TECHNICAL REPORT (TASKS 2.2 and 2.4)

CONTRIBUTION TO THE CREATION OF FLOOD ZONE MAPS FOR THE QUEBEC PORTION OF THE LAKE CHAMPLAIN/ RICHELIEU RIVER SYSTEM:

PRODUCTION OF A DIGITAL ELEVATION MODEL OF THE SHORELINE

TRANSFORMATION OF WATER SURFACES INTO FLOOD ZONE LIMITS

Submitted to: International Joint Commission

By:
Hydrological Expertise Team, Quebec Ministry for Sustainable Development, the Environment, and the Fight Against Climate Change

Research and analysis by:
Frédéric Côté and Stéphane Comtois

Written by:
Frédéric Côté, Stéphane Comtois and Richard Turcotte

Edited by:
Jacinthe Morency

November 27, 2015
# Table of Contents

1. Introduction ................................................................................................................................. 1

2. Topography: Production of a digital terrain model of the shoreline (Task 2.2) ......................... 4
   2.1 Source data ............................................................................................................................ 4
   2.2 Digital elevation model (DEM) ............................................................................................ 5
   2.3 Post-processing of data ......................................................................................................... 8

3. Mapping flood zones on the basis of water surfaces (Task 2.4/Quebec component) .............. 12

4. Conclusion ................................................................................................................................ 22
1. Introduction

The mission of the Hydrological Expertise Team of the Quebec Ministry for Sustainable Development, the Environment, and the Fight Against Climate Change (French acronym: MDDELCC) is to use its expertise in hydrology and its knowledge of the hydrology of the watercourses of Quebec to contribute to informed, safe, equitable decision-making about the management and use of Quebec’s water resources. In particular, the team provides products and services that meet the needs of Quebec water stakeholders so as to support them effectively. To do so, the team observes and forecasts water levels and flows, performs hydrological and hydraulic modelling, and applies geomatics to these activities.

In response to the flooding in the spring of 2011, the Hydrological Expertise Team, on behalf of the Government of Quebec, began developing tools that would let floods be forecast further in advance. To this end, a new hydrometric station was added at Saint-Paul-de-l’Île-aux-Noix, QC. This station transmits the levels of the Richelieu River in real time and posts them on the Internet. It complements the stations operated by Environment Canada on the Richelieu at Carignan and Saint-Jean-sur-Richelieu, QC and on Lake Champlain at St-Armand, QC, as well as those operated by the U.S. Geological Survey on Lake Champlain. In addition, a system that forecasts three days into the future was put in place to anticipate changes in the flows of the Richelieu River at Carignan, QC. This system is operated in co-operation with Environment Canada, for the weather forecasts, and with the U.S. National Weather Service for the forecasts of the water levels of Lake Champlain at Rouses Point. However, the complexity of the hydrological system of Lake Champlain and the Richelieu River (for example, as regards the effect of winds on flood flows) means that work on developing and improving these tools must continue.

In this context, a representative of the Hydrological Expertise Team (Richard Turcotte, Eng, Ph.D.) was appointed as a member of the International Lake Champlain-Richelieu River Technical Working Group (ILCRRTWG) established by the International Joint Commission (IJC). This working group has been tasked with providing the IJC with advice and guidance for the accomplishment of two major objectives that are part of the ongoing development of tools for observing and forecasting water flows and levels:

1. Address and close data gaps for the earliest possible initiation of a real-time flood forecasting and inundation mapping system;

2. Create static flood inundation maps.

The work plan issued by the ILCRRTWG in January 2015 describes the various tasks that the IJC wants performed to achieve these two objectives. The IJC has assigned two of these tasks to the MDDELCC Hydrological Expertise Team. These technical tasks involve applying geomatics to the hydraulics of watercourses and relate mainly to the second objective in the work plan. They represent a specific, targeted contribution by the Hydrological Expertise Team. Hence the sole purpose of the present report is to describe the technical work that has been completed. This report does not deal with broader issues related to the major objectives of the project. Geographically speaking, this report deals only with the work done in the Quebec portion of the Lake Champlain/ Richelieu River hydrological system. This portion includes the entire Richelieu River to the point where it empties into the St. Lawrence, as well as the Missisquoi Bay section of Lake Champlain.

---

The following excerpts from the work plan describe the basic tasks that are the subject of the present report:

Task 2-2 Creation of a quality-controlled Digital Elevation Model (DEM) from available LiDAR datasets along the Richelieu River and Missisquoi Bay of Lake Champlain (CEHQ).

