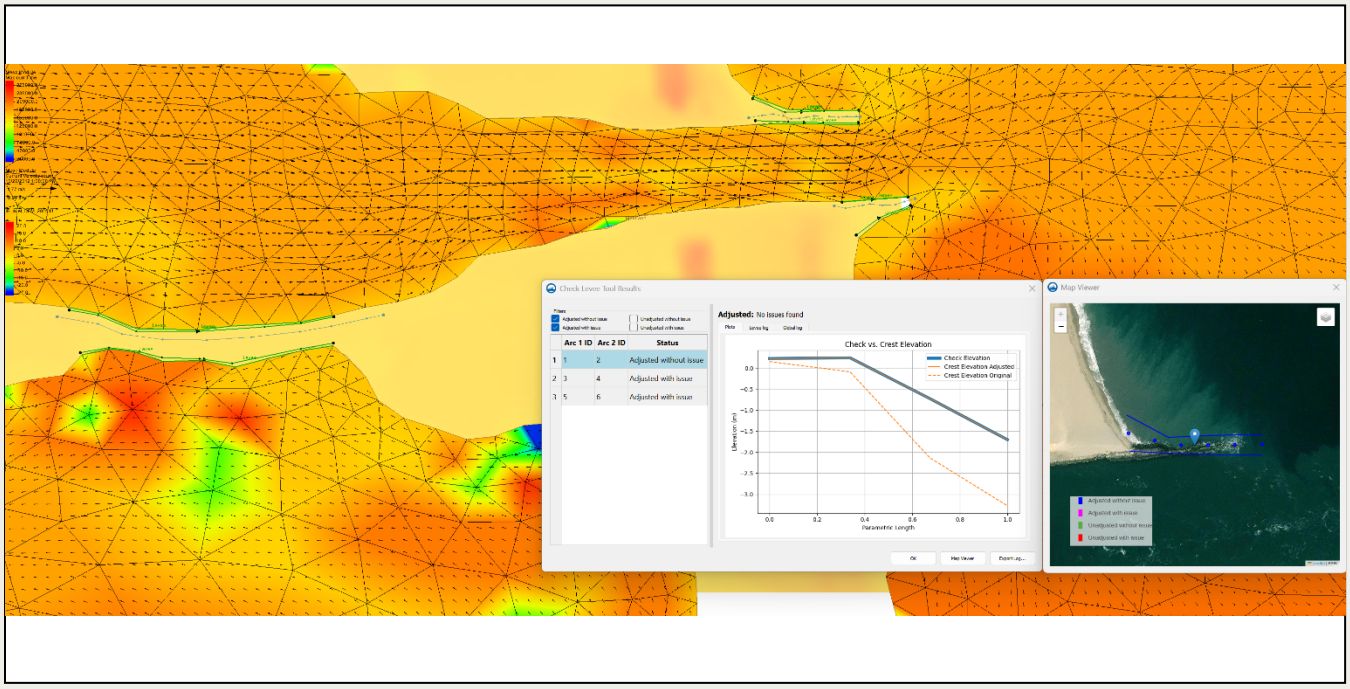
SMS 14.0 Training

Levee Options



Objectives

This tutorial demonstrates additional options for working with levees in an ADCIRC simulation.

Prerequisite Tutorials

- Overview
- Map Module
- Raster
- Background Data
- Simulation Domain
- Mesh Generation
- Mesh Quality
- Levee Mesh Generation
- Levee Simulation

Required Components

- SMS Core

Time

- 15–20 minutes

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1 Introduction

This tutorial illustrates how to review and edit an ADCIRC simulation with levees. This includes the possibility of editing the mesh or the levee crest. It also illustrates the option of defining crest elevations as a parametric curve.

This exercise utilizes data from the region around Indian River Inlet located on Delmarva Peninsula along the Maryland coast between Delaware Bay and Chesapeake Bay. It commences with the results of the *Levee Mesh Generation* tutorial.

