Polder Flood Simulations for Greater New Orleans: the neutral MRGO scenario

July 2008





Polder Flood Simulations for Greater New Orleans: the neutral MRGO scenario

M. Kok, M. Aalberts, W. Kanning, B. Maaskant, L. de Wit

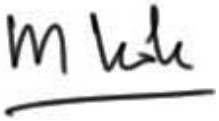
July 9, 2008

Preface

This research project has been carried out in the period January – May 2008. The objective of the project is to gain insight in the flow dynamics during Hurricane Katrina and the influence of the MRGO there on. The results depend on the data available for input and the results might change if new data comes available. In our opinion, the best available data is used.

The project team has the following members: M. Kok Ph.D. MSc. (project manager), B. Maaskant MSc., W. Kanning MSc. and M. Aalbers MSc. (all from Delft University of Technology). Reviewer of the project is Professor J.K. Vrijling MSc. (Delft University of Technology).

Delft, 9th July 2008



Index

1 Introduction 7
1.1 General introduction 7
1.2 Objective 7
1.3 Flood scenario 7

2 New Orleans Central Polder 9
2.1 Breach locations and boundary conditions 9
2.2 Simulation results 10
2.3 Results at specified locations 12

3 New Orleans East 17
3.1 Breach locations and boundary conditions 17
3.2 Simulation results 18
3.3 Results at specified locations 20

4 St Bernard polder 25
4.1 Breach locations and boundary conditions 25
4.2 Simulation results 27
4.3 Results at specified locations 28

5 Conclusions 35

6 References 37

1 Introduction

1.1 General introduction

On the morning of August 29, 2005, Hurricane Katrina struck southeast Louisiana and triggered what would become one of the worst disasters ever to befall an American city. The storm overtopped levees and floodwalls throughout southeast Louisiana and also caused the levees and floodwalls in the New Orleans area to fail or breach in more than 50 locations. Water rushed into New Orleans and flooded over 80 percent of the city - more than ten feet deep in some neighborhoods.

Flooding of the city of New Orleans was caused by several sources (or causes): breaches, overtopping (of the levees and flood control structures) and rainfall. One of the causes of the breaches might be the amplified surges generated by the Mississippi River Gulf Outlet (MRGO). The MRGO is a free-flowing man-made navigation channel connecting the Gulf of Mexico to the interior of the City of New Orleans. The MRGO project was approved by the U.S. Congress under the Rivers and Harbor Act of 1956. Construction began in 1958 and was completed in 1965. It was authorized as a 76-mile ship channel with a 36 foot controlling depth, 500 feet wide at the bottom and 650 feet wide at the top, that would cut through the marshes of lower St. Bernard Parish and across the shallow waters of Breton Sound.

In this report we investigate the flooding of the three polders in New Orleans, and this report is a follow up of our report **"Polder Flood Simulations for Greater New Orleans Hurricane Katrina August 2005"** of July 2007.

1.2 Objective

The objective of this study is to better understand the flooding of the three polders in New Orleans, using the scenario of a neutral MRGO. The water levels of a neutral MRGO scenario was assessed by the FINEL model **("Flow Modeling New Orleans -Mississippi River Gulf Outlet Hurricane Katrina August 2005").**

1.3 Flood scenario

In this paragraph a brief overview is given of the hydraulic boundary conditions, breaches and overtopping of flood simulations of a neutral MRGO scenario ("scenario 2C").
The characteristics of Scenario 2C:

