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Assessing Flood Risk Preparedness in Sussex Corner

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Introduction

Flooding is a major concern in New Brunswick, and repairing damage from floods is costly, and can amount to as much as $30 million per single seasonal event as was the case in the spring of 2012 (Department of Environment and Local Government: 2012). This event involved 25 communities including Fredericton, Moncton, Saint John, Campbellton, Bathurst, Sussex, Sussex Corner, St. Stephen, Perth-Andover, Florenceville-Bristol, and Grand-Falls. Due to increasing severity of precipitation events, there is an increasing need for accurately and comprehensively delineating and forecasting flood events as they would occur across NB and elsewhere. A great part of this can in principle be done by digitizing the flood-prone areas within the lay of the land using hydrologically corrected digital elevation models. These models, at 10 m resolution, can be used to delineate the extent of most floodplains across NB and associated open water surfaces, streams and river channels, and associated wet areas. With LiDAR-DEMs, depressions, flow channels and floodplains can be further refined at 1 m resolution, with good visual conformances between image- and/or ground-based flood extent delineations and their DEM-derived counterparts, from one neighbourhood to the next.

This report focusses on flood extent and hydrological infrastructure mapping for the Sussex Corner area in New Brunswick mapping. Flooding here is recurring due to the convergence of several streams (Trout Creek, Parsons Brook, Smith's Creek, Ward's Creek, etc.) with the Kennebecasis River. Flooding is compounded by rapid snowmelt coupled with limited capacities to drain rapidly increasing flood levels through (i) low floodplain slopes, (ii) bridge- and culvert-induced flow restrictions, and (iii) and ice and debris jamming of critical hydrological infrastructure. In total, the upland water contributing areas amount to 776 km^2 as the Kennebecasis River exits the Sussex area. The most recent flood events occurred in January and April 2014.

For the flood risk assessment purpose for Sussex Corner, the following initiatives were undertaken by collaborating with the Forest Watershed Research Centre (FWRC) at UNB:

(i) Acquire 10 m digital elevation models for the Sussex Corner area, and for all the adjoining watershed areas, using the latest DEM refinement as produced at FWRC.

(ii) Use this DEM for the delineation of depressions, and flow channels (streams and rivers)

(iii) Use the delineation of the depressions to ascertain the extent of local depression flooding

(iv) Use the delineation of the creek, stream and river channels for the delineation of the flood extent along streams and floodplains.

(v) Develop flood scenarios that determine the volume of water (precipitation) and time required to fill the floodplains to a depth of 1, 2, 3 and 4 m.

(vi) Develop maps that show which particular areas would be affected as the flood extent proceeds from filling local depressions, stream channels (up to 1 m) , and floodplains (up to 4 m).

(vii) Depression, flow-channel and flood mapping was further refined using 1 m resolution DEM (LiDAR based) that includes the general Sussex and Sussex Corner areas. The water-contributing areas to the extent of this DEM were determined from the surrounding 10 m DEM. The flow-channel and floodplain areas within the 1 m.

All of this was done to achieve the following key results:

(i) To develop a LiDAR based hydrological flood risk map for the Trout Creek watershed

(ii) To expand on this for the wider Sussex Corner, Sussex area including all of the water-contributing watershed areas.

(iii) Using these maps to enable increased communications and dialogue between regional and provincial stakeholders towards better flood risk mitigation planning. This includes provision of the GIS-generated datalayers for this project in ArcMap and pdf formats, and conducting an orientation and learning workshop on how to use these layers.

(iv) To enable the development of a draft flood mitigation strategy for priority areas in Sussex Corner.

Results

This report presents the results by way of a series on maps, as follows.

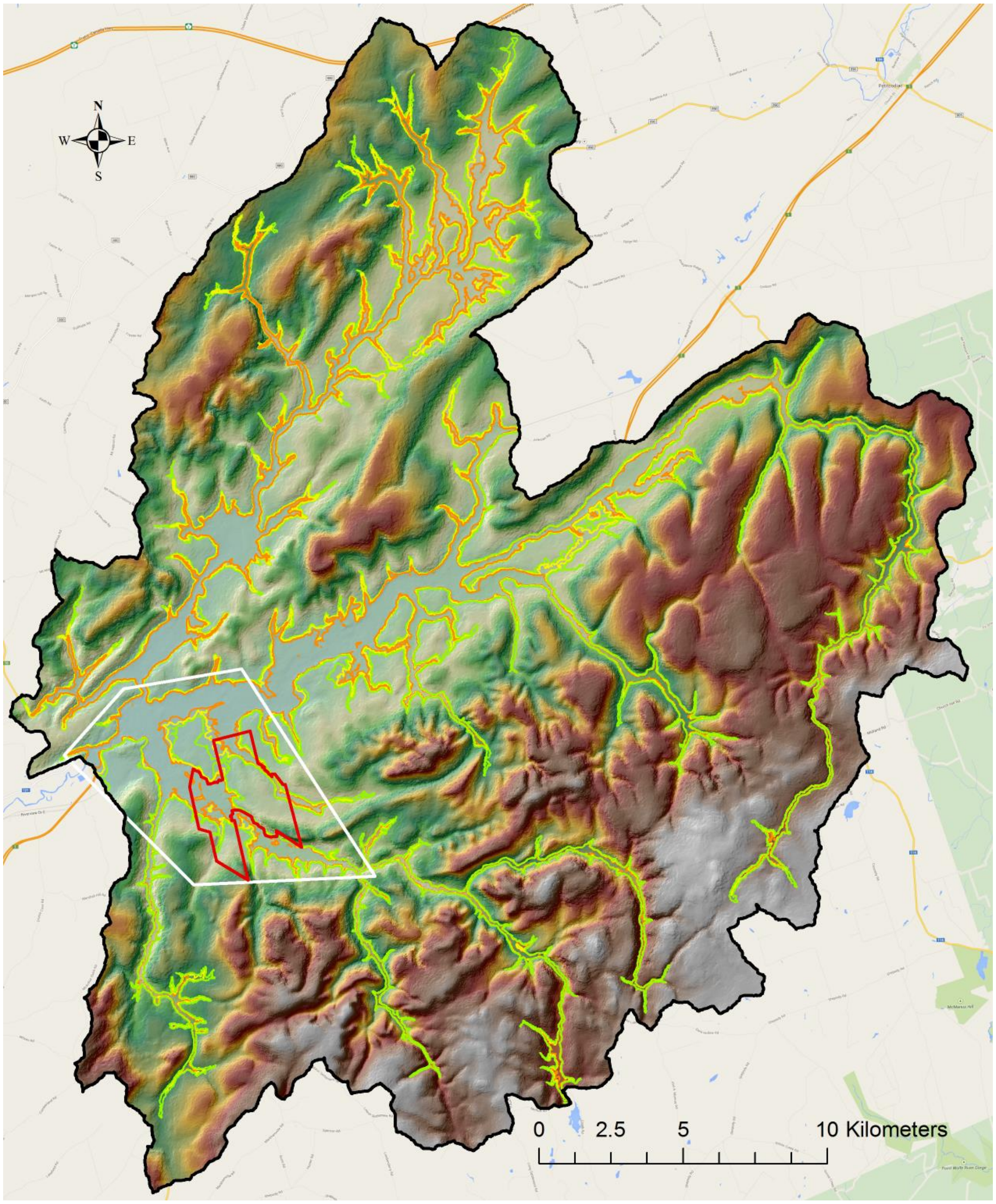

Fig.1: Map of the watershed areas of the greater Sussex Area, including Sussex Corner. This map shows the newly improved provincial DEM as hill-shaded background, with all DEM-derived flow channels and floodplains (1 to 4 m flood depth contours). The white outline depicts the LiDAR-DEM extent. The red outline delineates the Sussex Corner area.