2 Getting Started

Start by importing a project file containing a mesh generated for use with levees:

1. Launch the SMS application.
2. From the *Menu* bar, select the *File* | **Open…** menu command to bring up the *Open* dialog.
3. Navigate to the *data_files* folder.
4. Select the “start.sms” file.
5. Click **Open** to import the project and exit the *Open* dialog.
6. From the *Menu* bar, select the *File* | **Save As…** menu command to bring up the *Save As* dialog.
7. For the *File Name*, enter “IR_levee_sim.sms”.
8. Click the **Save** button to save the file.

This project is the output from the “Levee Simulation” exercise and should appear similar to Figure 1.

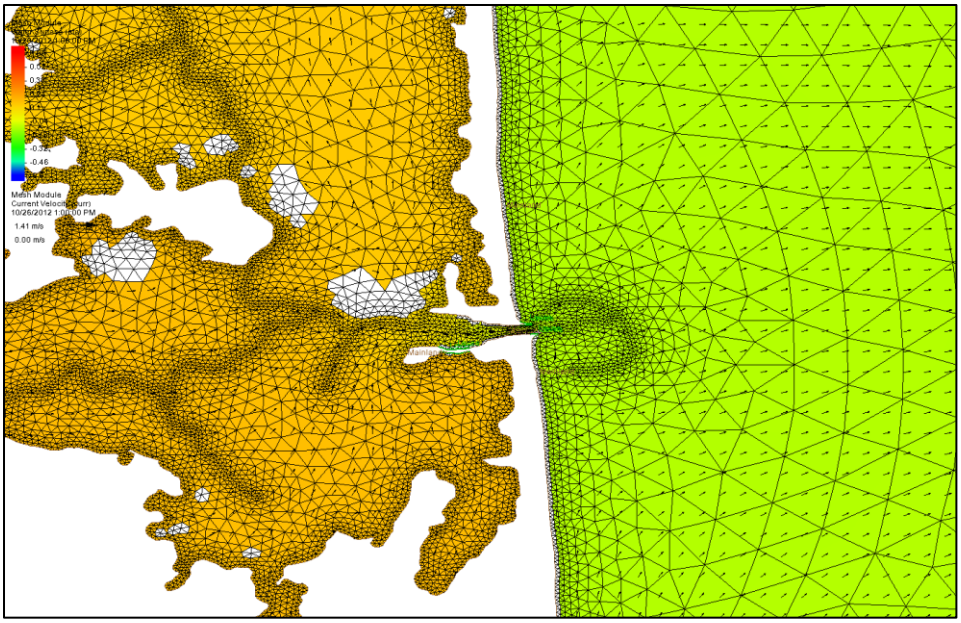

Figure 1 Initial project view

3 Checking the Levee Crest against the Mesh

In the “Levee Simulation” tutorial it was discovered that the levee crest for one of the defined levees was actually invalid. In other words, the levee crest elevation was lower than the ground elevation for at least one of the nodes that define the levee. This was identified by reviewing the boundary conditions.

Performing a complete review of all the levees in a complex simulation could become very tedious. This section illustrates how to use a custom tool to verify that the levee elevation is valid.

3.1 Using the Check/Fix Levee Ground Elevations Tool

This tool compares the elevations of the mesh at the levee points and modifies the mesh if the mesh elevations are higher than the levee crests. The tool outputs a new dataset on the mesh reflecting these modified (lowered) elevations as well as a dataset of the adjustments.

To use this tool:

1. Click on the **Toolbox** macro to open the *Toolbox* dialog.
2. In the *Tool* tab, select the *ADCIRC* | **Check/Fix Levee Ground Elevations** tool.
3. Click the **Run Tool…** button to open the *Check/Fix Levee Ground Elevations* dialog.
4. From the *Input ADCIRC Boundary Conditions coverage* drop-down, select “levee BC”.
5. From the *Domain grid* drop-down menu, select “patch inlet 50-1000m”.
6. For the *Minimum height of crest elevation above ground*, enter “0.05” meters.
7. For the *Output dataset*, enter “Adjusted Elevation”.

