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Lower Don River Delft3D Model Refinement

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Lower Don River Delft3D Model Refinement

Prepared for

Toronto and Region Conservation Authority

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1.0 EXECUTIVE SUMMARY

In support of the Don Mouth Naturalization and Port Lands Flood Protection Project Environmental Assessment (DMNP EA), the Delft3D model was used to evaluate the existing flood conditions in the study area, along with the potential flood impacts of the three construction phases of the preferred alternative identified through the Port Lands Acceleration Initiative (PLAI) process.

Refinement of the Delft3D model from Riverdale Park to the Inner Harbour was required to provide baseline design level model in advance of the design process, and to undertake scenario test runs to confirm impacts of early design decisions in a design level model. This report summarizes the modifications to the model, along with results predicted by the final set of refined models.

The model results are consistent with the DMNP EA model results. Moreover, the flood protection landforms and contours effectively eliminate flooding in east of the Don Roadway and north of the Keating Channel.

2.0 SUMMARY OF WORK UNDERTAKEN

The overall aim of the update was to refine the DELFT3D model for Existing Conditions and Construction Phases 1, 2 and 3, based on:

- Updated surveys and topographic information
- Previously-identified model refinements and grid extensions
- More realistic depiction of the proposed flood protection works, such as increased definition of land grading, replacing dry cells representing the Phase 2 works, and
- Currently known updates to the Phase 3 schematic design

The updates to the Existing Conditions model included refinement of the model grid in the following areas:

- East of the Don River and north of the CN railway embankment
- On the First Gulf Property from Don Roadway to the future Broadview LRT extension, including the east side of the Eastern Avenue underpass
- In proximity to the Lake Shore crossing and sediment management area, and
- The Margins of the Lower Don Lands development areas.

The model bathymetry was revised to incorporate recent survey data of the Don Valley Parkway and Don River between the CN Railway and Lakeshore, and to refine the area surrounding the ramps from the DVP to the Gardiner Expressway. A quality control check of topographic data was undertaken, focusing on areas where the LIDAR data interpolate poorly, such as in the underpass locations. In addition, fill piles and other irregularities were removed from the model, and the Don Narrows and Keating Channel bathymetric interpolation were refined to represent vertical walls more accurately.

Once the EC model was updated, it was converted to a refined Phase 1 model.

A refined Phase 3 model was also created. This included the revisions to the Existing Conditions bathymetry (where relevant), along with revised grading. This included:

- Importing of the more refined depth and building information from the 2013 model, and

- Incorporating the most recent changes from the MVVA grading plan, including grading representative of flood protection on the First Gulf site.

Once the refinements to the model grids and bathymetric files were complete, regulatory flood simulations for the refined Existing Conditions, and Phases 1, 2 and 3 hydraulic models were undertaken. These results were checked for stability and consistency. Note that the model remains uncalibrated at this time and consequently, appropriate caution should be used when interpreting these model results for design purposes.

3.0 SUMMARY OF MODIFICATIONS TO EXISTING CONDITIONS AND PHASE 1 MODELS

The Lower Don River Existing Conditions model was updated to improve alignment of the grid with the existing channel, to refine grid resolution, and to ensure the topographic data were appropriately represented in the model. The baseline model used for the Existing Conditions model update was the model submitted to TRCA by Baird in September of 2014. Additional data provided by TRCA as well as updated aerial photography were used during the updating of the model.

The first update to the model grid was improving the alignment of the grid to the channel boundaries. While the original model grid points were close to the channel boundary, they were not exactly aligned. Nearly all the grid points in the updated grid line up exactly with the channel boundary. An example of the grid update is presented in Figure 3.1. This upgrade is important because it improves the representation of the bathymetry interpolation and better represents the vertical walls that exist in the channel. The same procedure was undertaken in area around Don Narrows, and the interpolation of bathymetry at the vertical walls was improved.

The second update to the model was refinement of the grid at the locations suggested by TRCA. The grid was refined in the following areas: The First Gulf property, Lake Shore Boulevard Crossing, and the margins of the Lower Don Lands development areas. A comparison of the grids is provided in Figure 3.1. The final Existing Conditions and Phase 1 grid is shown in Figure 3.2.