The CEHQ will produce a digital elevation model (DEM) of the Missisquoi Bay and Richelieu River flood plain between the average high water shoreline delineation and an upper limit compatible with the U.S. DEM of 106 ft in first approximation, for Lake Champlain. This DEM will be developed from various existing LiDAR datasets that are already controlled for quality and have an average density of one point per square meter on the ground. This initial resolution may be reduced to limit computational costs if needed. As a final deliverable, the DEM will be exported for hydrodynamic simulation in a suitable format …

and:

Task 2-4 Creation of static inundation maps (CEHQ and USGS)

In Canada, a finite number of discrete maps (~10) are envisioned to represent a range of hydraulic scenarios comprised between the average spring flood and beyond the extreme high water observed in 2011. The flood inundation maps will cover the entire shoreline of the Richelieu River and of the Canadian portion of Lake Champlain to document the extent of the flooding under a finite number of hydraulic scenarios corresponding to lake elevations. Results of hydraulic simulations from task 2-3 will be imported in Arc/GIS to produce flood zone models by intersecting the profiles of the water surface with the DEM of the Richelieu River and Missisquoi Bay. These models will then be cross-referenced with the DEM to identify flood limits. Conventional maps (in pdf format) or digital maps would be produced as deliverable … ”

… Flood inundation maps from the U.S. and Canada will be consolidated by the CEHQ and USGS so that the final products are produced in as consistent a manner as possible for use by other agencies and communities on both side of the border. Static maps will refer to the historical observed context rather than through frequency analysis performed on lake levels and river discharges that could prove difficult to resolve under this directive. The IJC will publish the Canada – U.S. consolidated static maps.

To provide a better idea of the scope of these tasks, here are some more general information and some details that became clearer as the work progressed.

First, it was agreed that the digital model to be provided under Task 2.2 would show the elevation of the land surface but excludes the elevation of the water surface and of any buildings and other objects that rise above the land surface. Environment Canada would add the bathymetry data to the Digital elevation model (DEM) so as to produce a model compatible with the needs of hydraulic modelling.

Second, it was decided that the exact number of hydraulic scenarios to be mapped in Task 2.4 would be 11. For the Quebec part of this task, Environment Canada would be responsible for providing the water surfaces for each of these 11 scenarios, covering the entire flooded area. The MDDELCC Hydrological Expertise Team would then be responsible for delimiting the flood zones in a consistent manner for the 11 scenarios, applying the necessary quality controls and manual editing methods.
Lastly, the ILCRRTWG has agreed that the final cartographic products resulting from Task 2.4 will be numerical files. The IJC will assume responsibility for making these files viewable on an appropriate background map on a web site.

It should be noted that this version of this report does not discuss pooling with the U.S. partners.
2. Topography: Production of a digital elevation model of the shoreline (Task 2.2)

Remote sensing of elevation by laser, commonly known as LiDAR (Light Detection And Ranging), is a measuring technology based on analyzing the properties of a laser beam that is reflected back to the point from which it was transmitted. LiDAR elevation sensing has been commonly used in recent years to map the flooded areas corresponding to a water surface or profile. The vertical and horizontal accuracy of LiDAR elevation data surpasses that of the products used in the past, which were based on interpolating topographic curves and spot elevations. The accuracy of LiDAR data is fairly comparable with that of hydraulic simulations that provide water lines or surfaces. This makes LiDAR a tool that is very well suited for the delimitation of flood zones.

2.1 Source data

In the present project, three different sources of LiDAR data were combined. They came from three separate measuring campaigns, conducted in 2008, 2010 and 2013. The technical specifications for these three campaigns were the same, so the resulting data have similar characteristics. Figure 2.1 shows the geographic areas covered by each of these measuring campaigns.

It should be emphasized that the source data were made available to the present project solely for the purpose of delimiting flood zones. The data remain the property of their original owners. No distribution of the source data for purposes other than the production of the final products of the present project is authorized. Only the final derived products—the delimitations of the flood zones—will be the property of the IJC and may be distributed.
2.2 Digital elevation model (DEM)

The purpose of combining the data from the three sources was to create a digital terrain model for use in hydraulic modelling. A digital terrain model differs from a digital elevation model in that a digital terrain model does not include objects that rise above the land surface, such as buildings, vegetation, and bridges. Also, for hydraulic applications, it is essential to combine the topographic information on land elevations with the bathymetric information on the elevation of the beds of watercourses. The hydraulic model is thus used to estimate the level of the water or the depth of the water for various conditions of flow over the terrain model.