8. For the *Output diff dataset*, enter “Adjusted Elevation – Z”.
9. Click the **OK** button to run the tool.
10. The *Check/Fix Levee Ground Elevations* Log dialog will appear showing the progress of the tool.
11. When the tool has completed, the *Map Viewer* and *Check Levee Tool Results* windows will appear. The dialogs are movable and resizable. Refer Figure 2.

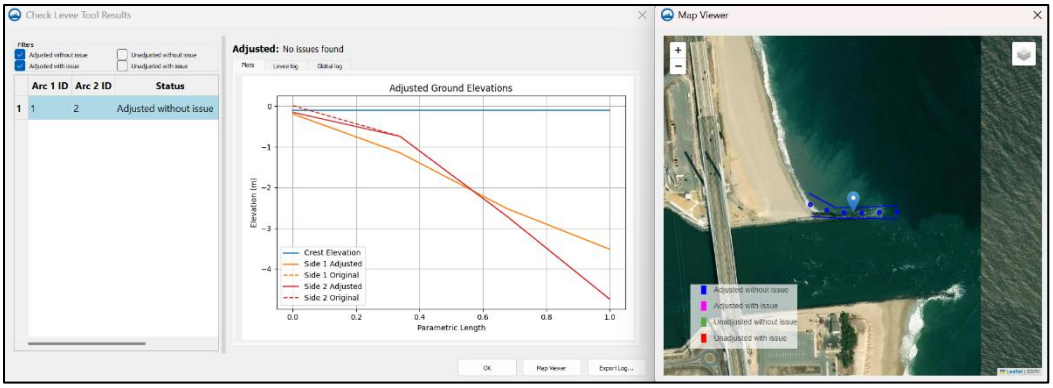

Figure 2 Check Levee Tool Results and Map Viewer

12. In the *Filters* section, turn on all filters to see all arcs.

This dialog lists all the levees on the left side with an indication of what issues were identified. In this case, two of the three levees have no issues. The plot shows the one levee point on the north jetty that is higher than the levee crest. The tool creates a new dataset with this point lowered to be valid.

Note: In the Levee Simulation tutorial, the levee crest was raised to make the simulation valid. Either adjustment is valid. It is up to the user to define which adjustment represents physical reality better.

13. Review the data in the tool illustrating the levees.
14. When complete, click the **OK** button to close the *Check Levee Tool Results* dialog and return to the main window.
15. When complete, click the **OK** button to close the *Check/Fix Levee Ground Elevations* Log dialog and return to the main window.
16. The *Graphics Window* updates to show the *Adjusted Elevation – Z* data.
17. Using the **Zoom** static tool, zoom into the inlet, refer Figure 3.