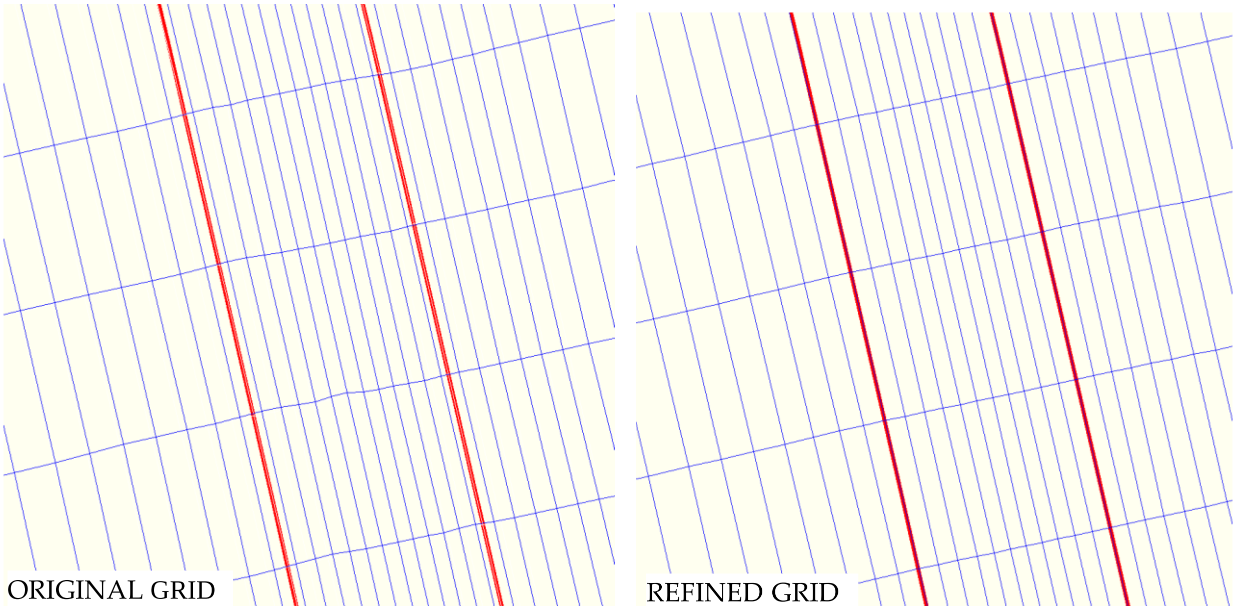

Figure 3.1 Existing Conditions grid realignment along channel boundaries

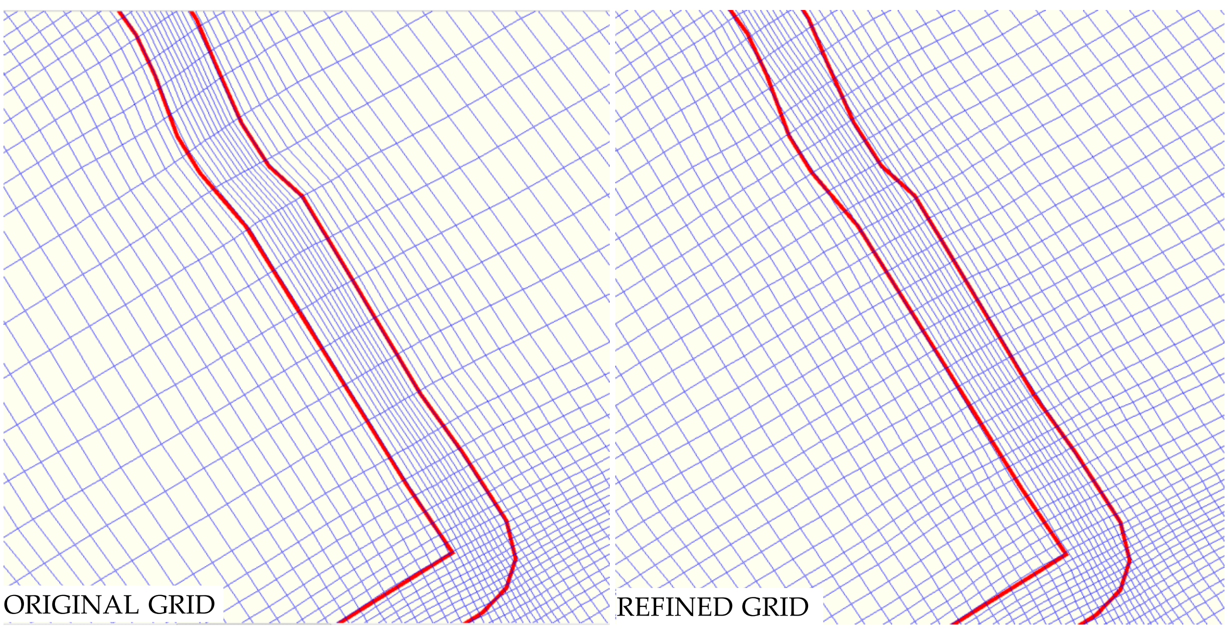

Figure 3.1 Existing Conditions grid refinement near First Gulf property

Figure 3.2 Refined 2015 Existing Conditions and Phase 1 grid

Once the grid was appropriately realigned and refined, new model depth files were created. The depth files were created using the bathymetry from the original Existing Conditions model and the most recent LiDAR data. The updated depth files were used to verify the topographic representations in the model. This step included reviewing LiDAR data, checking cross-sections of the bathymetry and topography represented in the grid, and confirming elevations with as-built drawings provided by TRCA. The main area of focus for this review was the Eastern Avenue underpass and the CN Railway bridge crossing. The crossing at the Eastern Avenue underpass was adequately represented in the original model. Given the refinement and realignment near the CN Railway bridge crossing, however, model depths in this area required minor modifications. Additional detail about the verification of topography is provided below.

The updated Existing Conditions model grid and bathymetry were also used to update the Phase I model. Phase I proposes development in the vicinity of Cherry Street and Commissioners Street. To represent buildings and development blocks in the proposed development, dry points were added to the model. The dry points were extracted from the previous version of the Phase I model submitted to TRCA. A comparison of the Existing Conditions model and the Phase I model is provided in

Figure 3.3.

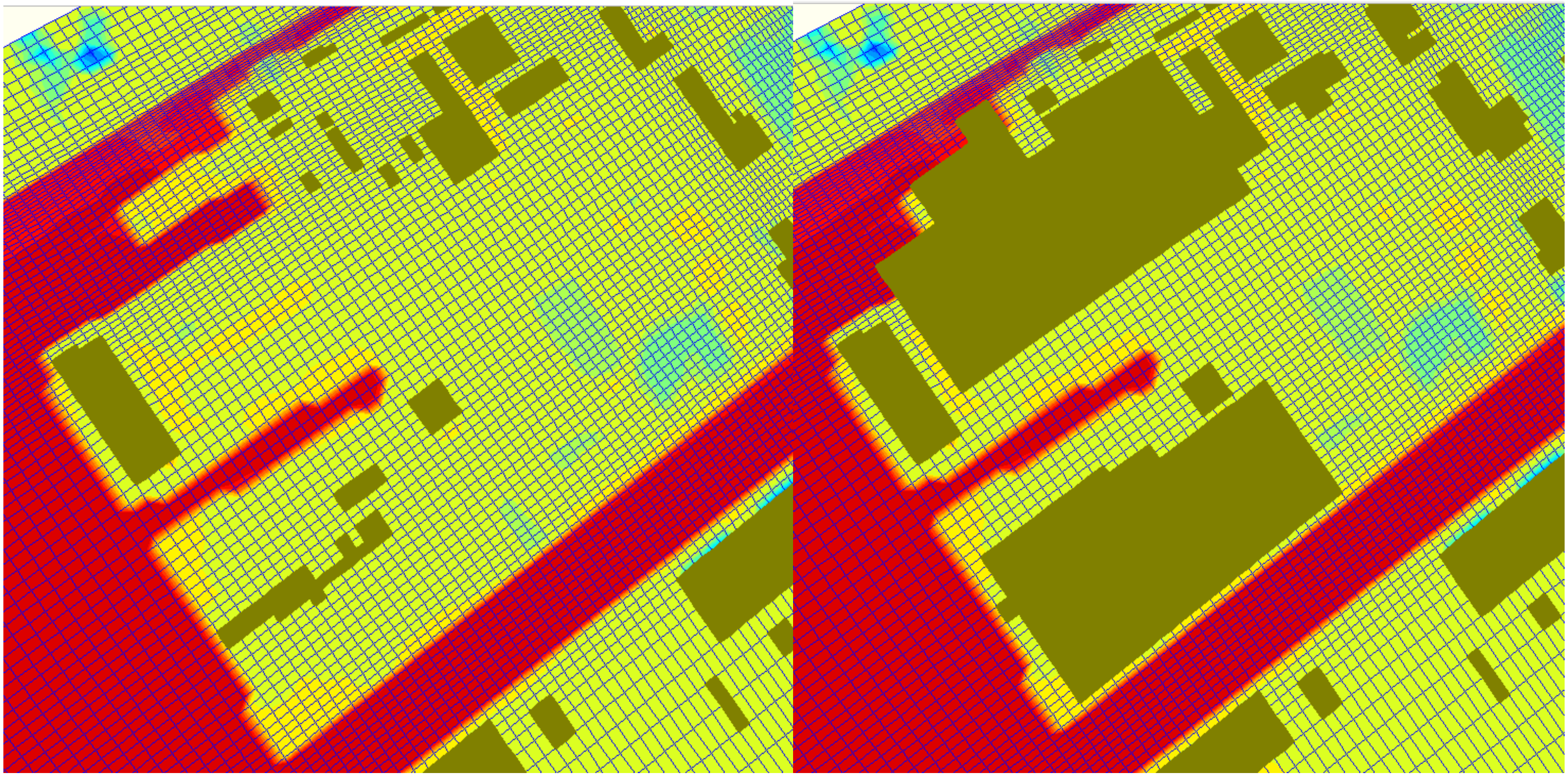

Figure 3.3 Updated dry points for Existing Conditions model (left pane) and Phase I model (right pane)

3.1 Roughness

Spatially-varying roughness was incorporated into the Existing Conditions and Phase 1 models (Figure 3.4). Three classifications were used: channel, impervious urban floodplain, and pervious urban floodplain. The floodplains were characterized by using orthoimagery to delineate roads, parking lots, and other such surfaces.

Spatially varying roughness values were used to define different land use characteristics throughout the model domain; these are summarized in Table 3.1. Note that values are lower than standard TRCA roughness coefficient values, which were developed to support one-dimensional modelling.

Table 3.1 Roughness Coefficients used in 2D Model (Manning's "n").

Component	Manning's "n" Roughness
Channel – Watercourse/Channel	0.02
Floodplain – Urban (Impervious)	0.016
Floodplain – Urban (Pervious)	0.03

The values were determined using the following documents:

MNR (2002). Technical Guide – River & Stream Systems: Flooding Hazard Limit. Ontario Ministry of Natural Resources. Water Resources Section, Peterborough, Ontario, 2002.

Chow V.T. (1959). Open-Channel Hydraulics. McGraw Hill, New York, NY.

Engineers Australia (2012). Australian Rainfall & Runoff Revision Project 15: Two Dimensional Modelling in Urban and Rural Floodplains

A value of 0.02 was defined in the main river channel to represent a watercourse with minimal vegetation and the significant conveyance of water under the regulatory flood condition. Significant (asphalt/concrete) roadways and parking lots were defined with a roughness coefficient of 0.016. The remaining urban (pervious) areas were defined using a value of 0.03.