Figure 2.2 shows an overview of the DEM for the Richelieu River basin. As this map shows, this area is divided into two distinct sub-areas, both of them fairly flat, with potentially quite extensive flood zones. An elevation change of about 10 m, upstream from the Chambly Basin, marks the dividing line between these two sub-areas.
Figure 2.2. Overview of the DEM for the shorelines of the Richelieu River and the Missisquoi Bay portion of Lake Champlain. Unit: metres

The data from which Figure 2.2 was generated come from a dot plot whose density is generally about one point per square metre on the ground. The trace of each point on the ground is also about 1 m². The elevation obtained at each point is thus an elevation that represents, on average, a surface area of 1 m² on the ground. The vertical error specific to the airborne positioning system is on the order of 3 cm. However, the various properties of the soil and its occupancy influence the quality of the return
signal, so that the accuracy of the elevation measurements is generally assumed to be about ± 15 cm in open terrain and ± 25 cm in wooded terrain.

The data producer provides a classification of the various points. To create our digital terrain model, only the “Ground” class was used. For the entire project area (the selected tiles shown in red in Figure 2.1), there are 2.3 billion points classified as “Ground”, or 85% of the LiDAR points surveyed in the selected tiles as shown in Figure 2.3.

![Classification Codes](image)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Point Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Unassigned</td>
<td>38 350 105</td>
<td>1.38</td>
</tr>
<tr>
<td>2 Ground</td>
<td>2 372 075 937</td>
<td>85.50</td>
</tr>
<tr>
<td>3 Low Vegetation</td>
<td>367 470</td>
<td>0.01</td>
</tr>
<tr>
<td>5 High Vegetation</td>
<td>278 419 942</td>
<td>10.04</td>
</tr>
<tr>
<td>6 Building</td>
<td>8 616 420</td>
<td>0.31</td>
</tr>
<tr>
<td>9 Water</td>
<td>76 363 127</td>
<td>2.75</td>
</tr>
</tbody>
</table>

Figure 2.3: Screen shot showing the distribution of points within the various classes from the data sources

The other classes that would have been relevant in a digital elevation model, such as the heights of vegetation or buildings, were not used in our digital terrain model. Lastly, the data classified as “Water” were also excluded. In the specific context of creating a model for purposes of hydraulic modelling, the elevations of the points below the water surface come from bathymetry data. The task of officially including these data in the model is the responsibility of Environment Canada. However, as we note in the section on post-processing of the data, we did use certain bathymetry data to validate and adjust the DEM.

Figure 2.4 shows an example of a distribution of LiDAR elevation points, in the area around Saint-Jean-sur-Richelieu, QC. As just discussed, only the points representing ground (the coloured areas in the figure) have been retained. Some of the excluded data points (the white areas in the figure) can be readily identified as water surfaces or as buildings in built-up areas.
2.3 Post-processing of data

To minimize the number of points that would have been classified as ground but that were actually water surfaces, we performed a validation and correction step. For this purpose, we used some additional data from other sources.

First, we used a set of orthophotos from the 2009 database for the administrative region of Montérégie, QC and the 2011 database for the Montreal Urban Community to validate the positioning of the limits of the watercourses. Polygons delimiting the water surfaces were prepared manually by a technician.

Figure 2.5 presents an example of the final result of the delimitation of the polygons that represent the water surfaces in the orthophotos. In those cases where LiDAR data points had been classified as ground but the orthophotos showed that these points were actually in areas of water, these points were excluded from the terrain model. In total, 76 million points were deemed to be associated with water areas and hence excluded from the DEM—slightly less than 3% of the 2.3 billion points initially identified as ground.
Figure 2.5. Polygons (blue areas outlined in red) representing water surfaces according to the orthophotos, shown on the base map, in the area around the Chambly Basin

Figure 2.6 shows a case where the bases of a band of trees were at approximately the same elevation as the water, which made the associated points hard to classify. In cases such as these, we considered it best to exclude the points from the DEM and use the bathymetry data for these areas instead.

