owners to consider planned adaptation. Planned adaptation was presented initially as an anticipatory response for future development articulated as “do not build so darn close to the coast.” It also led many to decide to act now, and take action for existing coastal infrastructure, centred around: (1) doing nothing; (2) retreating by physically moving infrastructure away from the coast; (3) accommodating the vulnerability by adjusting the infrastructure such as raising homes on pilings; and (4) protecting by armouring the shoreline with soft engineering (for example, nourished beaches) or hard engineering (for example, seawalls) approaches. These adaptation options were the only ones raised in the public hearings.

The team that created CLIVE won an award in 2014 from the Massachusetts Institute of Technology for Communicating Coastal Risk and Resilience. The PEI Association of Planners name the team winner of the 2014 Murray Pinchuk Community Builder Award. The award recognizes the highest standard of community building in the public and private realms, and recognized UPEI efforts to develop a coastal erosion visualization tool and work to share ideas on how best to adapt to coastal erosion and sea level rise.

A similar visualization tool to consult with communities about planning issues and environmental change can be built for the town of Collingwood, ON.
3. Terrestrial Data Needs to Build CLIVE-Collingwood

The terrestrial component of CLIVE-PEI was built using fine-resolution aerial photos overlaid over a LiDAR-derived fine-resolution digital elevation model (DEM). Both of these types of data are very expensive and time-consuming to capture and process. One of the major obstacles in developing CLIVE for other regions is access to this high resolution imagery which has been overcome through the application of a small unmanned aerial vehicle (sUAV). The sUAV is a system that provides integrated end-to-end surveying and GIS (Geographical Information Systems) solutions that can be applied to develop CLIVE. After the initial start-up cost, the operation and maintenance costs of the sUAV are quite low, effectively being only that of personnel, and travel. An appropriate launch site can be chosen up to several hundred metres away and using a preprogrammed flight path, the sUAV flies itself to the desired location and captures high resolution imagery using an array of multi-spectral sensors including a new LiDAR sensor. The sUAV is Geographical Positioning System (GPS)-enabled and can fly the exact same path repeatedly, capturing imagery of a particular location at different times of the year. With this approach, locations can be monitored producing incredibly high resolution data (<2cm) to feed the development of a CLIVE-Collingwood.

The Precision Hawk Lancaster is a light weight (2.4kg) fixed wing aircraft complete with a carbon fiber framework, a swappable payload capacity for a multitude of sensors, and range up to 5km. The Lancaster is a battery operated, front propulsion unit with a 50 minute endurance. The system is launched by hand; flight monitored using a ruggedized tablet PC and communicates with the aircraft via a ground control station. A demonstration video of the Precision Hawk Lancaster system and procedure is available at its website at www.precisionhawk.com. The multitude of sensors that can be swapped on the Lancaster include an enhanced resolution visual sensor, a high resolution multi-spectral sensor, a radiometric thermal sensor, a line scanning LiDAR sensor, and a line scanning (push broom) hyperspectral sensor.
The Precision Hawk Lancaster is a known airworthy system receiving a grant of exemption by the US Federal Aviation Administration (FAA) which relieves the system from regulations described in the documentation [www.faa.gov/uas/legislative_programs/section_333/media/trimble_navigation_limited_11110.pdf](http://www.faa.gov/uas/legislative_programs/section_333/media/trimble_navigation_limited_11110.pdf). The exemption requires compliance with safety procedures, approvals, and airworthiness standards.

The communication system is comprised of two 2.4 GHz radio modems, 1 onboard the aircraft and 1 connected to the ruggedized tablet PC. The system is used to relay the flight performance and other important values down to the ground control station for the pilot to monitor as well as transmit flight safety manoeuvres to the aircraft in case of emergencies. The field application software allows the pilot to monitor the flight performance (air speed, ground speed, location, flight height, and throttle) along with other important values (battery and flight progress) as well as perform flight safety manoeuvres (right, hold, here, fly to, land and Flight Termination System (FTS)).