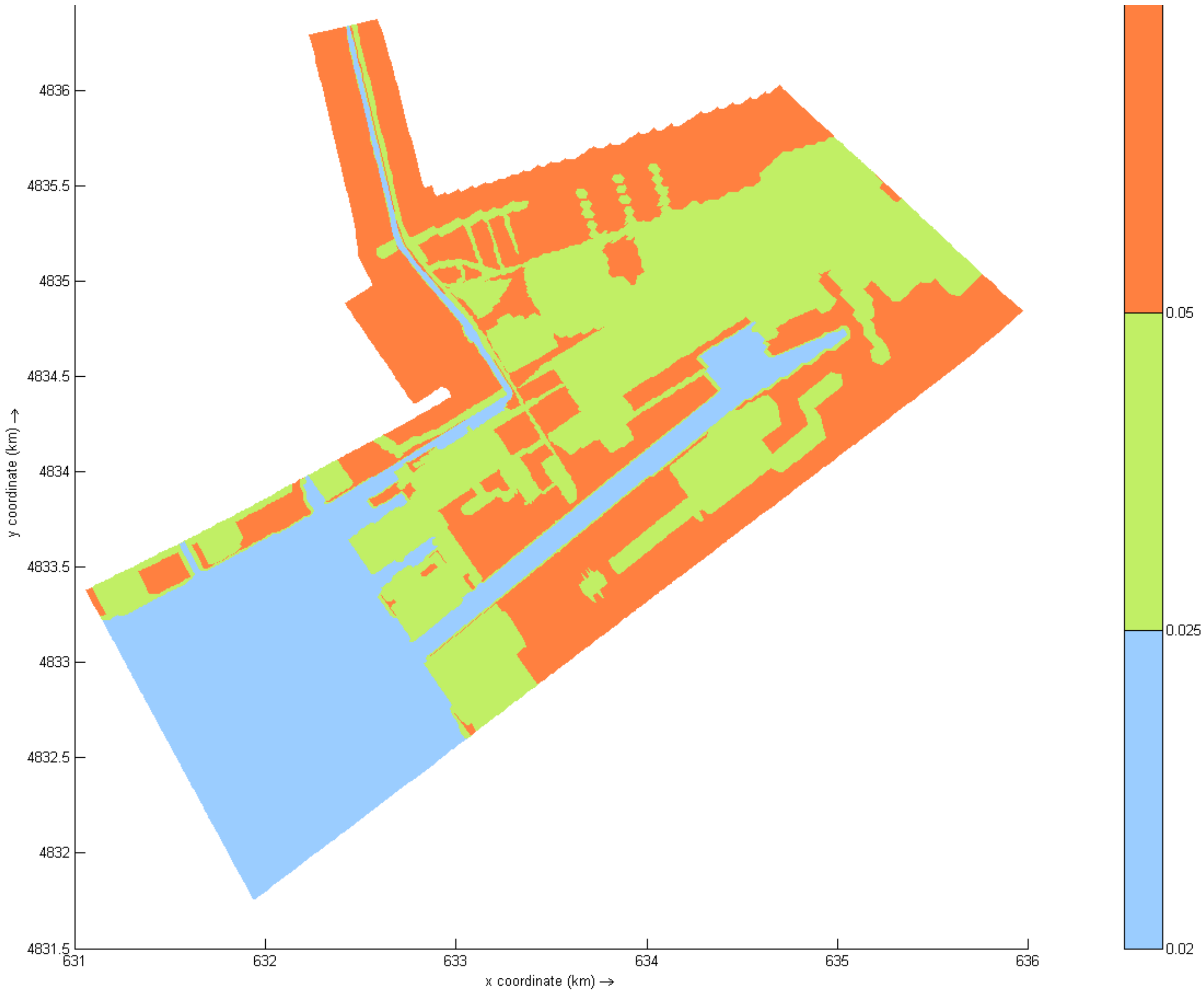

Figure 3.4 Spatially-varying roughness coefficients in the Existing Conditions model

3.2 Bridges

It is assumed that bridge decks are not included in the regulatory flooding model. Delft3D cannot adequately define bridge decks in 2D mode, and requires a 3D model in order to include them. Even with a 3D setup, the available options for specifying bridges do not at present adequately represent those of the Don River (i.e. CN, Old Eastern Ave, and Lakeshore) at the currently-used model scale. Large piers and abutments are represented by a combination of the bathymetry (where represented in LiDAR data) and dry cells (blocked portions of model grid). Significant additional testing may be required to adequately model the complex network of bridges and highway ramps in Delft3D near the area of interest during design.

4.0 SUMMARY OF MODIFICATIONS TO THE PHASE 2 MODEL

The Phase 2 model grid was extended to the east of the Don River channel to incorporate the major roadways north of Eastern Avenue and the port lands to the east of the Don Roadway. The model was also extended north of the Keating Channel to the CN railway tracks. The final results of the grid extension are presented in blue in

Figure 1.

The grid was refined by a factor of 2 in the horizontal and vertical direction in most places. Extra refinements were made along the main river channel and in areas with varying or steep grading as indicated in the revised grading plan to be used for Phase 3 supplied by MVVA. This was done to increase precision and accuracy in the representation of vertical walls and sudden changes in elevation in the model, specifically along the designed flood protection landform to the east of the Don Roadway, around the Gardiner ramp piers, and the new river valley walls. Figure 4.2 illustrates the grid refinement along the upper river channel.

Gridlines were snapped to land boundaries along the Keating channel and along the new channel to the south, and realigned to follow the contours more accurately. Localized grid cell orthogonalization and grid line smoothing techniques were applied during the refinement process.

The depth files for the Phase 2 model were updated to reflect any changes made during the review of the Existing Conditions model bathymetry, and to incorporate elevations as specified by the MVVA 2015 Phase 3 grading plan, north of Lakeshore Blvd and for the construction of the valley wall feature, and spillway. Figure 4.3 indicates areas in which the grading plan supersedes the LiDAR data for the Phase 2 model bathymetry.

In keeping with the Existing Conditions model, the roughness coefficients in the Phase 2 model were updated from a constant value of 0.02 to one that varies with paved, unpaved, and river surfaces (Figure 4.4).

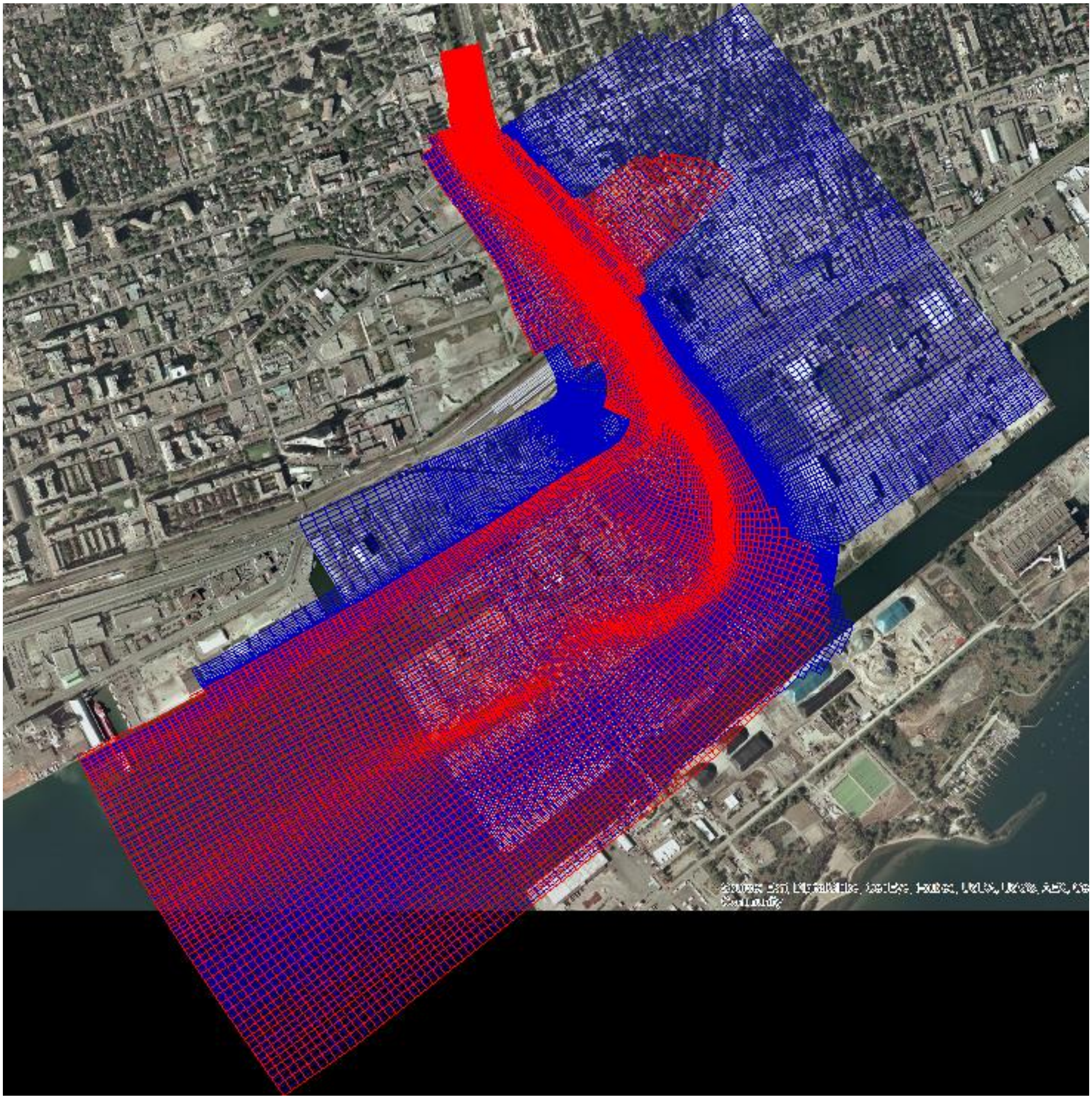

Figure 4.1 Phase 2 and 3 grid extension. The 2013 Phase 2 grid is shown in red, and the extended 2015 Phase 2 grid is shown in blue