The second additional dataset that we used consisted of bathymetric measurements, which we incorporated on a preliminary basis to check whether the areas that should have been below the water’s surface had in fact been excluded from the ground points in the DEM. We did this by comparing the DEM and the bathymetry data. However, in cases where the classification data were ambiguous, we did not apply corrections ourselves, but instead notified the hydraulics team at Environment Canada so that they could apply the most appropriate corrective processing. Figure 2.7 shows an example of a situation which suggests that the error might have been attributable to outdated bathymetry data.
Figure 2.6. Example of a case where a band of trees whose bases were at approximately the same elevation as the water made it more difficult to classify the data points.

Figure 2.7. Example of a case where the classification is ambiguous because of contradictions between DEM LiDAR data and bathymetric data (blue: LiDAR data points classified as water; yellow and orange: bathymetric survey points). The area in the centre of the illustration shows an inconsistency that additional information suggests may be attributable to use of outdated bathymetry data.
The last step in the post-processing was the spatial transposition onto a grid. For this purpose, we used a grid with a resolution of 1 m² and populated it by linear interpolation of the LiDAR elevation points retained in the DEM. Two final products were thus available for the subsequent processing: one product on a grid and one with the original data points.
3. Mapping flood zones on the basis of water surfaces (Task 2.4/Quebec component)

The ILCRRTWG selected 11 different reference scenarios for levels of Lake Champlain for which static maps of flood zones were to be produced. These scenarios are shown in Table 3.1. The levels (measured at Rouses Point) range from 100 feet to 106 feet, with one level at every 1-foot increment. Within this range, three levels were added at 101.5, 102.5 and 103.5 feet, because these levels are considered critical for flood-response efforts and would thus make the maps more useful when such levels are reached. The 103.2-foot level was added to represent flooding comparable to that in the spring of 2011. The equivalences in the NGVD29 and NAVD88 reference systems and imperial and metric units and the estimated corresponding flows of the Richelieu River were all produced by Environment Canada. Table 3.2 shows, for information purposes, some approximate relationships between these scenarios and flood threshold levels that are of interest to the public safety authorities in Quebec.

Table 3.1: Eleven scenarios for Lake Champlain water levels at Rouses Point, expressed according to NGVD29 and NAVD88 reference systems, in feet and metres, and approximate corresponding flow of the Richelieu River. The levels shown in bold in the second column will be used as the reference for the discussions.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>NGVD29 Level (feet)</th>
<th>NAVD88 Level (feet)</th>
<th>NGVD29 Level (metres)</th>
<th>NAVD88 Level (metres)</th>
<th>Estimated Flow (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100.000</td>
<td>99.570</td>
<td>30.480</td>
<td>30.349</td>
<td>937</td>
</tr>
<tr>
<td>2</td>
<td>101.000</td>
<td>100.570</td>
<td>30.785</td>
<td>30.654</td>
<td>1106</td>
</tr>
<tr>
<td>3</td>
<td>101.500</td>
<td>101.070</td>
<td>30.937</td>
<td>30.806</td>
<td>1195</td>
</tr>
<tr>
<td>4</td>
<td>102.000</td>
<td>101.570</td>
<td>31.090</td>
<td>30.959</td>
<td>1294</td>
</tr>
<tr>
<td>5</td>
<td>102.500</td>
<td>102.070</td>
<td>31.242</td>
<td>31.111</td>
<td>1393</td>
</tr>
<tr>
<td>6</td>
<td>103.000</td>
<td>102.570</td>
<td>31.394</td>
<td>31.263</td>
<td>1492</td>
</tr>
<tr>
<td>7</td>
<td>103.200</td>
<td>102.770</td>
<td>31.455</td>
<td>31.324</td>
<td>1539</td>
</tr>
<tr>
<td>8</td>
<td>103.500</td>
<td>103.070</td>
<td>31.547</td>
<td>31.416</td>
<td>1612</td>
</tr>
<tr>
<td>9</td>
<td>104.000</td>
<td>103.570</td>
<td>31.699</td>
<td>31.568</td>
<td>1710</td>
</tr>
<tr>
<td>10</td>
<td>105.000</td>
<td>104.570</td>
<td>32.004</td>
<td>31.873</td>
<td>1958</td>
</tr>
<tr>
<td>11</td>
<td>106.000</td>
<td>105.570</td>
<td>32.309</td>
<td>32.178</td>
<td>2204</td>
</tr>
</tbody>
</table>
Table 3.2: Relationship between some of the 11 scenarios and some flood threshold levels used by Quebec’s public safety ministry