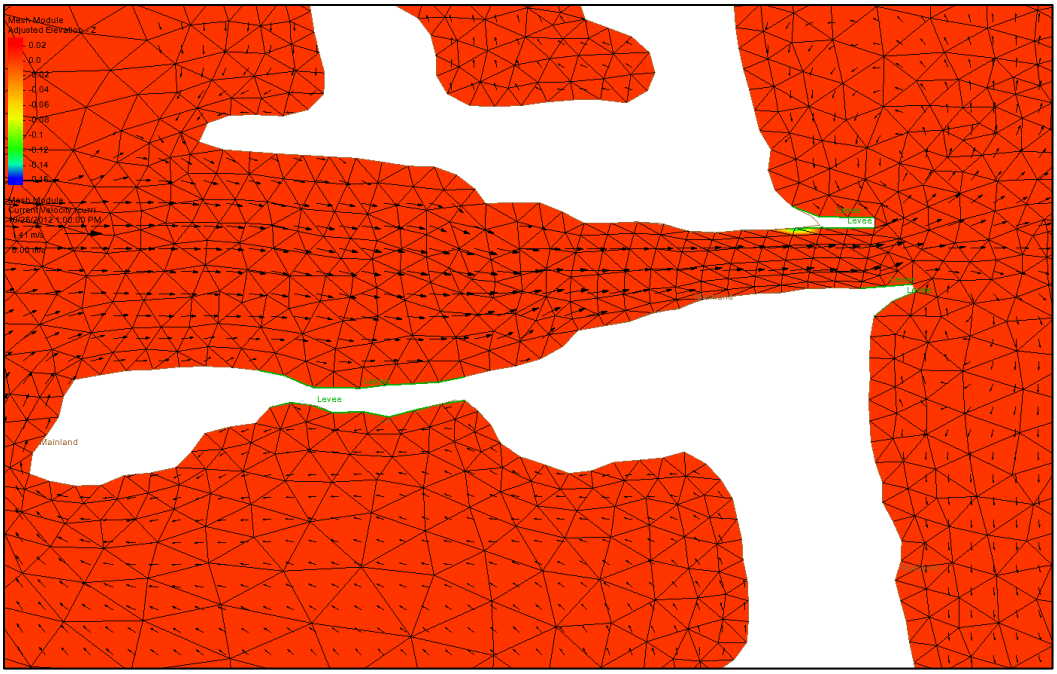

Figure 3 Inlet Levee and Jetties

Note: Lowering the node elevation makes the simulation valid for ADCIRC, but additional modifications may be desired. This would be the case if the nodes adjacent to the levee nodes are higher than the crest elevation. In most situations, the mesh elevation decreases as the distance from the levee increases, but complex geometry may need to be considered.

3.2 Using the New Elevation Dataset

The new dataset defines how the elevations of the mesh need to be changed in order to make a valid ADCIRC simulation. In order to apply these in the simulation:

1. In the Project Explorer, select the "patch inlet 50-1000m" mesh to make it active.
2. From the *Menu* bar, select the *Data* | **Map Elevation…** menu command to update the elevation data on the mesh.
3. In the *Select* section, select the "Adjusted Elevation" dataset.
4. Click the **Select** button. A warning that the existing Z values will be replaced will appear. Click the **OK** button to continue. This changes the elevation data for the mesh.
5. In the Project Explorer, right-click on the " Levees constant Zc" simulation and select the **Map Boundary Conditions…** context menu command. A feedback window appears while the command is running, which will close automatically once complete. This updates all the information so that the simulation is ready to be run again. Refer Figure 4.