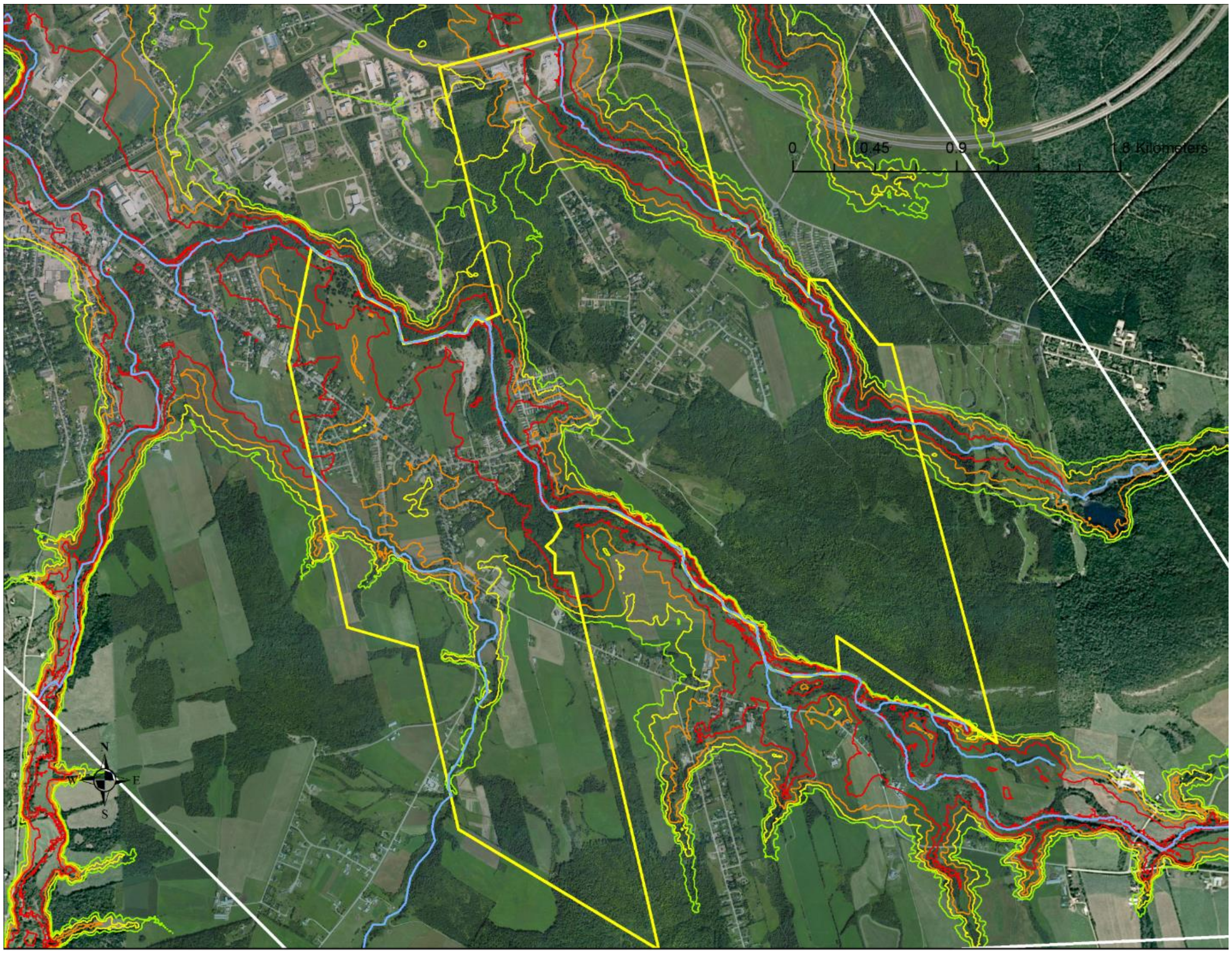

Fig. 2. Sussex Corner close-up of Fig. 1, with potential flood depths up to 4 m overlaid on surface image.