<table>
<thead>
<tr>
<th>Station</th>
<th>Local level at station, in metres (NGVD29)*</th>
<th>Flow</th>
<th>Flood threshold level</th>
<th>Scenario(s) that correspond approximately</th>
</tr>
</thead>
<tbody>
<tr>
<td>030401  (Fryers Rapids, Carignan, QC)</td>
<td>27.07 1064</td>
<td>Minor</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>27.25 1221</td>
<td>Moderate</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>27.37 1335</td>
<td>Major</td>
<td>3 and 4</td>
<td></td>
</tr>
<tr>
<td>030419  (Marina, Saint-Jean-sur-Richelieu, QC)</td>
<td>30.10 1070**</td>
<td>Minor</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.32 1225**</td>
<td>Moderate</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.47 1330**</td>
<td>Major</td>
<td>3 and 4</td>
<td></td>
</tr>
<tr>
<td>030430  (Outdoor recreation centre, Saint-Paul, QC)</td>
<td>30.56 1150**</td>
<td>Minor</td>
<td>2 and 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.89 1415**</td>
<td>Moderate</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31.06 1560**</td>
<td>Major</td>
<td>7 and 8</td>
<td></td>
</tr>
<tr>
<td>030409  (Lake Champlain, Saint-Armand, QC)</td>
<td>30.61</td>
<td>Minor</td>
<td>1 and 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.92</td>
<td>Moderate</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31.12</td>
<td>Major</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

* Not to be confused with the level of Lake Champlain

** Approximate value derived empirically from the local level

The rest of this section describes the steps that we are following to delimit the flood zones under the 11 different scenarios to produce the maps that will be posted on the IJC web site. The raw material for delimiting the flood zones is the hydraulic modelling done by Environment Canada. Thus the 11 scenarios have been (or are in the process of being) subjected to hydraulic simulations by Environment Canada (Task 2.3). At the present stage of the flood-zone-mapping exercise, the results from Environment Canada are available in shapefile format and include a wide array of simulation data and results. The result of interest for the present task is the one that contains all of the water levels reached for each of the scenarios.

The information on water levels is provided in the shapefile in the form of dot plots, most of which correspond to the nodes in the finite element mesh of the watercourse for the hydraulic model. Since only the values of the nodes are transferred for the present mapping application, the water surfaces have to be reconstructed using geomatic tools that are external to the hydraulic model and its finite element mesh.

The conversion from nodes data to water surfaces data is done by linear interpolation. In this process, a polygon is created that contains all the points and follows their limit. Within this limit, a triangulated irregular network (TIN) is then constructed, as shown in Figure 3.1. Though there can be some similarities between them, it can be helpful to clearly understand that the mesh from the hydraulic model and the TIN from the cartographic analysis are two distinct entities. For one thing, it
should be noted that the peripheral points in the domain in Figure 3.1 (the points along the limit of the polygon) have been added by Environment Canada in post-processing. These points, which here turn out to be more widely spaced than the other points in the domain, are not nodes in the hydraulic simulation mesh, but rather an interpolated extension of it. This ensures that the limits of the TIN will contain the entire flood water area. If this post-processing were not done, then in many cases the peripheral nodes in the modelling mesh would lie inside the flooded area, limiting the ability to capture the flood zone between two points.

Figure 3.1 – Example of watercourse nodes (red points) for which water levels are available. The black line represents the limits of a polygon containing all of the points. The purple lines delineate the triangles forming a triangulated irregular network (TIN).

Once the water levels at the nodes have been interpolated, the depth of the water is calculated by subtracting the DEM elevations from the water levels reached (i.e., water level minus DEM elevation = water depth). To do so, however, it is practical to perform the operations on a common spatial structure. For this purpose, we have used the grid of the DEM, with a resolution of 1 m², converting the DEM described in section 2 to the NAVD88 reference system, which is the one in which the hydraulic simulation data were produced by Environment Canada and is also the system common to the Canadian and U.S. teams working on this project. The matrix version of the water levels reached is known as the Digital Flood Zones Model (DFZM).

Figure 3.2 shows an example of the depths obtained by subtracting the DEM elevations from the DFZM elevations (i.e., DFZM elevation – DEM elevation = water depth). Analysis of this subtraction allows the following classification to be made: negative depths are exposed zones, and positive depths are flooded zones. The -0.2 m to 0.2 m interval illustrates the uncertainty of the technique. For a given scenario, the limit of the flooded area can be located anywhere within this interval.
In order to provide the user with a single line within this interval, flood zone limits are identified as zero-depth contour lines. GIS tools are used for that propose. These lines must, however, be subjected to several adjustments to make their properties satisfactory for mapping.