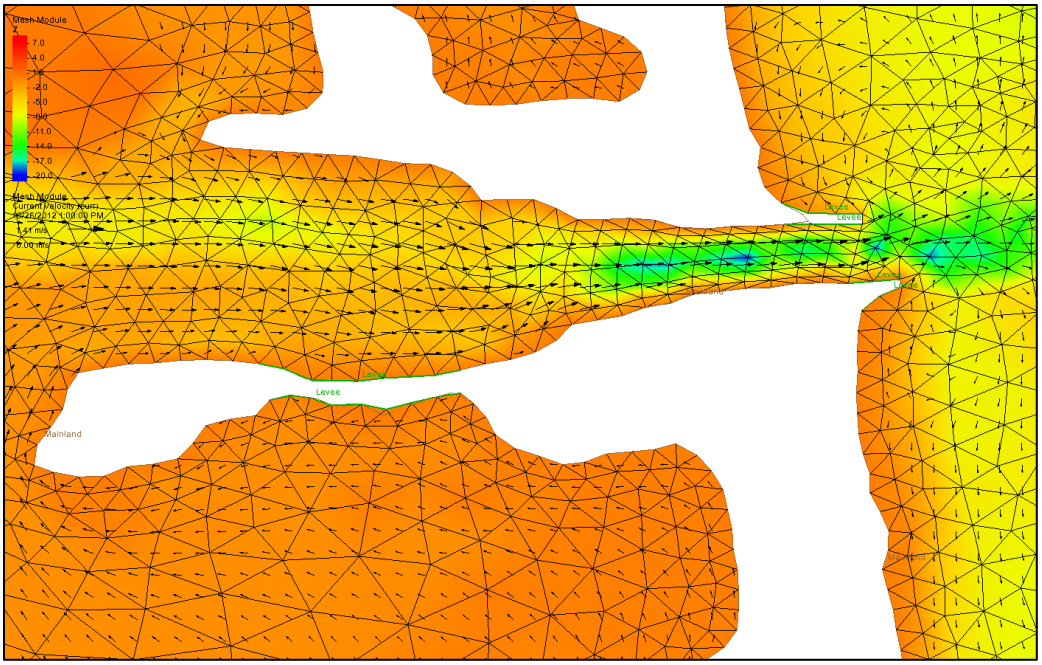

Figure 4 Adjusted elevations

4 Updating Levee Crest Elevations

Levees can be over-topped for various reasons. In the Levee Simulation tutorial, the reason was because the ground elevation was too low. There the elevations were adjusted manually, but that can be tedious to do if there are many levees to model.

SMS allows levee crest elevations to be updated to reflect current real-world conditions automatically for a simulation.

4.1 Getting Levee Crest Definitions from Terrain

In order to update levee crest elevations, a representation of the desired or existing crests must exist in the form of arcs along the levee crests.

One approach to getting this information is to extract the elevations from a DEM. To illustrate this process:

1. In the Project Explorer, turn on the "IR_Inlet_DEM_2015.tif" GIS dataset.

Note: you may want to adjust the display options for the TIF file to highlight the elevation range near the shoreline. This has been set in this project.

2. Turn on and select the "*levee BC"* coverage. This coverage includes an arc for each of the three levees in the simulation. They were digitized in an observation coverage to follow the levee crests.

Note: you could create your own crest coverage and digitize your own arcs. These were included to provide more consistency in the operation of this tutorial. These arcs should extend beyond the ends of the associated levee and should follow the levee crest. They should also be between the "levee arcs" for the associated levee in the boundary conditions coverage.

3. Right click on the "  IR_Inlet_DEM_2015.tif" DEM and select the *Interpolate to* | **Active coverage** context menu command. This updates the elevations of the nodes and vertices in the arcs from the DEM.
4. Using the *Select Object*  static tool in the Map module to select the nodes and vertices of these arcs to examine their elevations from the terrain in the *Edit window*.

Note: a profile plot of these arcs can be created using the observation profile tools.

4.2 Importing Levee Crest Definitions from Levee Survey

Another source of a levee crest elevation line would be a local survey of the levees. In this case the survey points could be stored as a csv file of points. To illustrate how to use this type of data:

1. Select the *File* | **Open** menu command and load the "Levee Survey.txt" file from the *data_files* folder. This will open the *File Import Wizard – Step 1 of 2* dialog.
2. Select the *Comma* delimiter option since this file uses commas. Note the format of the data in the *File preview* section.
3. Click the **Next** button. This will open the *File Import Wizard – Step 2 of 2* dialog.
4. From the *SMS data type* drop-down menu, select "Scatter Set".
5. In the *Mapping options* section, turn off the *Triangulate data* checkbox.
6. Click the **Finish** button.
7. SMS will ask that the projection for this data be specified. Click the **OK** button to bring up the *Projection* dialog.
8. In the *Projection* dialog, click the **OK** button to accept the default geographic projection. This will create a scatter set with points along the levee crests.

4.3 Using the Arcs from UGrid Points Tool

1. Click the "Toolbox  " macro to open the *Toolbox* dialog.
2. In the toolbox, select the *Coverages* | *Arcs from UGrid Points* tool. This tool connects adjacent points defined in scatter sets, meshes, or UGrids into arcs.
3. Click the **Run Tool…** button.
4. From the *Input grid* drop-down menu, select the "Scatter Data/Levee Survey" checkbox.
5. Leave the other arguments at default values.
6. For the *Output coverage name*, enter "Levee Crests from Survey".
7. Click the **OK** button to run the tool, the *Arcs from UGrid Points* feedback dialog opens.
8. When the tool has successfully completed, click the **OK** button to close the feedback dialog.
9. Turn off the "  Levee Survey" scatter set checkbox.
10. Turn on the "  *Levee Crests from Survey"* coverage and select it to make it active.