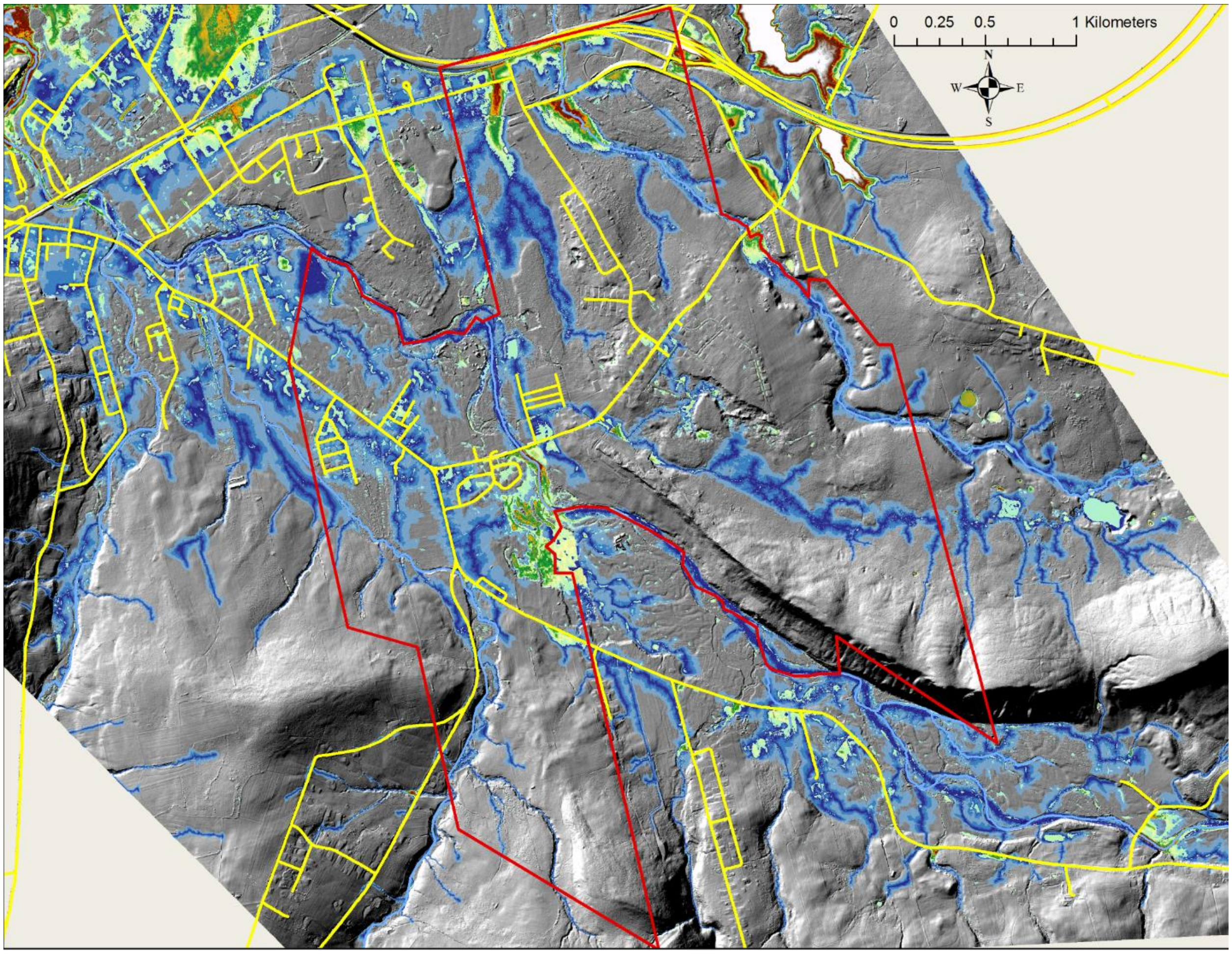

Fig. 3. Hill-shaded LiDAR-DEM for the Sussex Corner area, with roads and local flow channel influenced wet areas overlaid. Blue shading corresponds to end-of-summer soil saturation depths from 0 (dark blue) to 1 m (light blue). This also corresponds to soil drainage from very poor to moderately well, and can also be used for the interpretation of likely flood extent and depth along local flow channels, up to 1 m.

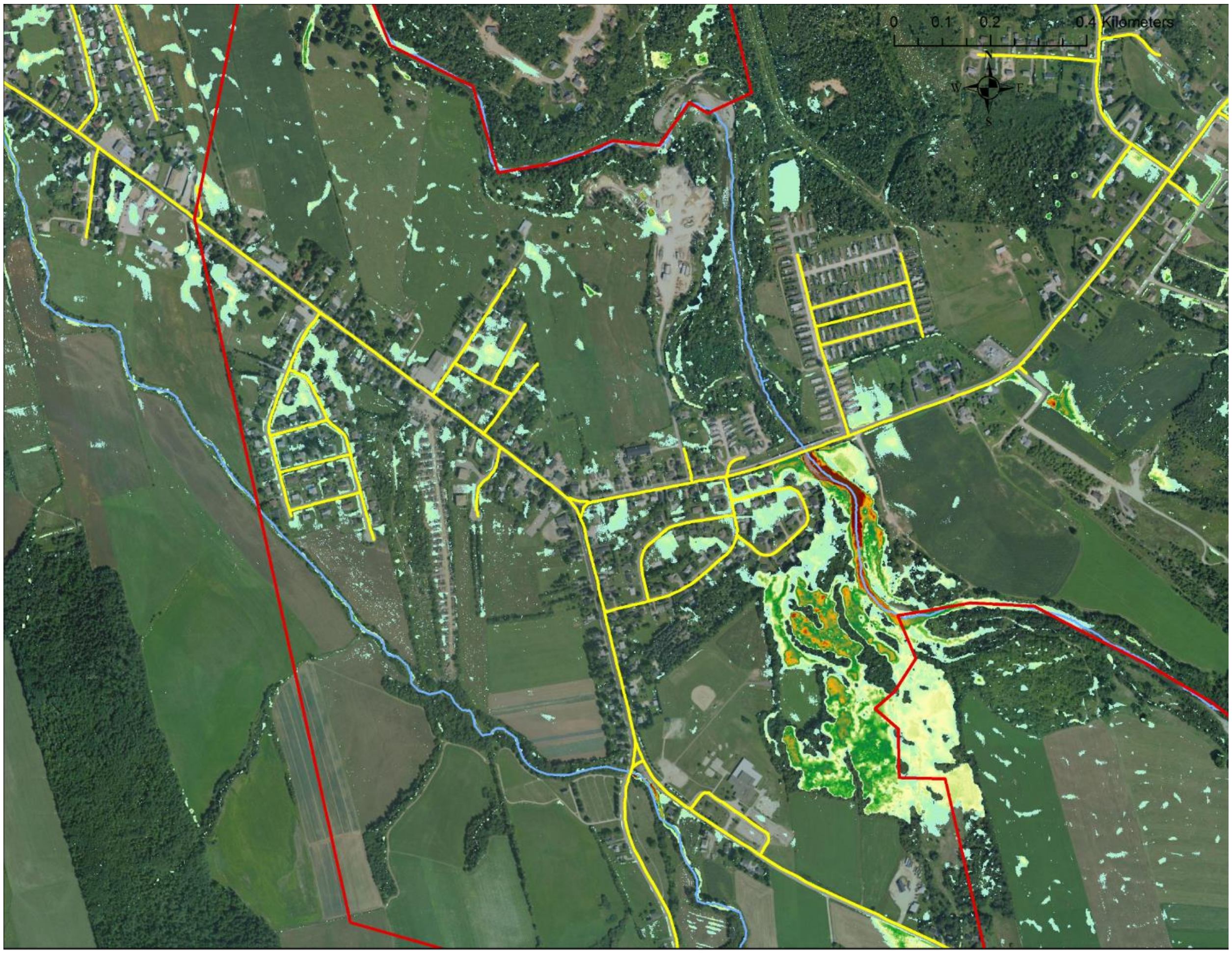

Fig. 4. Further close-up on Sussex Corner, delineating all LiDAR-DEM derived depressions local depressions, here colored by depth from light green (0.1 m deep) to red (uo to several meters deep)