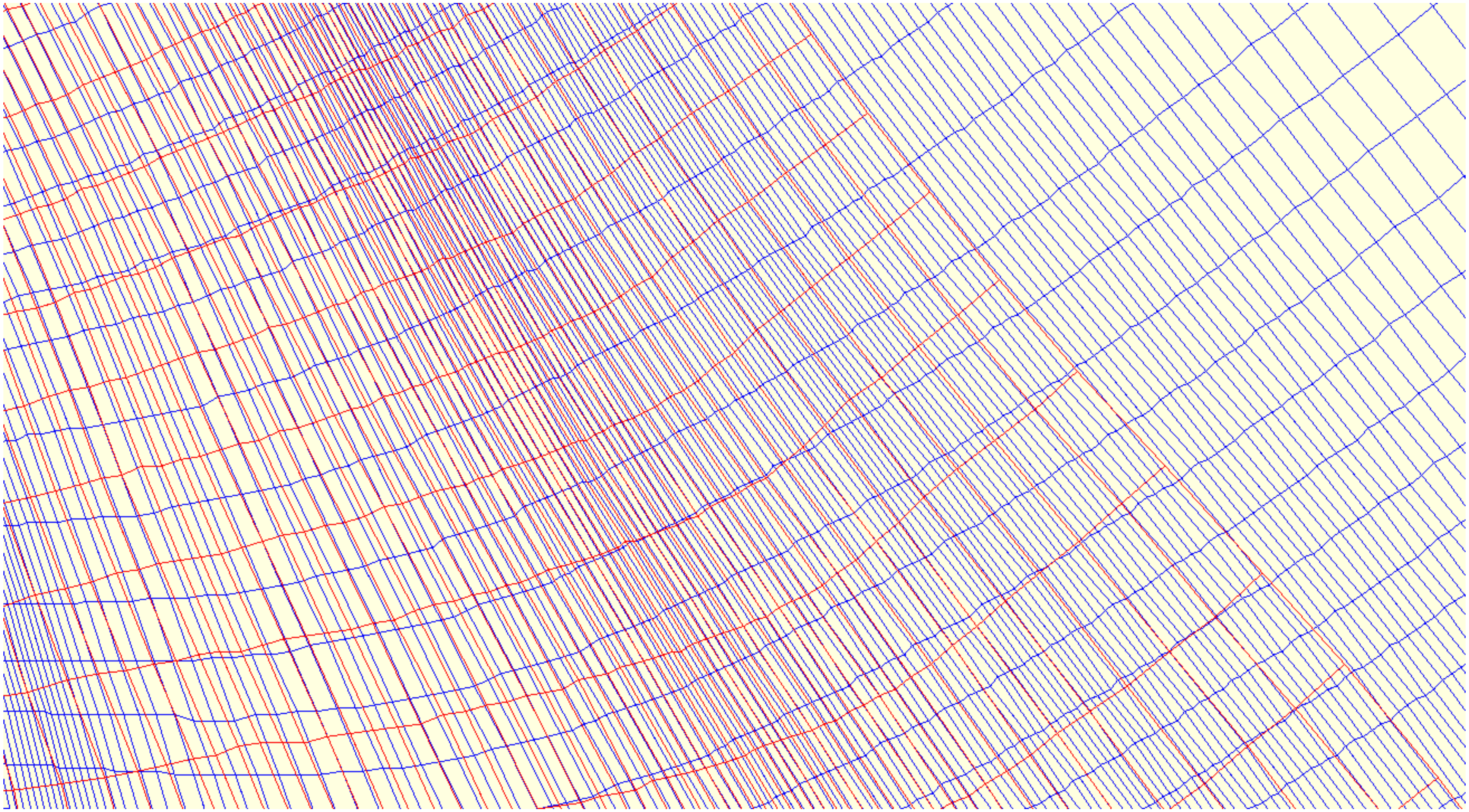

Figure 4.2 Phase 2 and 3 model grid refinements: 2013 Phase 2 model grid is in red, refined 2015 Phase 2 model grid is in blue

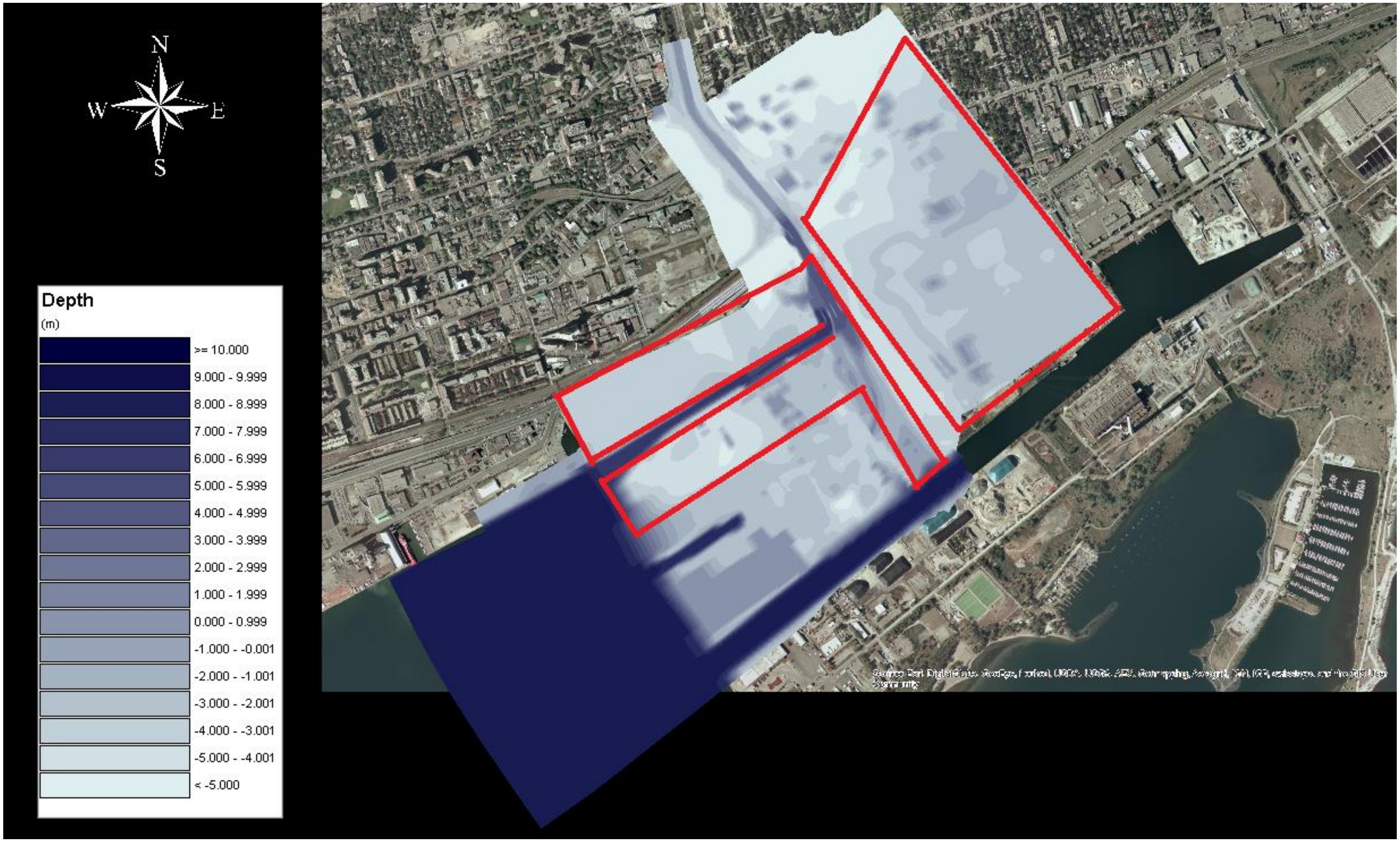

Figure 4.3 Phase 2 model bathymetry. Areas outlined in red indicated where LiDAR data is superseded by MVVA 2015 Phase 3 Grading Plan