The primary mode of distant communication will be the Cobra CXT 145C Walkie Talkies. This Walkie Talkie is ideal for situations where you need reliable two-way communication. The compact, water-resistant design boasts a 50 km range, 22 channels (7GMRS/FRS, 7 FRS, 8 GMRS), and a range of convenient features that ensures dependable, hassle-free communication no matter the situation. 10 NOAA weather channels keep you prepared for storms and emergencies and rechargeable batteries with micro-USB make it easy to recharge. The operating vehicle will be equipped with recharging docking stations. It can be seen below from the navigation chart in Figure 5 that the study area falls outside the controlled airspace of local airports. Communication will take place prior to beginning the project and before each flight to ensure safety in the airspace with air traffic controllers at local airports.

![Figure 5 – Study Area navigation chart showing controlled airspace at local airports.](image-url)
A control link operating in the 2.4 GHz frequency band is used between the Precision Hawk Lancaster and the ground control station. This link provides real-time position and flight information to the pilot in command as well as control of the aircraft for pilot-directed operations (e.g., manual fail-safe modes). No R/C frequencies are utilized for aircraft operation. The Precision Hawk Lancaster is developed and sold for the purpose of photogrammetric surveying & mapping applications. The imagery that is captured by the aircraft is stored directly on the sensor payloads and is not transmitted in real-time to the ground control station. Once a flight is complete, the ground crew is responsible for downloading the flight data and images from the aircraft.

Visual observers are always ground-based and within 750 m horizontally and 300 m vertically from the aircraft under normal flight conditions. Visual observers are usually stationed at or near the take-off and/or landing area for the duration of the flight. However, this is not a requirement or limitation and visual observers can be stationed at any safe location necessary. The data control link offers up to 5 km range on 2.4 GHz spread spectrum with robust, channel hopping interference resistance. Ground crew will have cell phones on their person at all times with all crew members, air traffic control, and emergency numbers preprogrammed into the contacts. Backup power docking stations will be available in the operation vehicle. Cell coverage is known to be available in the study area.

The ground control station is comprised of a ruggedized tablet PC with specialized field application software designed to plan and monitor unmanned aircraft operations. The tablet PC communicates with the aircraft using a communication system (described below). The Lancaster system utilizes one ground control station per aircraft. The communication system is comprised of two 2.4 GHz radio modems, 1 onboard the aircraft and 1 connected to the ruggedized tablet PC. The system is used to relay the flight performance and other important values down to the ground control station for the pilot to monitor as well as transmit flight safety manoeuvres to the aircraft in case of emergencies.

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<thead>
<tr>
<th>Ground Control Rugged Tablet</th>
<th>Ground Control Modem</th>
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<tr>
<td><img src="image1.png" alt="Rugged Tablet" /></td>
<td><img src="image2.png" alt="Modem" /></td>
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**Figure 6 – Ground Control Station**

The primary operating crew will consist of three graduate student members; Andrew Clark (Pilot in Command or PIC), Derek Ellis (Visual observer and support), and Evan Macdonald (Visual observer and
support). Additional students may be onsite for additional support. All crew members are Environmental Scientists with extensive GIS experience. Crew members have participated in a 3-day training session offered by the Precision Hawk company in flight principles, air law, flight performance, operational procedures, meteorology, operational planning, human factors, UAS flight training, and emergency handling. During the 3-day training session, crew members received 5+ solo flights each and took a written test on the last day of training. Upon satisfactory completion of flights and test, crew members received a “pilot’s certification” from Precision Hawk. Crew members are trained in first aid and will operate under the direction of Pilot in Command, Andrew Clark. The crew will work together to ensure no scheduling conflicts occur during the proposed mission timeline.