11. Using the **Zoom** static tool, zoom into the inlet. This should appear similar to Figure 5.

The new *Levee Crests from Survey* coverage is identical to the “levee BC” survey in that it defines the elevations down the centerline of the levees. It just came from a different data source.

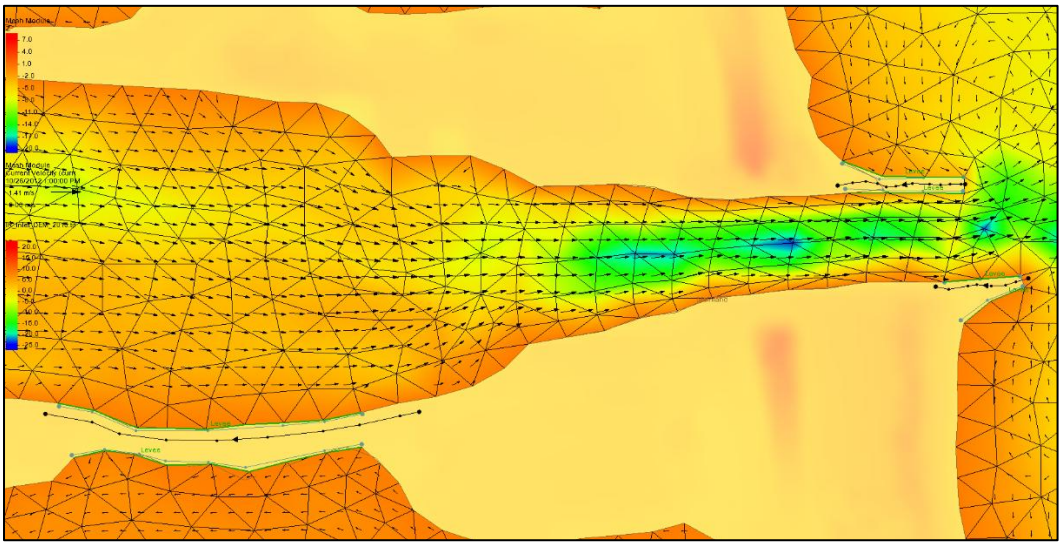

Figure 5 Levee Crests from Survey

4.4 Using the Check/Fix Levee Crest Elevations Tool

We will now run the *Check/Fix Levee Crest Elevations* tool. This tool creates a new ADCIRC Boundary condition coverage.

1. Click on the “ Toolbox” macro to open the *Toolbox* dialog.
2. In the *Toolbox*, launch the *ADCIRC* | **Check/Fix Levee Crest Elevations** tool. The *Check/Fix Levee Crest Elevations* dialog opens.
3. Click the **Run Tool…** button.
4. From the *Input ADCIRC Boundary Conditions coverage* drop-down menu, select “levee BC”.
5. From the *Domain grid* drop-down menu, select “patch inlet 50-1000m”
6. From the *Input check geometry coverage* drop-down menu, select “Levee Crests from Survey”.
7. For the *TauZ (allowable levee elevation error threshold)*, enter “0.0” meters
8. For the *Output coverage*, enter “Adjusted Levees”.
9. Click the **OK** button to run the tool.

This will bring up the *Check Levee Tool Results* and *Map Viewer* windows as shown in Figure 6. The *Check Levee Tool Results* dialog lists all the levees on the left side with an indication of what issues were identified. In this case, two of the three levees report possible issues. All three levees indicated that the crest elevations will be adjusted.