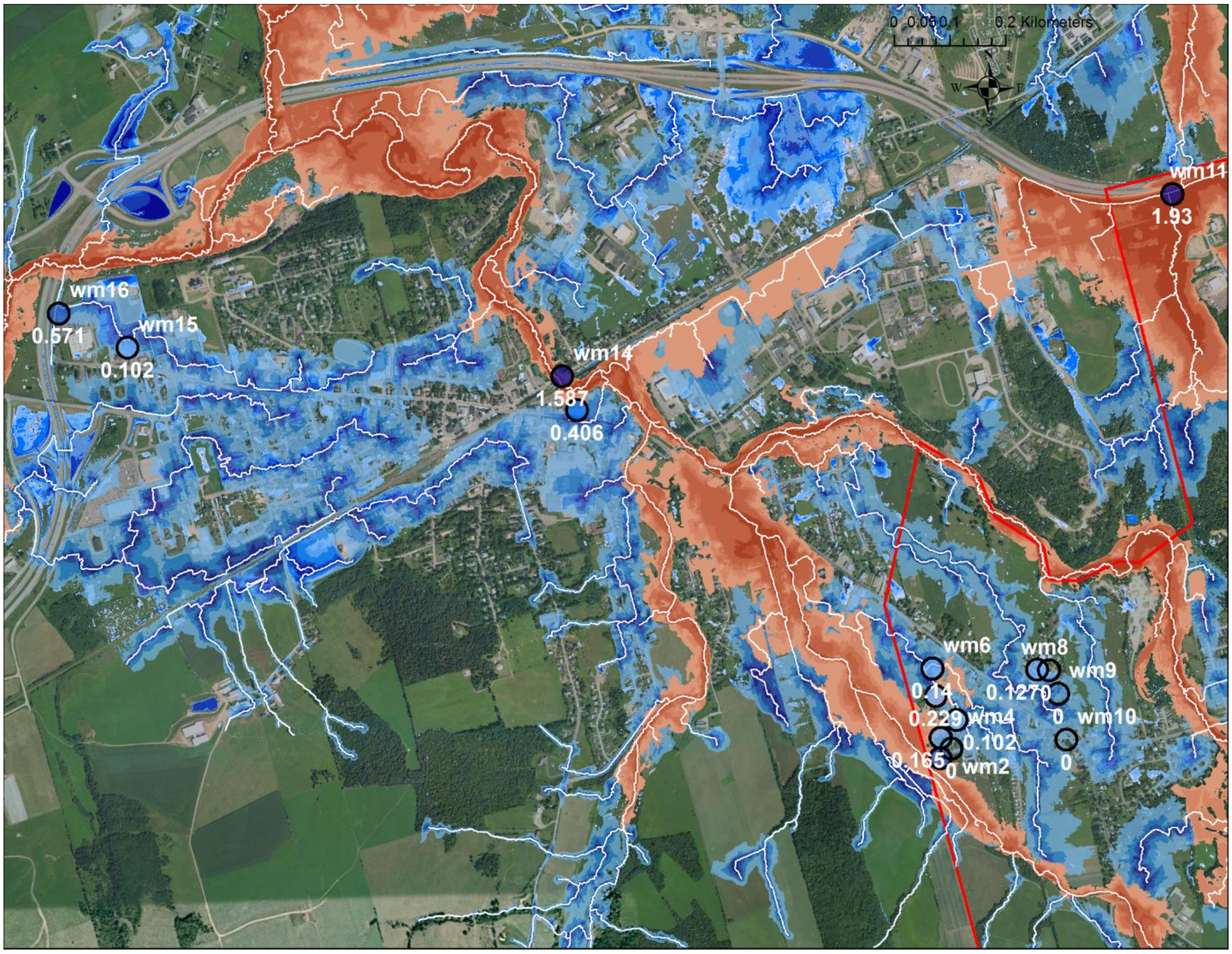

Fig. 5. LiDAR-DEM-derived extent of areas likely subject to flooding, on account of three causes: flooding due to rising water levels in the Kennebecasis River and its tributaries, colored dark to light brown, up to 1.75 m, (ii) combined depression on flow channel flooding, colored dark to light blue. The dots refer to in-field verify after-the-fact in-field verifications of the January (WM 1-6) and April (WM7-16) 2014 flooding events, generally conforming to (i) the combined LiDAR-derived depression on flow channel flooding projection, and (ii) the flood crests along bridges (e.g., WM14), and culvert-based flow restrictions (WM11).

These maps were generated from the Project –generated flood-risk assessment database for Sussex Corner. This database includes the following datalayers:

Provincial DEM for the wider Sussex area
LiDAR DEM for the Sussex Corner Sussex extent
Floodplain layers (at 1 and 10 m resolution)
Depression layer
Stream layers
Stream flood layers (1 and 10 n resolution)
Provincial stream and surface water layers
Provincial road layer

Discussion

Flooding within the Sussex Corner area, and Sussex in general, is due to multiple causes: (i) the filling of local depressions, either natural, or due to flow-restricting blocking above culverts and bridges, (ii) the filling of wet areas along flow channels, (iii) and the rising water levels within the floodplains of the Kennebecasis River and its tributaries. The flooding of local depressions and flow channels would be due to surface run-off during intense precipitation events, and low capacity of the saturated soils to accommodate this water through infiltration. Flooding along the floodplains is cause by the convergence of the watershed-focussed water, and the slope- limited capacity along the main flow channels to drain that water. The low slope conditions within and along the flood plains exacerbate this situation by limiting drainage, thus leading to water back-up. This situation is particularly the case for Sussex corner, where high water levels along the Parsons Brook and Trout Creek slow the drainage of the residential areas, in spite of their slightly elevated locations.

The in-field inspection of the after-the fact high water marks produced reasonable agreement between the LiDAR-derived flood extent after calibration. For example, the wet-area maps with a 0 to 1.25 cm depth-to-water delineation correspond well the flood depth water mark, where the flood-depth mark refers to the height of the flood above the LiDAR-derived bare-earth elevation. The same was the case by comparing the high water marks with the depth of the depression, and the difference between the flood plain generated flood level up to 2 m above the bare-earth elevations along the floodplains.

While the above calibrations correspond to the January and April 2014 flooding events, flood levels could reach higher levels, meaning that residential, commercial and industrial areas may yet experience higher flood levels depending on specific flood-producing events, such as a combination of a high rain event (100 mm/day) that also leads to a substantial snow melt situation.

While LiDAR-based flood extent mapping is more accurate than relying on provincial DEMs based on 10 m resolution, it appears from Fig. 1 that the latter can be used to assess flow volumes and flood levels across large areas for general purpose modelling and mapping, whether the flood volumes and levels are based on actual weather events or design floods based on, say, 20 to 100 year events. The LiDAR-based mapping could be interfaced with individual property maps, and related flood risk assessments.

Owing to the difficulties and expenses in establishing actual flood levels, it is recommended that high water marks be established geosptatially at the time of flooding, to enhance the accuracy of the LiDAR based flood mapping calibrations. It is also recommended that a map can be generated or provided that shows the relevant hydrological infrastructure across the community. Such a map can then be used to more fully establish local drainage patterns as provided by ditches and subsoil drainage channels. It is further recommended that this report and the related project deliverables will be used for further detailed inspections and general to specific community planning purposes. In this regard, it should be recalled that the 1m and 10 m delineations are only as accurate as the elevation determinations: these can be low as +/- 15 cm for the LiDAR DEM (open field locations) , but as high as +/- 2m for the 10 m DEM. Hence, exact correspondences between actual and project flood levels should not be expected.

There is also the need for further mapping refinements so that the mapping can be adjusted to varying weather events, and to accommodate on-going development changes as these would effect local elevations and drainage patterns.