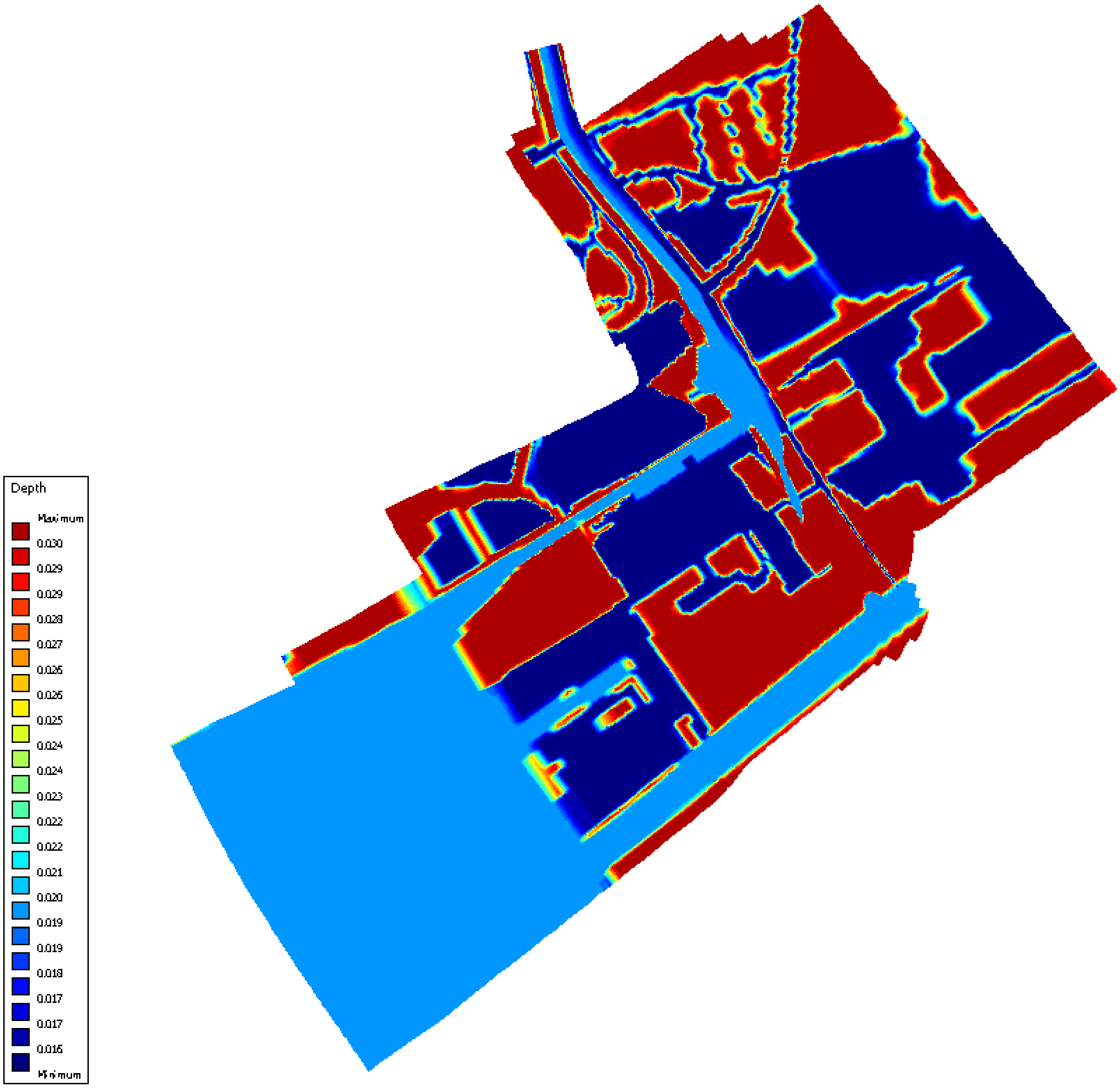

Figure 4.4 Phase 2 model varying roughness coefficients

5.0 SUMMARY OF MODIFICATIONS TO THE PHASE 3 MODEL

The extended and refined model grid used for the Phase 2 model, was also used in the Phase 3 model. Model bathymetry was modified to reflect information outlined in the updated grading plan supplied by MVVA, LiDAR data, and 2014 survey data. Figure indicates areas where the LiDAR data was superseded by the MVVA grading plan.

As with the Phase 2 model, the roughness coefficient was updated from a constant value of 0.02 to reflect spatially-varying roughness in the model (Figure 5.2). Dry points were added to the model to represent bridge piers for Basin St., Commissioners St., and Cherry St. bridges, based on drawings submitted by MMM group (Figure 5.3). Dry points were also included to represent heritage buildings on Villiers Island.

Figure 5.1 Phase 3 model bathymetry. Areas outlined in red indicate where LiDAR data was superseded by MVVA 2015 Phase 3 Grading Plan