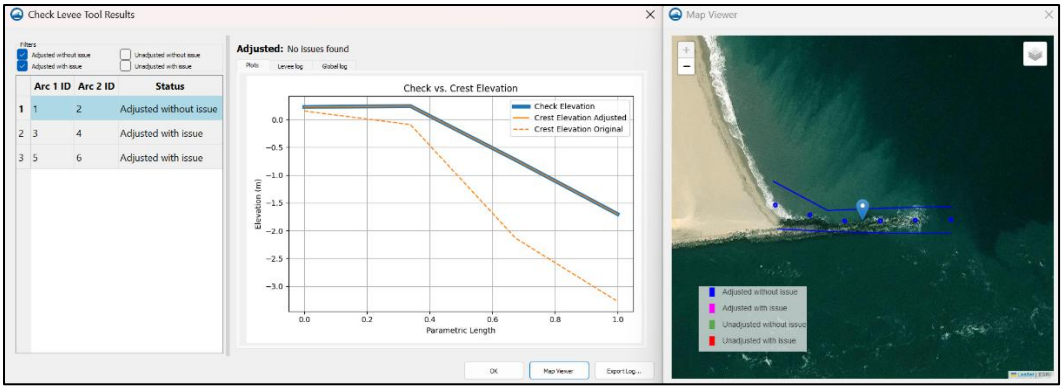

Figure 6 Comparing levee elevations to levee crest coverage.

10. Select the first line of the table on the left. The plot and viewer windows update. The viewer window zooms on the north jetty.

Notes: The plot shows the crest elevation before and after adjustment. The adjusted elevation matches the check arc elevation.

The title at the top of the plot identifies that no issues were detected. This line indicates that the levee was adjusted without issues.

11. Select the second line of the table on the left. The plot and viewer windows will update. The viewer window zooms on the south jetty.

Notes: The plot shows the crest elevation before and after adjustment. The adjusted elevation matches the check arc elevation.

The title at the top of the plot identifies that there is a possible units mismatch. This is because some of the errors between the previous crest elevation and the new crest elevations are in the range of the conversion between feet and meters. This warning just indicates that the user should review the units of the check arc coverage and the boundary condition coverage.

12. Select the third line of the table on the left. The plot and viewer windows update. The viewer window zooms on the west levee.

Notes: The plot shows the crest elevation before and after adjustment. The adjusted elevation matches the check arc elevation.

The title at the top of the plot identifies that there a partially unused checkline and potential units mismatch. This is because some of the errors between the previous crest elevation and the new crest elevations are in the range of the conversion between feet and meters. This warning just indicates that the user should review the units of the check arc coverage and the boundary condition coverage.

The log also includes the possible issue that the levee check line is longer than the levee in the simulation. This warning alerts the user to make sure the length of the levee in the boundary condition coverage is appropriate.

13. Click on the “Levee log” tab at the top of the plot.

Notes: This log lists the changes that are being applied for each node pair in the levee.

14. Click the **OK** button to close the review window.
15. Click the **OK** button on *Check/Fix Levee Crest Elevations* feedback dialog to close the tool.

Notes:

A new ADCIRC boundary conditions coverage has been created that is identical to the input coverage with the crest elevations of the levees updated. The crests are actually updated in two ways:

First, the elevations of the arc nodes and vertices have been updated based on the check lines.

Second, the levee definition has been updated to use a parametric curve to represent the crest elevation of the levee. This curve also matches the check arc elevations.

This highlights how levees are represented in SMS. SMS allows the levee crests to be defined by the arcs, or by a parametric crest curve. If there are enough vertices in the arcs to represent the variations in the crest, that approach is more intuitive.

However, if there are only a few (or even just two) points in the arc, a parametric curve allows for the crest definition to be more precise. In this case, either approach works just fine.

Remember that the crest elevation will eventually be saved for ADCIRC at the resolution of the mesh. If the mesh resolution is lower than the resolution of the arcs or the detail in the parametric curve, information stored in the levee definition in SMS will be lost when it is passed to ADCIRC.