References

ADI Ltd. 1982. Hydrotechnical Study SussexArea Flood Plain. Project No. 1852-1

ADI Ltd. 1982. Hydrotechnical Study SussexArea Flood Plain. Supplementary Report on Field Invesitigations. Project No. 1852-1

Acknowledgements

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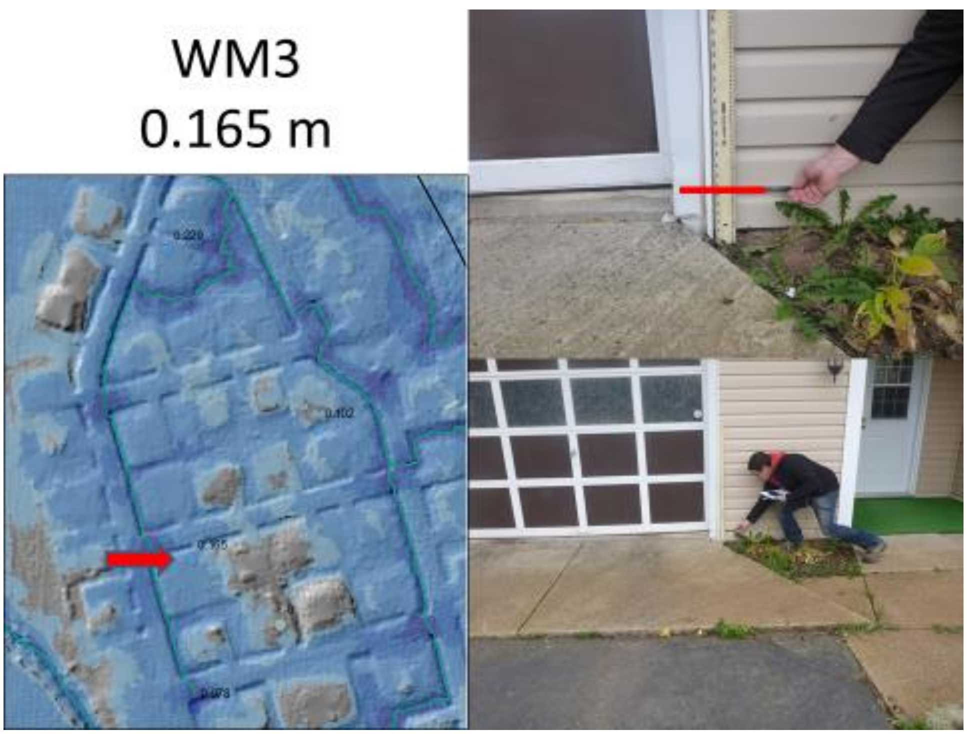
Appendix: In-field verification of flood high-water marks in Sussex Corner and beyond for January (Water Marks WM1-WM6) and April 2014 (Water Marks WM7-WM16)

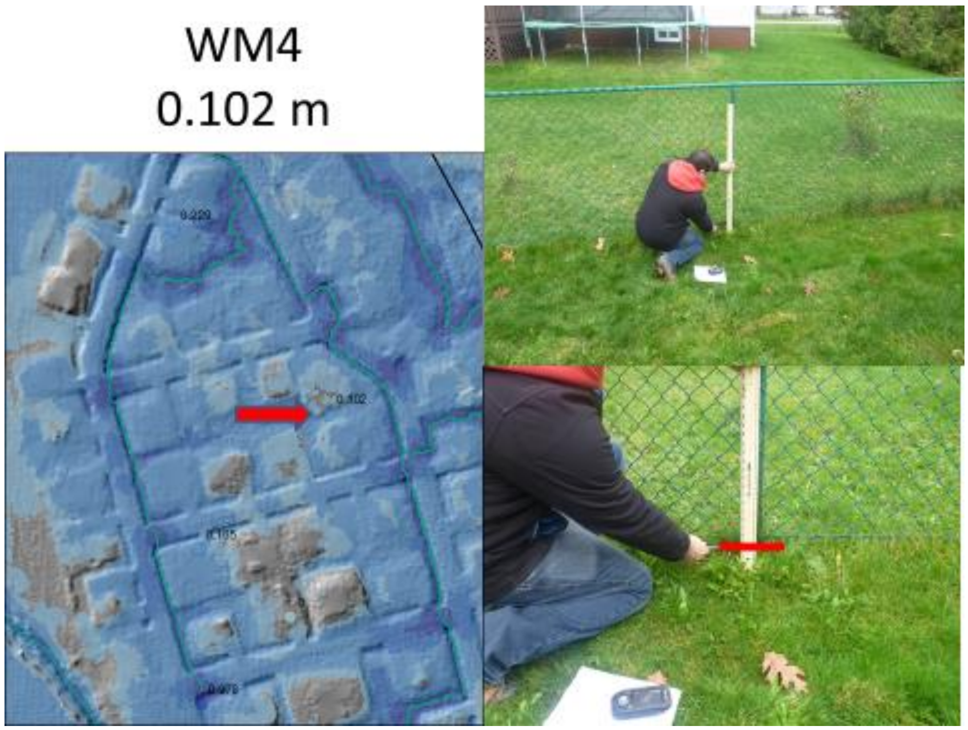
The January flood event only affected the areas represented by WM1-WM6. The more severe flooding event in April did not affect this area, but affected the other areas represented by WM7-16. The local January flood may have been caused by local ice/debris jamming along Parsons Brook towards Sussex. The April flood would have been due to rising flood levels everywhere, and especially so along Trout Creek, but the rise along Parsons Brook would not have been as high in April than in January.

Parsons Brook flood. Creighton Drive – Stockton Street. Flood filled ditch up to the red mark on top of the water hydrant; Jan. 2014.

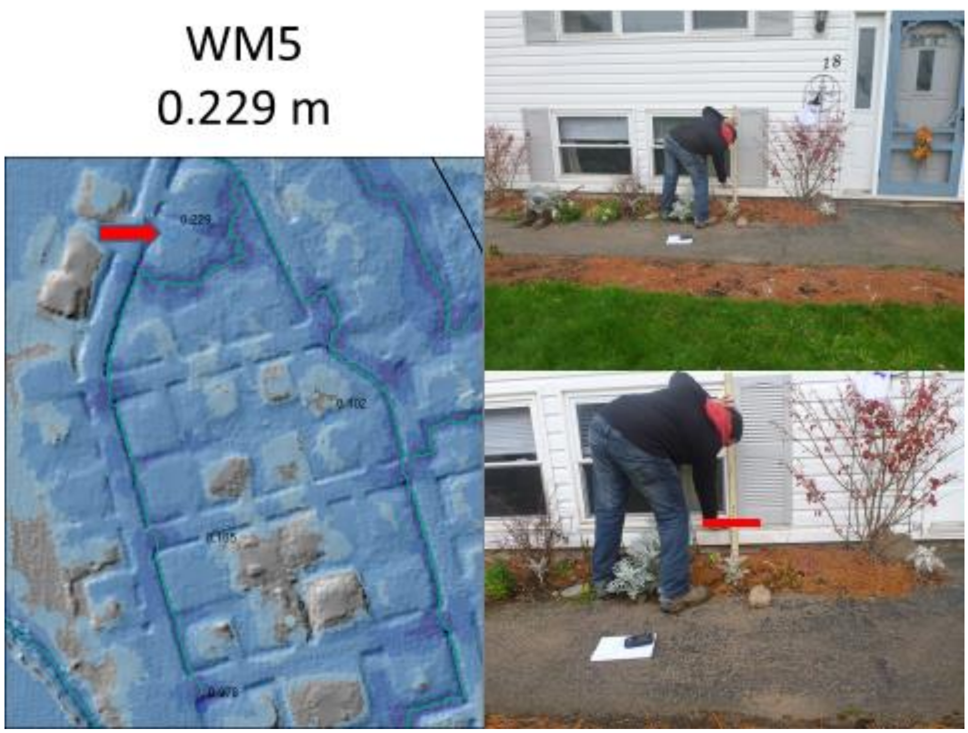
Flooding up to garage door, Stockton Street; Jan. 2014.