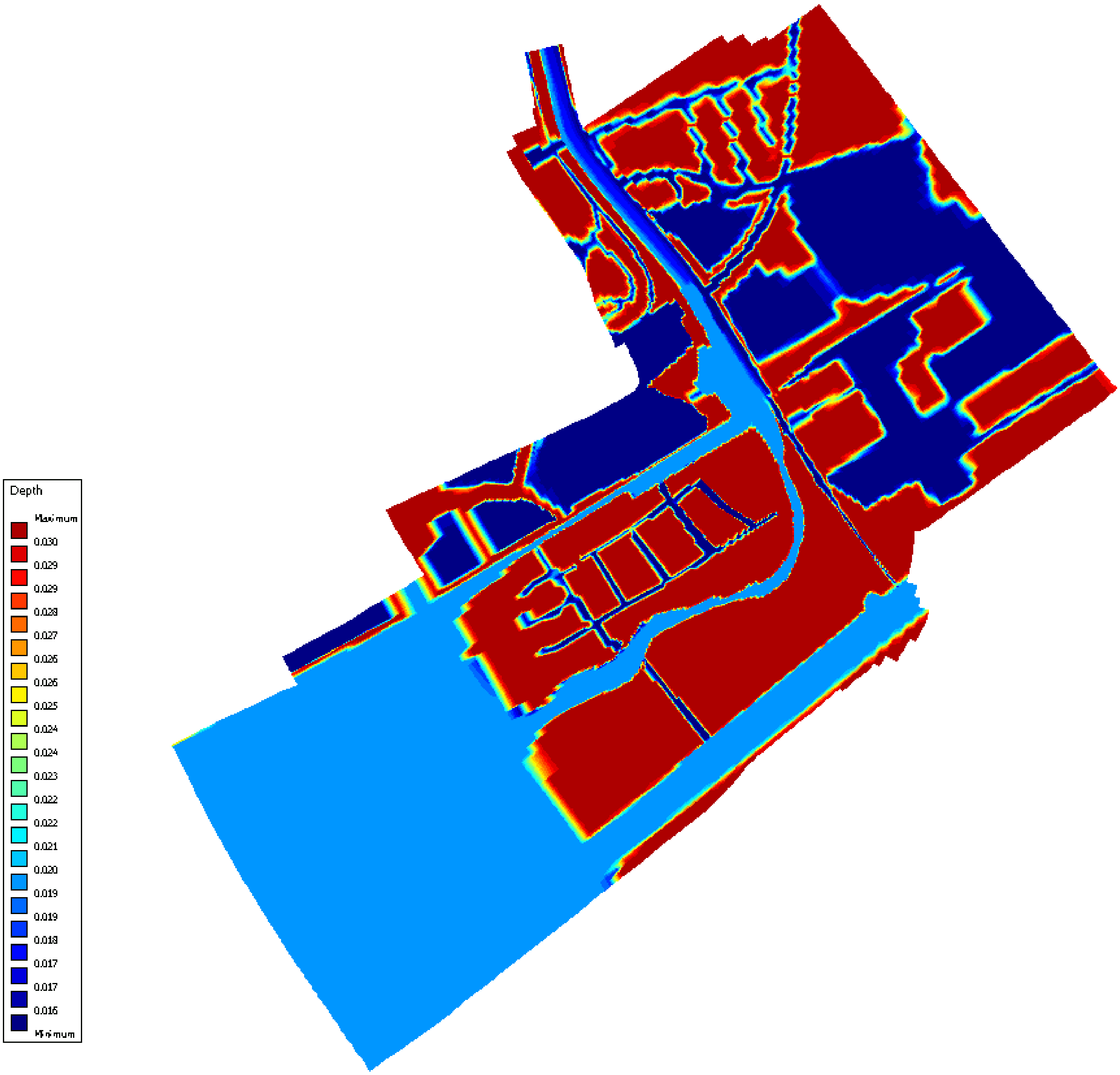

Figure 5.2 Phase 3 model varying roughness coefficients

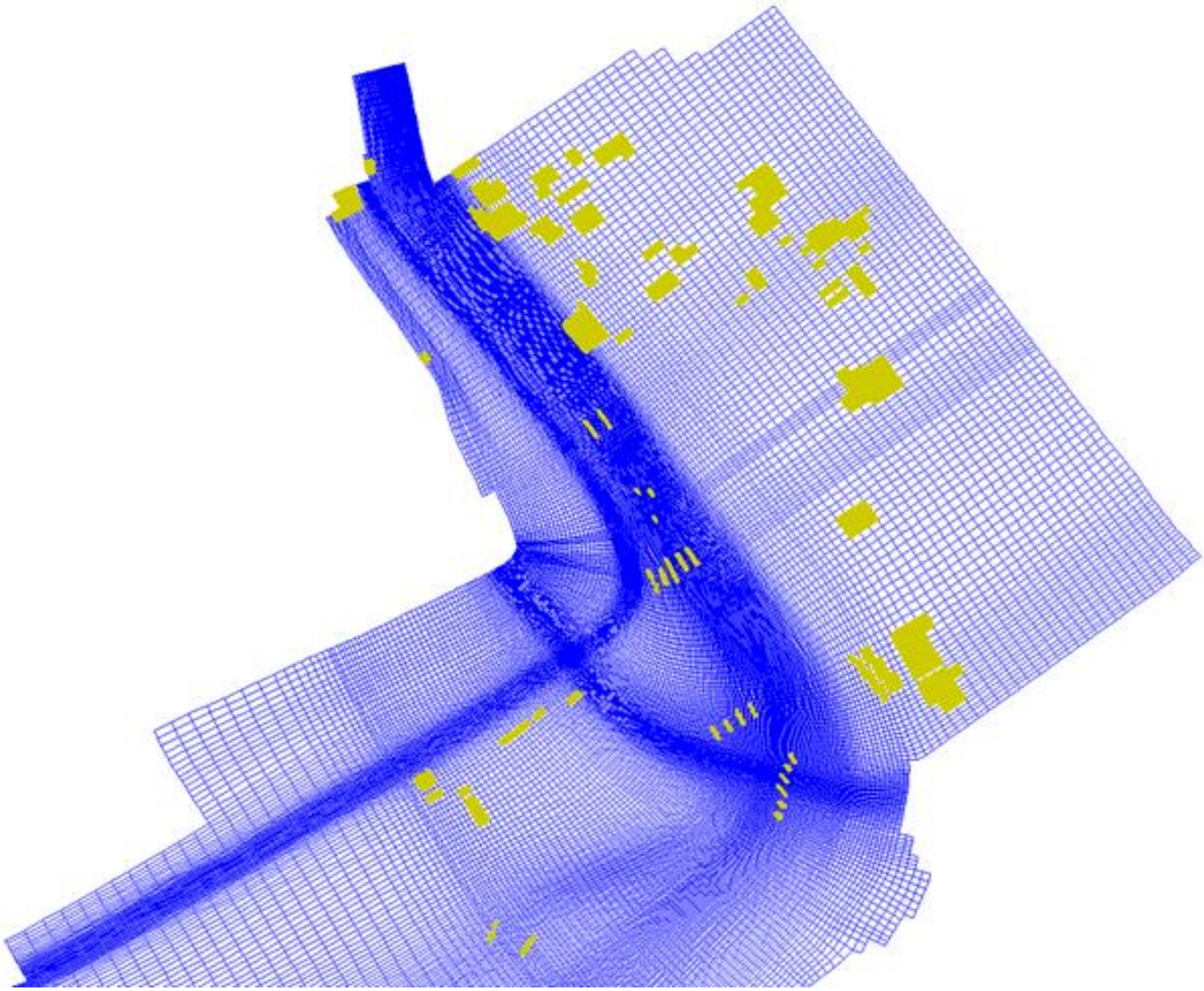

Figure 5.3 Phase 3 model dry points representing bridge piers and buildings

6.0 QUALITY CONTROL

QA/QC of Don River Existing Conditions Model

Three different aspects of the Existing Conditions model were checked using the most recent aerial photography available from Google Earth. The three tasks were: confirming that the alignment of the Don River and Don Narrows channels were accurate; confirming that the buildings represented in the model were still current since the last update, and confirming that the spatially-varying roughness values were still appropriate after the grid was refined. All three tasks were performed in a similar fashion. The land boundary, dry point, and roughness files were exported from the Delft model to files that could be spatially referenced in Google Earth. After those files were established, they were loaded into Google Earth, and a visual inspection was performed to ensure the features of interest were consistent with the most updated aerial photographs. From the visual inspection, no significant changes since the last Existing Conditions model were found.

After the grid, channel boundary, buildings, and roughness values were confirmed, the bathymetry along the Lower Don River was verified. TRCA provided Baird with an updated survey (dated February 2013) of the Don River that included over twenty cross-sections from Riverside Park to Lake Shore Boulevard. The extents of the cross sections were imported into Delft as a land boundary file. The elevations provided by the TRCA survey were compared to the depths represented in the model, and any discrepancies were corrected in the model. For this section of the Lower Don River, only the areas around the CN Rail bridge crossing needed updating as a result of changes to the grid. The changes primarily involved grid points on the east bank of the Lower Don River. These changes were expected given the realignment of the grid, and because they allow the model to better represent the vertical walls associated with the channel banks.

The configuration of the Eastern Avenue Underpass was also evaluated during the quality checks of the updated Existing Conditions model. For this area, the as-built drawings provided by TRCA were used to compare the underpass layout to the elevations represented in the model. The depths extracted from the model were compared to the elevations provided in the drawings. For the Eastern Avenue underpass area, the original Existing Conditions model adequately represented the configuration.

In order to quality check the adjustments to the bathymetry in the Phase 2 and 3 models (in particular the grading of the flood protection landforms and around the bridge piers), cross-sections from the models were examined and compared to the LiDAR data, survey data, and/or the grading plan as appropriate. An example of a cross-section comparison is presented in Figure 6.1.