4.5 Using the New BC Coverage

The new boundary condition coverage defines new crest elevations for the levees. You may want to update an existing simulation to use these new definitions, or you may want to duplicate the original simulation and use the new boundary condition in the duplicated simulation. To illustrate:

1. In the Project Explorer, right click on the "Levees constant Zc" simulation and select the **Duplicate** context menu command.
2. Right click on the "Levees constant Zc (2)" simulation and select the **Rename** context menu command and enter "Levees varied Zc". Press the *Enter* key to set the new name.
3. Under the "Levees varied Zc", right click on the "levee BC" coverage link and select the **Remove** context menu command.
4. Drag the "Adjusted Levees" map data coverage and drop onto the "Levees varied Zc" simulation, a black drop location line will appear.
5. Right click on the "Levees varied Zc" simulation and select the **Map Boundary Conditions…** context menu command. The *Applying Boundary Conditions* feedback dialog will appear showing progress and will close automatically once complete. This updates all the information so that the simulation is ready to be run again.

5 Running the Simulation(s)

With a completed simulation, we will now save and run the simulation.

1. From the *Menu* bar select the *File* | **Save as…** menu command to open the *Save As* dialog.
2. For the *File name,* enter "IR_levee_options.sms".
3. Click the **OK** button to save the file and close the *Save As* dialog.

4. Right-click on the "Levees varied Zc" simulation and select the **Save Project, Simulation and Run** context menu command.
5. The *Simulation Run Queue* dialog will open. Note: Running ADCIRDC in serial mode will take about 25 minutes for this simulation.

To review the simulation results:

6. When done, in the *Simulation Run Queue* dialog, click the **Load Solution** button.

To save the project:

7. From the Menu bar, select the *File* | **Save Project** menu command.
8. Using the **Zoom** static tool, zoom into the inlet. This should appear similar to Figure 7.

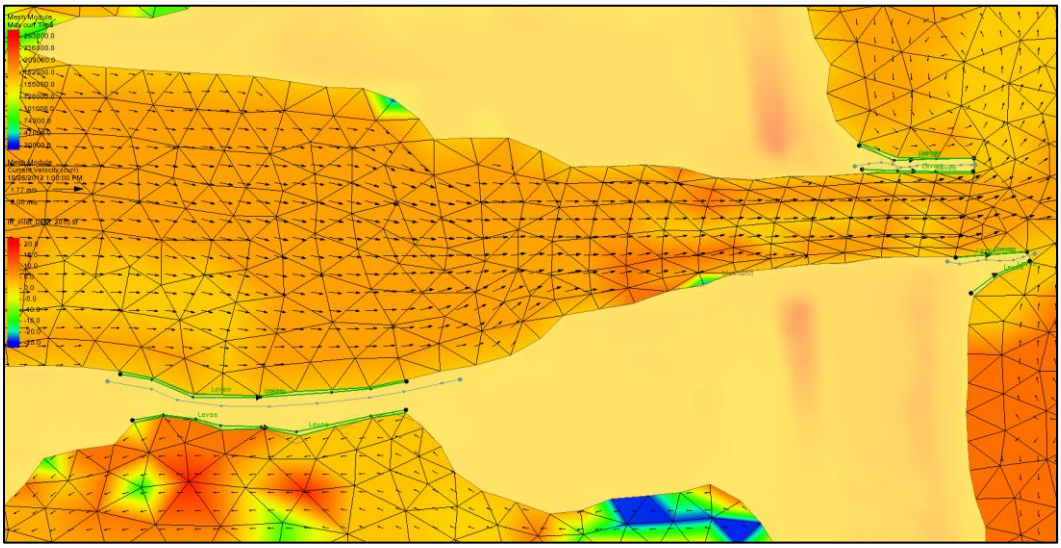

Figure 7 Completed Simulation

6 Conclusion

This concludes the "Levee Options" exercise. Several features have been demonstrated including:

- Fixing mesh elevations to be consistent with ADCIRC levee definitions.
- Extracting levee check arcs from a DEM.
- Loading levee survey data for use as check arcs.
- Assigning levee crest elevations.