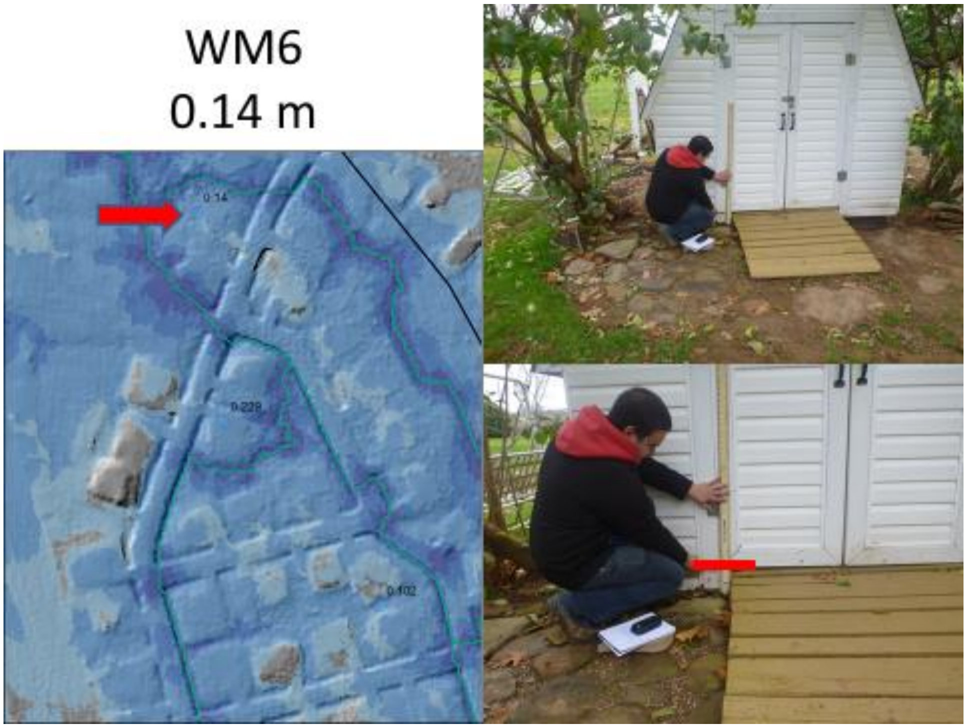
Flooding at house level, Phillip Street; Jan. 2014.



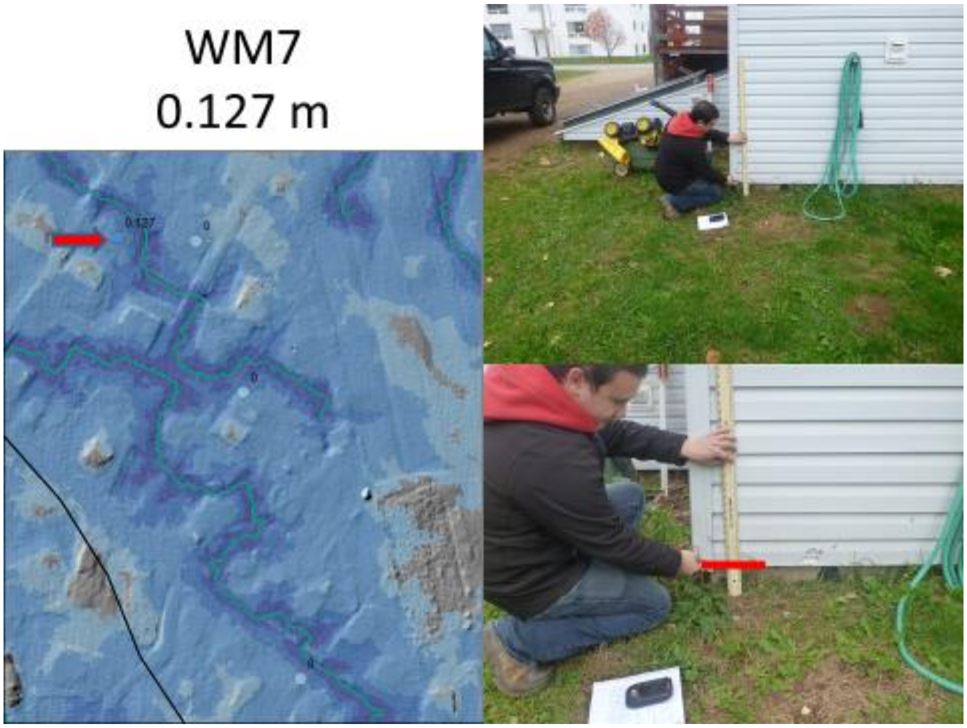
Flooding to fence line, Skyline Avenue; Jan. 2014.



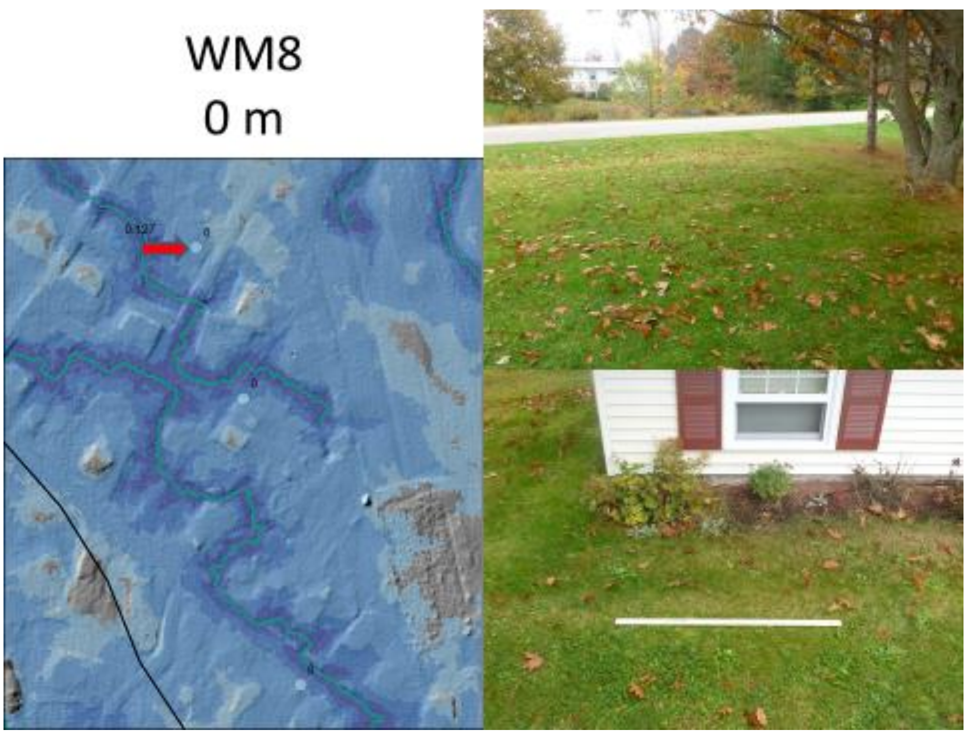
Flooding at house level, Creighton Drive; Jan. 2014.