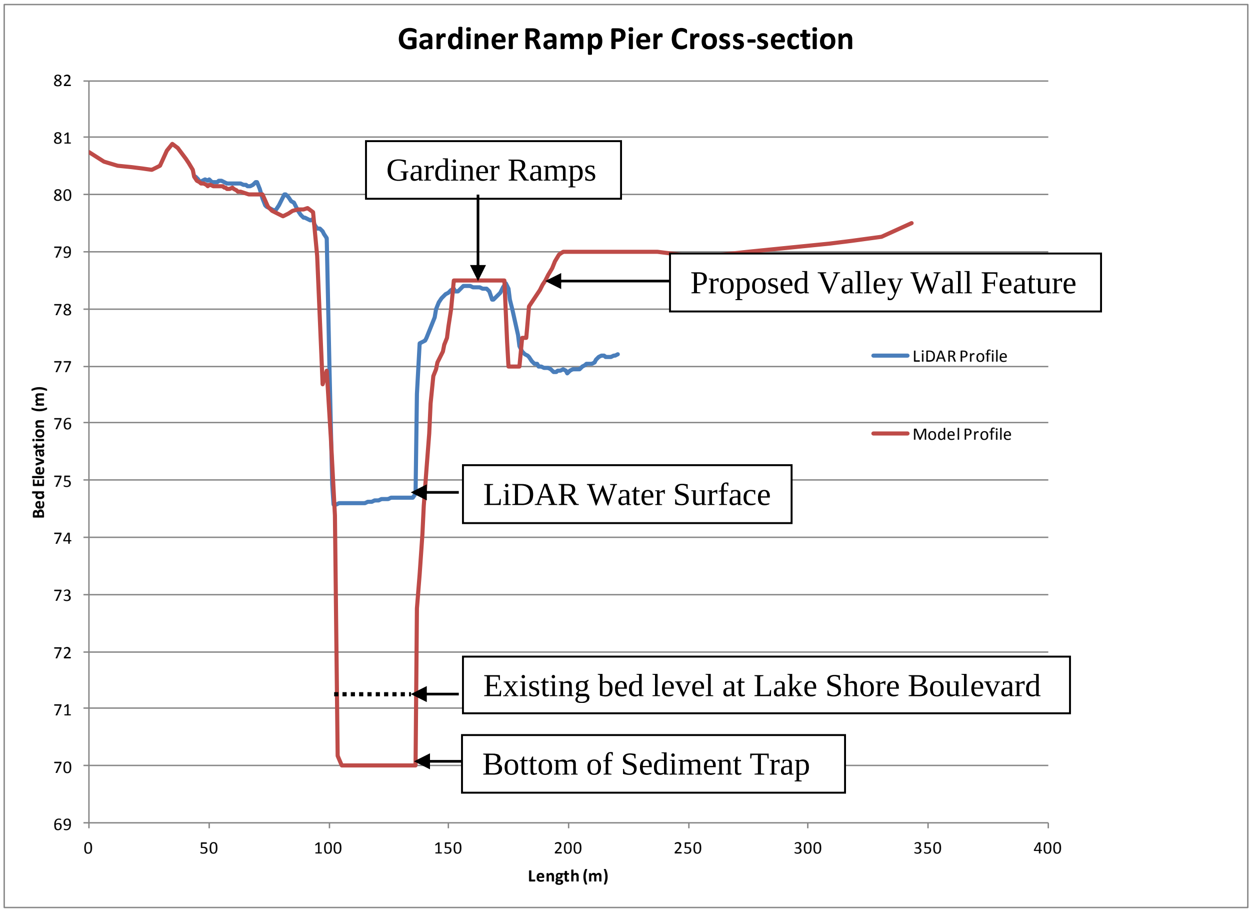

Figure 6.1 Cross-section of the Don River Channel and Gardiner ramp piers, comparing LiDAR data with Phase 2 and Phase 3 model bathymetry

Following interpolation, the model bathymetries were also visually evaluated using the 'Quickin' Delft3D module to check for irregularities and to ensure consistency with the Phase 3 grading plan. Spot checks of the elevations of the grid cells were conducted in areas where the grid and bathymetry were refined, such as around the Gardiner ramps.

Model results were reviewed to confirm that the results were realistic and that the model was stable. Water levels were checked at points and cross-sections immediately north and south of the CN rail bridge and at various other points along the river, and were found to rise and fall to reasonable levels in accordance with the flow conditions. The maximum water level for each cell was also viewed to examine the extent of the flooding and to check that flooding was contained to designated areas as per the Phase 2 and Phase 3 design plans.

7.0 ADDITIONAL ASSUMPTIONS AND UNCERTAINTIES

The following highlights other assumptions and uncertainties associated with the flood modelling:

Additional Inflows: The model is driven by river flow at the upstream boundary and does not include additional flows from contributing tributaries, stormwater outfalls, non-point source runoff.

Debris & Structural Failure: The influence of debris or ice on the river's conveyance at bridges and other structures is not accounted for in this study. The model also does not account for the hydraulic influence of structural failures such as bridge collapses or embankment failures.

Bridge Structures: Bridge decks are not included in the regulatory flooding model. Large piers and abutments are represented by a combination of the bathymetry (where represented in LiDAR data) and dry cells (blocked portions of model grid).

8.0 MODEL RESULTS

Figure 8.1 and Figure 8.2 present the maximum water level experienced in each cell of the Existing Conditions and Phase 1 models, respectively throughout the regulatory flood event. The maximum levels were determined independantly for each grid cell, then assembles into a map, since the maximum water level may occur at different times in different parts of the study area. Figure 8.3 and Figure 8.4 present the maximum water level experienced in each cell of the Phase 2 and Phase 3 models, respectively throughout the regulatory flood event.

The model results are consistent with the DMNP EA model results. Moreover, the flood protection landforms and contours effectively eliminate flooding in east of the Don Roadway and north of the Keating Channel during Phases 2 and 3.