Mission planning calculations based on sensor specifications and image overlap required by post processing software to accurately create ortho-mosaics is essential. The highest resolution data possible with the Precision Hawk Lancaster system at 2.4cm resolution (GSD) will be gathered for the Collingwood area. This will require more images and flight lines (calculations shown below) but will result in better imagery. The Enhanced Resolution Visual Sensor and the customized LiDAR instrumentation used in the Precision Hawk Lancaster has a wide field-of-view with increased shutter speed and has a larger overlap of images than other systems, resulting in better accuracy of the DSM that is generated from the photos. A focal length of 15mm, 4.8µm CCD and array size of 4912 x 3264px results in the following calculations pertinent to the mission – flight height = 75m, each flight will cover = 2 km², total flights needed for Collingwood area = 17 flights, total flights per day = 3, total days required for mission = 6 weather friendly days. Considering the variability of the weather in this region we will estimate the total time needed to complete data acquisition for the mission to be 2 full weeks.

The most time consuming field aspect of the mission will be in the placing and measuring of ground control points. However, this is essential for accurate ortho-rectification and appropriate time should be allocated. Photo identifiable ground control points will be utilized when available; however, the majority will be pre-marked control points. For this mission we want to ensure the highest accuracy possible so we will use 8 ground control points when possible, evenly spaced, for each flight. A goal of 2 hours is set for setting up and measuring ground control points for each flight. This would lead to about 3 hours per flight including flight time. Depending on crew size and availability, placing ground control points can begin during flight. The crew will utilize several large capacity SD cards for sensor storage for a streamlined workflow. A fresh SD card will be loaded into the sensor after each flight so the next flight can begin immediately. During the next flight, a crew member will download the data from the previous flight onto the field laptop. Post processing will begin on off days due to weather and will continue for 1 week following data acquisition. Therefore, an estimated time of delivery for Collingwood 2.4cm resolution imagery is set at 3 weeks.

The data shown in Figure 7 was captured using a lower resolution sensor than that used in the Precision Hawk Lancaster. The dataset which was provided by GeoCUE, Corp. was flown over a gravel mining site located in the Wiregrass Region of Alabama and contains the following items: 1) 89 JPEG files. The images have impeded geotag for the camera position extracted from an airborne GPS. The geotag defines the location of the image in space at the instant of the image exposure. 2) Coordinates values for 8 Ground Control Points in NAD83 (2007), Alabama State Plane Coordinates System, East zone in
meter and Elevations are provided in NAVD88, Geoid 12A (control.csv). The imagery was processed using Pix4D software and demonstrates a proof of concept for image capture and ortho mosaic and DSM (Digital Surface Model) generation. The sample data output can be seen below. This imagery was used to produce a mini-CLIVE as shown in Figure 9.

Figure 7 – Ortho Mosaic(left) and DSM(right) at 2.0cm resolution processed in Pix4D.
Red represents higher elevations in the DSM.

Figure 8 – Zoomed in versions of the output data showing the detail capable with this technology.
4. Bathymetric Data Needs to Build CLIVE-Collingwood

To capture bathymetric data of the accuracy equivalent to the sUAV-derived terrestrial data (<2cm), a cost and time effective approach is also required. The best approach is using the Bathymetric Automated Survey System (BASS) developed by the Ontario Ministry of Natural Resources which catalogues the steps, and provides computer software, to construct a map showing water depth contours and underwater structure of lakes and rivers. A tool that can be used to efficiently conduct surveys of lake bathymetry is one that combines sonar, a global positioning system (GPS) and a data recorder/processor. To construct these water depth contour maps, a series of transects are run from the shoreline using an echo sounder to measure water depth, a GPS for location, and a computer to record the observations. Feeding this information into a geographic information system (GIS) or the BASS software, allows for contour lines to be drawn at desired intervals (probably 0.1m). The equipment used to conduct lake surveys is mounted in a boat, and, as the boat moves across the water surface of a lake, depth readings from the sonar and position readings from the GPS are recorded simultaneously at time intervals selected by the user. See Figure 10 for an example of a lake transect survey for bathymetric data.
A Garmin GPS sounder/depth finder system can be attached to a standard 5-gallon bucket lid-mount for quicker, more efficient bathymetric survey data collection (Figure 11a). This system provides for ease of transport, set up and storage (Figure 11b), and needs only a boat and two people to operate (Figure 11c). Utilizing a high sensitivity global positioning system (GPS) receiver and dual-beam transducer (sonar transponder) (Figure 11d) to plot location and water depth, the system transfers stored data using a Secure Digital (SD) card for rapid download to a computer. Data processing involves opening the *.adm file extension, and loading it into the MapSource® software program, transferring it and saving the data as a text file.