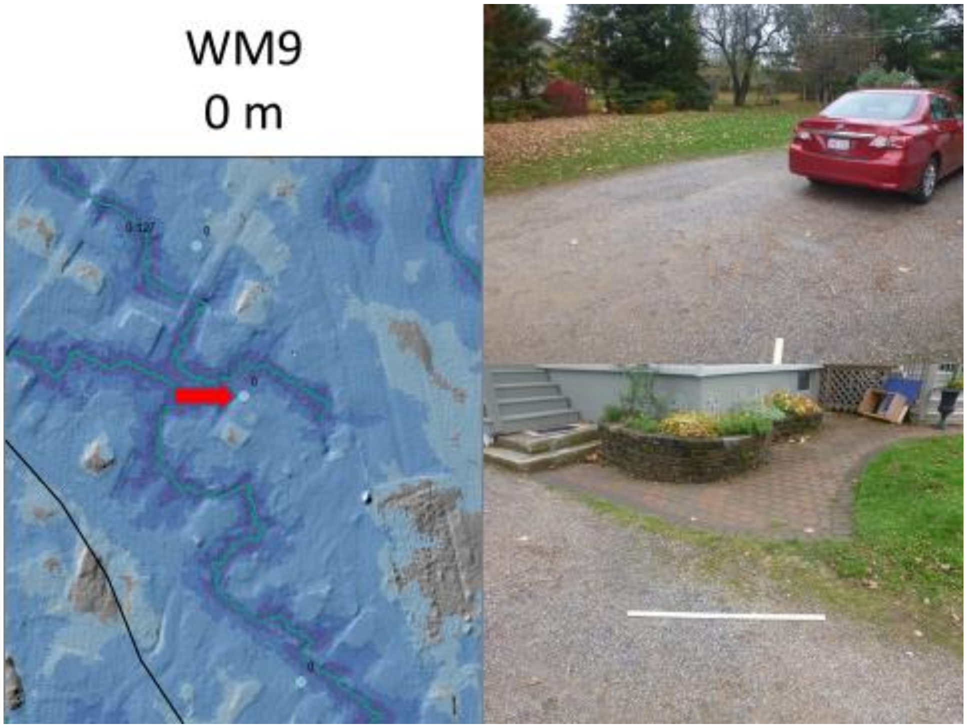
Flooding at house level, Creighton Drive; Jan. 2014.



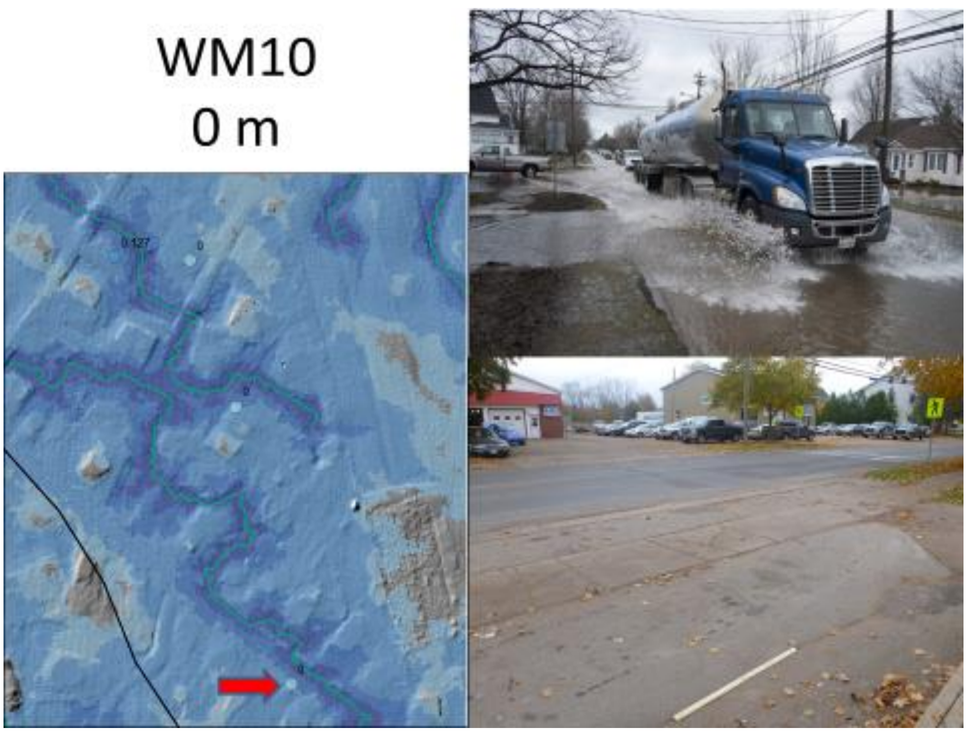
Water reaching house at Harding Avenue; April 2014.



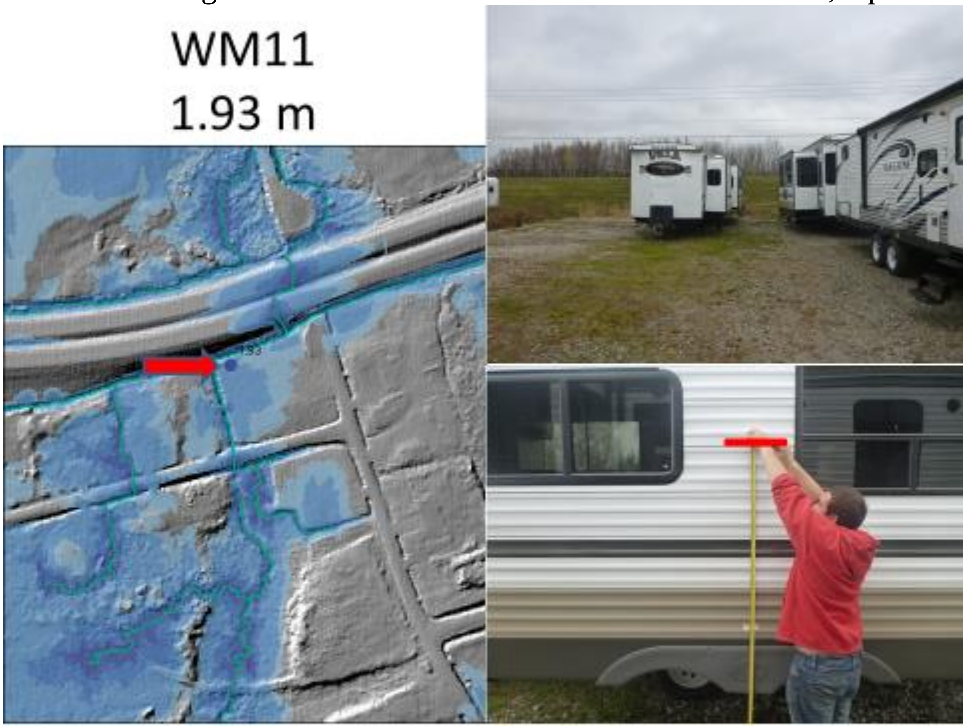
Water almost reaching house on Geldart Street; April 2014.



Water almost reaching house on Webster Avenue; April 2014.