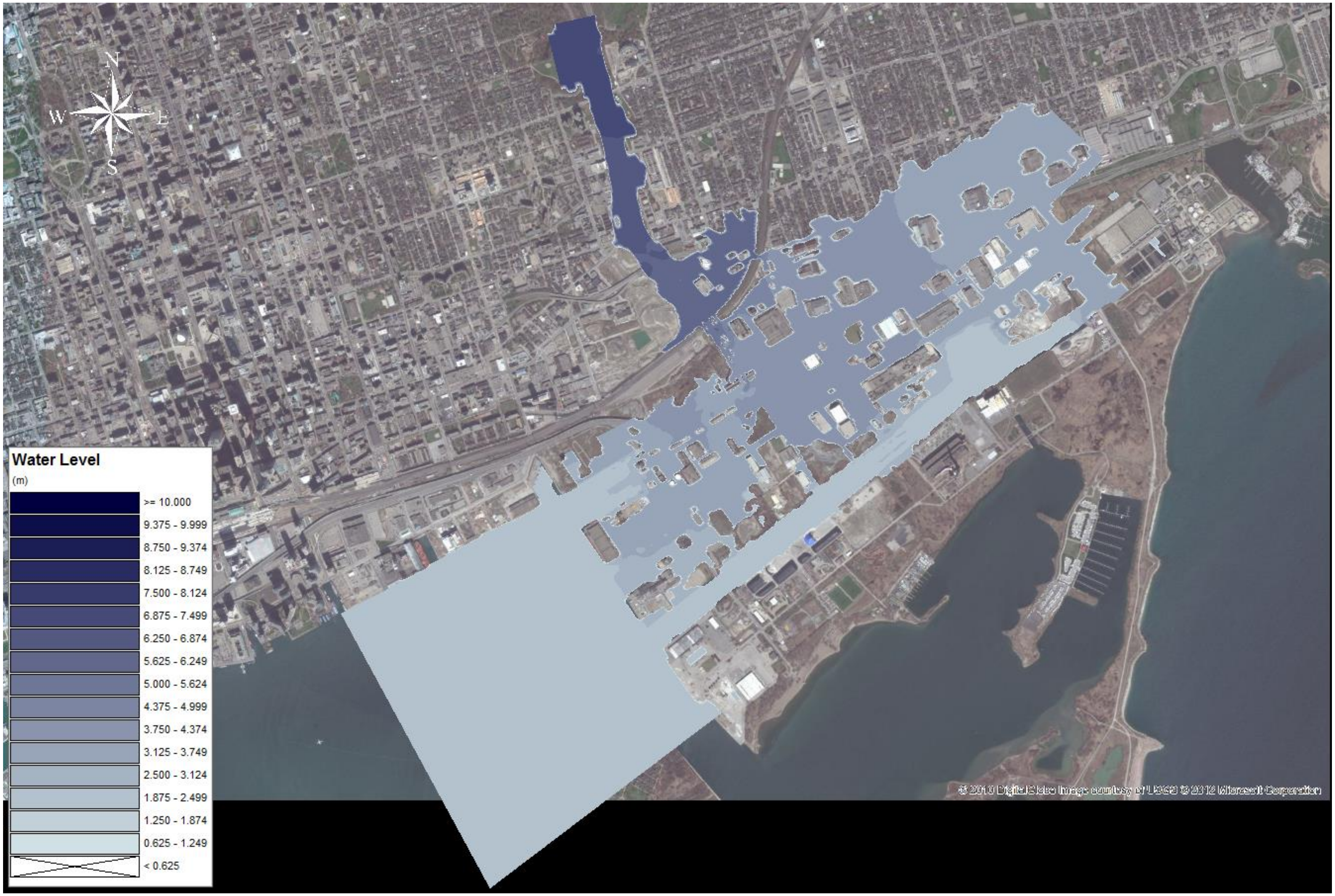

Figure 8.1 Existing Conditions model maximum water level above 74.2m datum

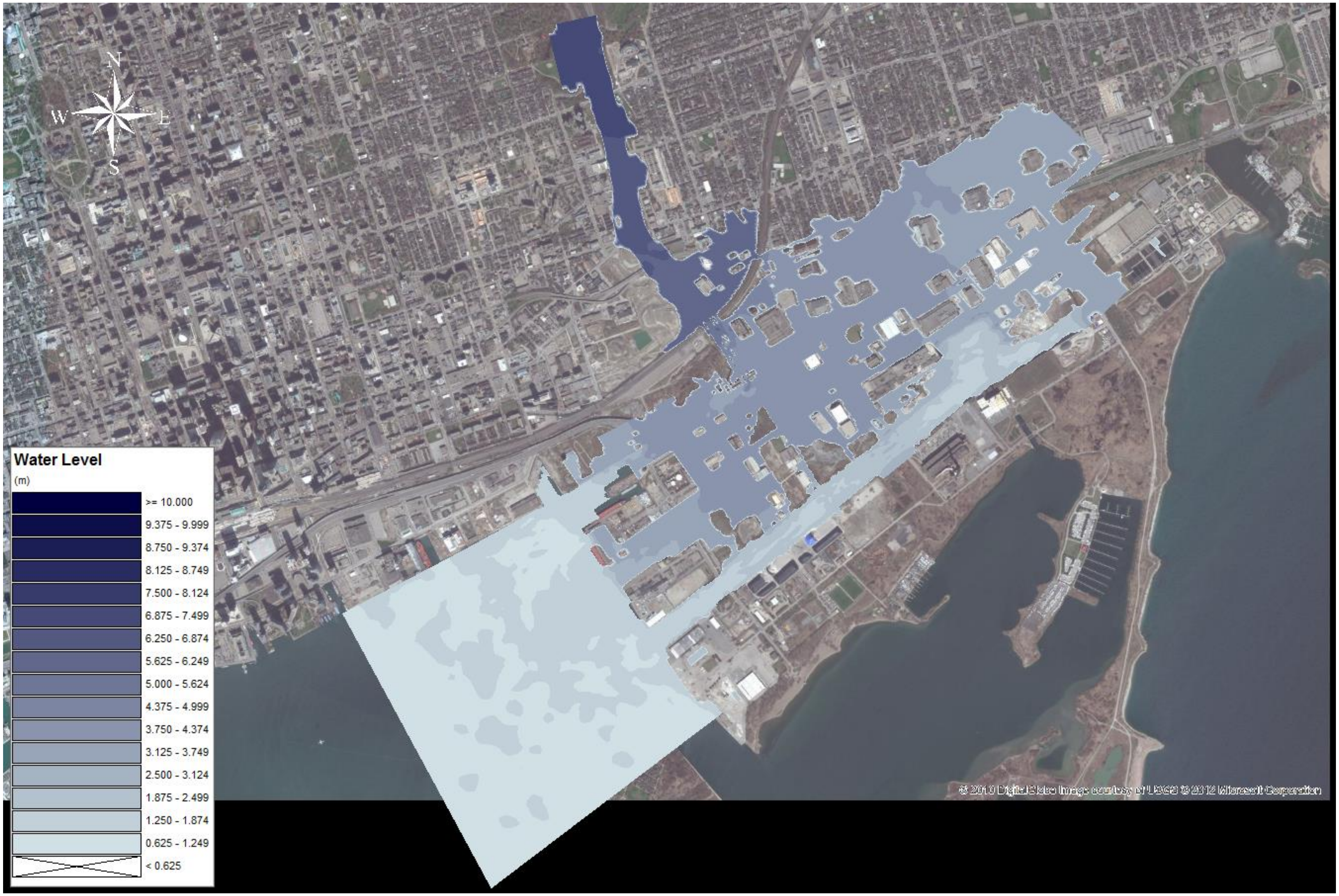

Figure 8.2 Phase 1 model maximum water level above 74.2m datum

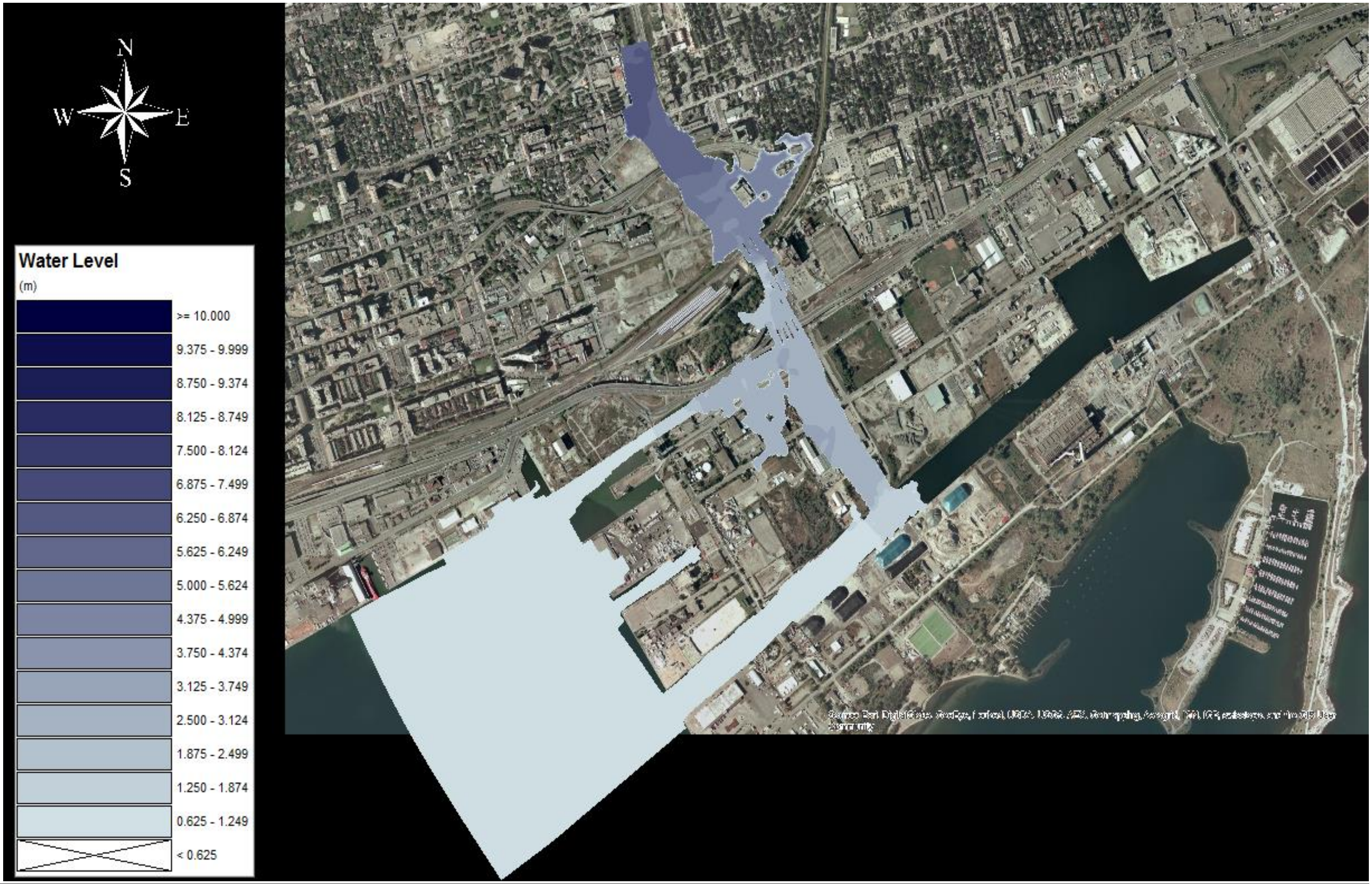

Figure 8.3 Phase 2 model maximum water level above 74.2 m datum

Figure 8.4 Phase 3 model maximum water level above 74.2 m datum

9.0 RECOMMENDATIONS

During detailed design, a fully-calibrated flow and sediment transport model is necessary to determine the optimal sediment trap performance, further evaluate the maintenance dredging frequency of the sediment trap, and determine potential sediment maintenance requirements downstream from Lake Shore Boulevard.

In addition to the detailed numerical modelling to be undertaken during detailed design, we acknowledge that a key limitation to the present study is the lack of measured velocities and accompanying sediment transport rates in the Don Narrows and Keating Channel. Consequently, any interpretation of these model results as input to the design process needs to be undertaken by suitably qualified technical personnel in order to appropriately account for the inherent uncertainty in an uncalibrated model.

We therefore recommend that a detailed field measurement program is undertaken prior to entering the detailed design of the Port Lands Flood Protection and Enabling Infrastructure Project. This will allow the sediment transport and hydrodynamic models to be calibrated and validated to observed values in the project study area, rather than the relationships established from measurements at the Todmorden gauge site. In particular, a season of Acoustic Doppler Current Profiler measurements, along with sediment load samples, will provide valuable input to the detailed design as the model can then be evaluated for accuracy of predictions, and an appraisal of the amount of uncertainty in the model predictions can be made.