The first adjustment is to ensure that there is a continuous line from one end of the area under study to the other. In the present analysis, there were numerous cases where the area simulated by the hydraulic model did not extend far enough. Environment Canada therefore added points at the periphery of the hydraulic mesh as discussed earlier.
Next, adjustments have to be made on the basis of experts’ interpretations, which are guided mainly by the consistency of the results and their compatibility with the cartographic scales of the products. Thus, the shortest contour lines—generally closed curves around exposed zones—are removed. This step is known as purging. For very small lines (100 m or less), automatic methods are used. For slightly larger closed curves, an expert interpretation is applied. Otherwise the curves are closed, working upstream in each secondary watercourse according to the level reached at its mouth. When a bridge is crossed, a line consistent with the local configuration is traced.

Lastly, smoothing algorithms are applied, for which the tolerance is chosen by the expert.

Figure 3.3 shows an example of the results after application of adjustments (basically the purging and smoothing steps) to the raw lines resulting from the subtraction of the DEM elevations from the DFZM elevations.

![Figure 3.3: Example of identification of zero-depth contour lines (purple) from the grid of depth values. The black lines represent the zero-depth contour lines after purging. The green lines represent the zero-depth contour lines after smoothing.](image)

Lastly, all of the adjustments must be done in such a way as to ensure consistency among the scenarios. For example, the flood limits for Scenario 1 must fall within those for Scenario 2, and so on. This last step means that the adjustments described above, and in particular the smoothing of the lines, must be made by analyzing the 11 scenarios simultaneously.

Figure 3.4 shows all 11 scenarios for the Quebec portion of the study area. Without being able to see all the details, one can still note that water surfaces cover the banks of the Richelieu River and those of Missisquoi Bay of Lake Champlain. Also, for the scenarios with the highest water levels and streamflows, a hydraulic connection between Missisquoi Bay and the Richelieu River
by way of the South River clearly appears on the map. Figures 3.5, 3.6 and 3.7 provide enlargements of three areas of interest. The increase in the size of the flooded areas from lowest streamflow scenarios to higher streamflow scenarios is obvious in each of these figures. They also show the extent and the boundaries of where water can reach for each scenario. One should note that some small islands located within these boundaries could remain dry while being surrounded by water.
Figure 3.4 : Overall illustration of the limits of the flooded areas for all 11 scenarios that were studied
Figure 3.5: Illustration of the limits of the flooded areas for all 11 scenarios that were studied in the vicinity of Saint-Paul-de-l’Île-aux-Noix
Figure 3.6: Illustration of the limits of the flooded areas for all 11 scenarios that were studied in the vicinity of Venise-en-Québec
Figure 3.7: Illustration of the limits of the flooded areas for all 11 scenarios that were studied in the vicinity of Saint-Jean-sur-Richelieu

As a first check, Figure 3.8 shows the result when scenario 7 is superimposed with two existing sources of information about the area that was flooded in the Spring of 2011. Scenario 7 is the one that comes closest to the most extreme conditions seen during the 2011 flood although there are important differences between this scenario and the conditions existing in 2011. For example, Scenario 7 does not take into account the effects of wind or the inflow of local tributaries. In the first source of information, the extent of the 2011 flood is assessed based on the general interpretation of satellite images which have their own uncertainties. Also, this source of information is not specific to local conditions. The second source identified some areas that were known to be flooded in 2011 based on a database owned by the Quebec government. This database gives only a partial portrait of flooded areas. The analysis of Figure 3.8 leads us to believe that the hydrodynamic modeling coupled with mapping procedures represents reasonably well the flooded areas without being perfect. However, a too precise comparison of the details of what happened on the ground in 2011 with Scenario 7 will clearly show some inconsistencies as several assumptions were made for this project.
Figure 3.8. Example of a comparison between Scenario 7 (red line) and the extent of the flood in 2011 according to data sources from the Ministry of Public Security of Quebec (blue polygon: approximate water surface from a global analysis of remote sensing images taken on May 2011; red dots: a few sites identified as having been flooded)

4. Conclusion

This report describes the main activities that were carried out by the Quebec MDDELCC Hydrological Expertise Team. As described within, all of the activities associated with Task 2.2 and 2.4 in the Technical Work Group’ workplan have been completed.