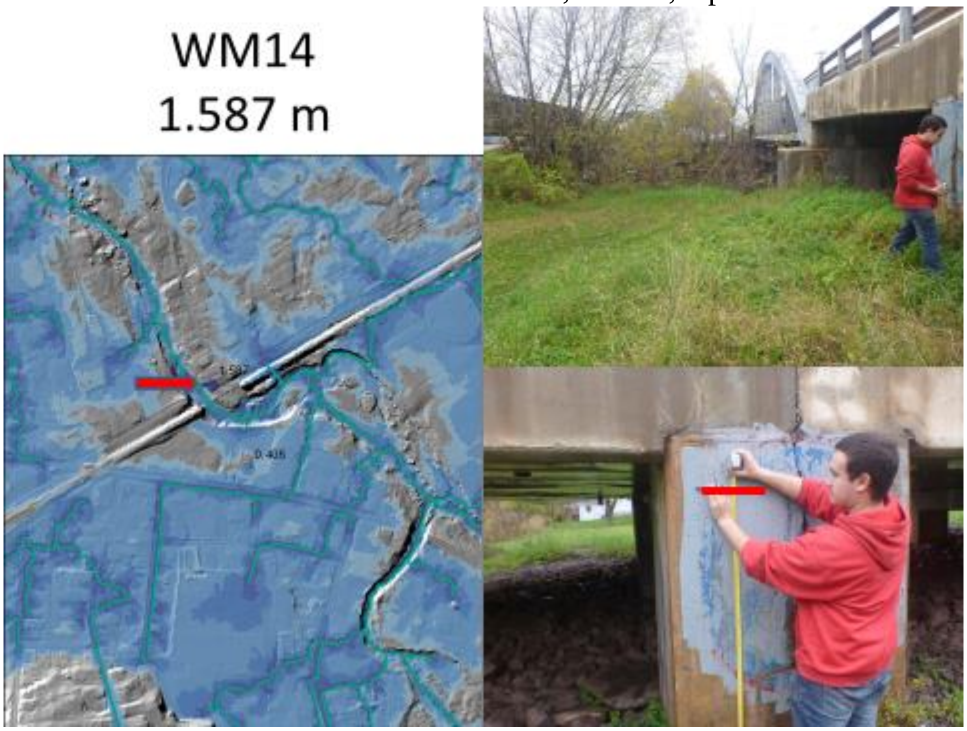


Water overflowing Main Street. White mark shows extent of flood; April 2014.

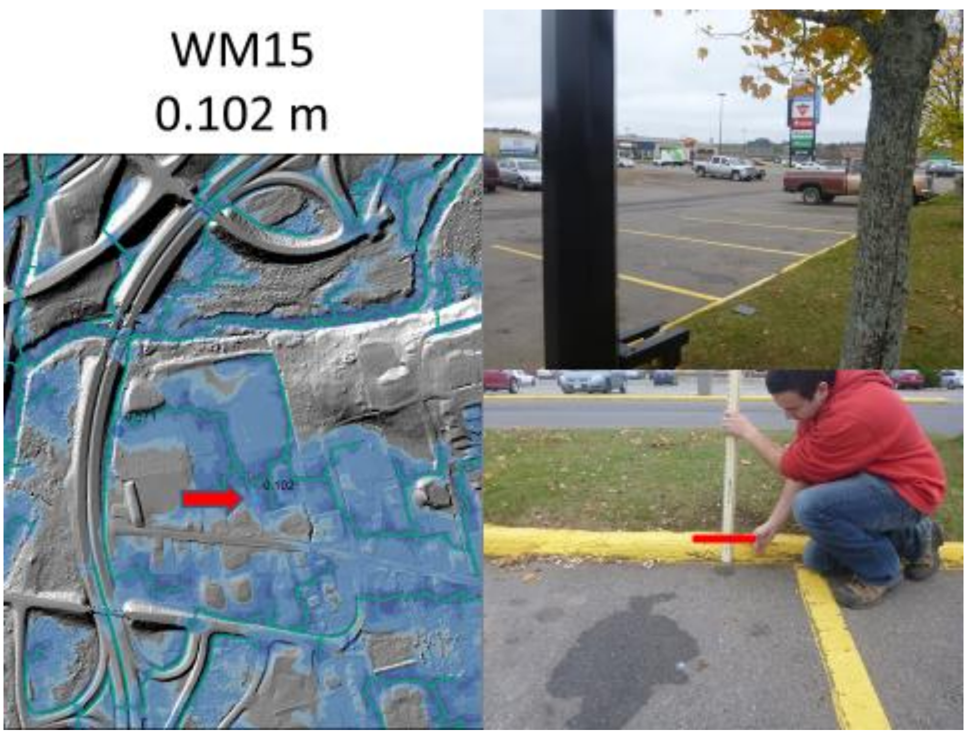


Water backing up in a depression towards Highway 1 along Leonard Drive. Flooding was aggravated by culvert blocking; April 2014.

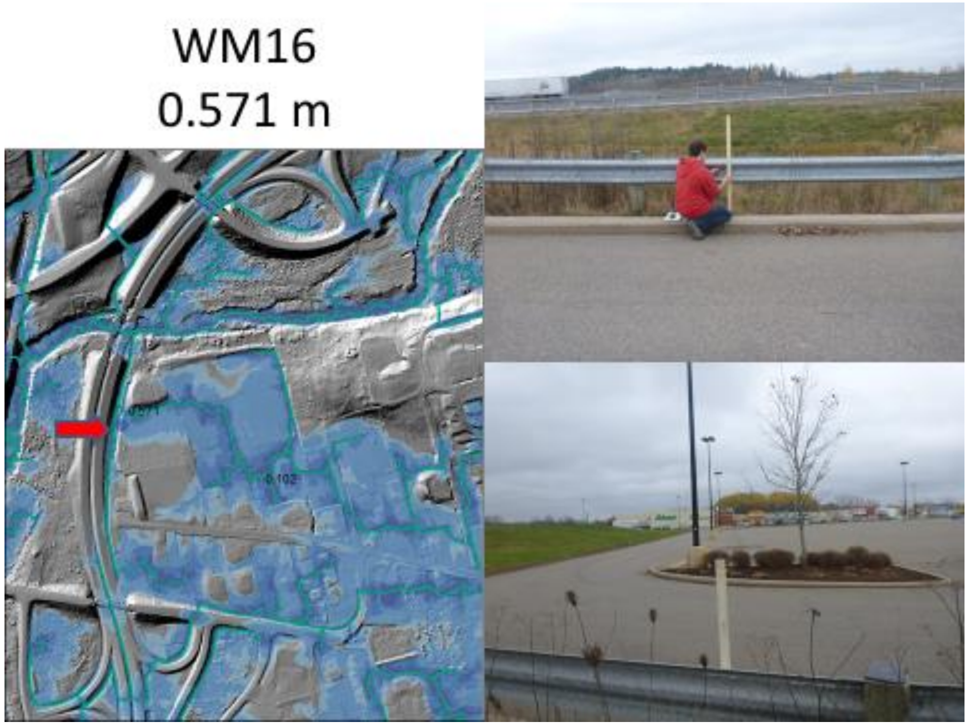
Water flood level at Tim Hortons, Sussex; April 2014.



High water mark at the Trout River Bridge along Main Street; April 2014.



High water mark at the Canadian Tire parking lot in Sussex, due to low lying area; April 2014.



High water mark at the Walmart parking lot in Sussex, due to river flooding; April 2014.