![Figure 11 - (a) 5-gallon bucket lid-mounted Garmin GSPmap 536s sounder/depth finder system. Transom mount (at right) resting on bucket lid; (b) Depth finder system components: Garmin GSPmap 536s sounder/depth finder, dome antennae (both mounted on bucket lid), battery charger with vehicle adapter plug, 12V battery with vehicle adapter socket, and transducer clipped to bucket rim; (c) Manual depth readings are used to verify depth finder readings. This is done to confirm depth finder accuracy and/or determine the need for a correction factor; (d) Transducer (lower left) shown where it is to be bolted to the bottom of the transom mount and depth adjusted on site. External GPS antennae shown mounted to bucket lid.](image)

The text file is cut and pasted into an Excel spreadsheet, processed and saved as a *.csv file extension format for import into the ESRI ArcMap GIS program. ESRI ArcMap is used to analyze the data and display the map. The shoreline is digitized from the National Agricultural Imagery Program (NAIP) imagery. The *.csv file can be imported and overlaid onto the imagery. The 3D Analyst routine in ArcMap is used to create a Triangular Irregular Network (TIN) of the data points and the shoreline (Figure 12). The TIN creates bathymetric contours and enables the calculation of reservoir volume. Surveyed benchmarks and the inlet riser structure elevation serve as points of known reference. Shoreline points serve as the zero contour to tie bathymetric data to the surrounding ground topography (Figure 13). The distance of the transducer below the water surface is measured (Figure 11c) to provide a plotting correction factor for the data processing phase of the survey.
The system allows for use of two people in the field; a boat driver and bathymetric survey equipment operator. Using two people provides for safety, increased speed, accuracy, and efficiency in conducting a bathymetric survey, as opposed to using a smaller or larger team. The team coordinates to prepare the boat for launch, system set up, adjusting the transducer to a transom mount assuring a proper and equipment safe reading depth, and connecting the transducer cable to power. Once powered up the unit requires a short time to acquire a satellite signal. A calm weather day on the water is preferred for more accurate data collection as well as general boating safety.

Generally, a bathymetric survey can be carried out at any time during the ice-free period. However, aquatic vegetation can significantly interfere with accurate depth readings. In order to minimize this error, it is strongly recommended that water bodies with prolific aquatic vegetation are sampled either in early spring prior to establishment of macrophytes or late fall following macrophyte die off.

This approach will provide bathymetric data (underwater topography) from shoreline to 12m at 0.1m intervals for inclusion into a mini-CLIVE tool to be known as CLIVE-Collingwood.

5. Budget

The total budget cost for the collection of the terrestrial and bathymetric data, and the development of a CLIVE-Collingwood visualization tool that allows users to fly over Collingwood and raise and lower water levels up onto terrestrial environment and down through bathymetry is estimated at about $90k.
### Development of CLIVE-Collingwood

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1. Terrestrial Data

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#### Equipment

- Lancaster sUAV supplied
- Imagery sensor supplied
- Ground control station supplied
- Miscellaneous equipment supplied
- Differential GPS supplied

#### Output

Aerial imagery at fine resolution (<2.5cm) for Collingwood coastline that can be developed into a 3D visualization tool known as CLIVE-Collingwood.

2. Bathymetric Data

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#### Equipment

- Garmin GPSMAP7612 supplied
- Boat Rental supplied
- Miscellaneous supplied

#### Output
Contour data at fine resolution (<10cm) for Collingwood bathymetry that can be developed into a 3D visualization tool known as CLIVE-Collingwood.

3. CLIVE-Collingwood

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Output

3D visualization tool known as CLIVE-Collingwood whereby users can fly over Collingwood and raise and lower water levels up onto terrestrial environment and down through bathymetry.

Works Cited