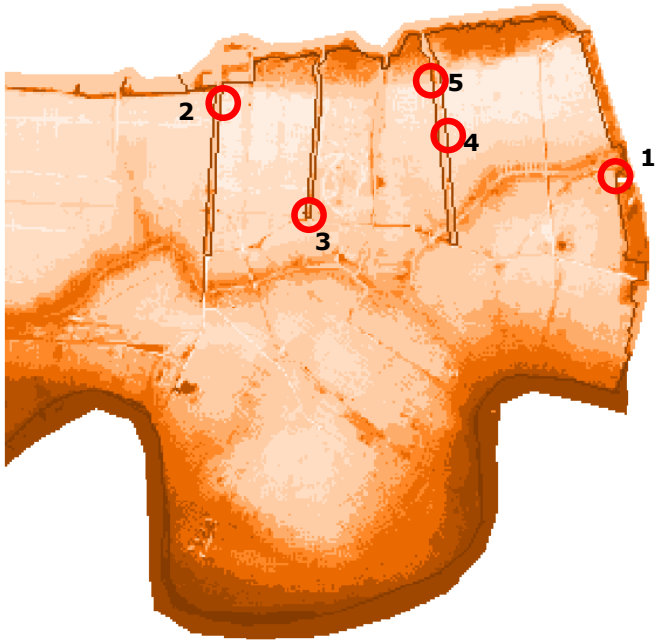
- No swamp, marsh, trees or vegetation loss in wetlands
- No MRGO channel
- MRGO Levee as existed before Katrina
- 40-Arpent levee as existed before Katrina

The breaching scenarios used in these simulations are presented in the appendix. The breaching scenarios are incorporated as boundary conditions and are given to us by professor Bob Bea.

2 New Orleans Central Polder

2.1 Breach locations and boundary conditions

For the New Orleans central polder the boundary conditions at lake Pontchartrain do not change with respect to the previous flood simulations, Kok et al, 2007. Only the boundary conditions in INHC are adjusted to the FINEL scenario 2C results. The breach in the IHNC is the only breach that has been modelled with a different boundary condition compared to the original simulation. The other breaches in the IHNC levees have been removed.

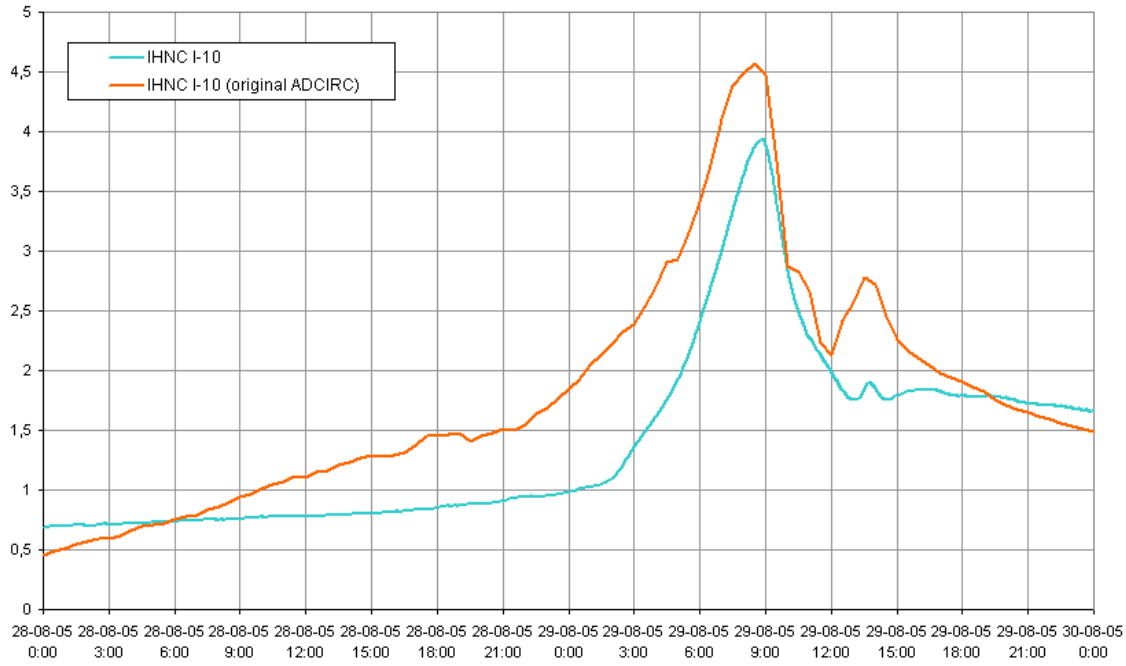


Figuur 2-1: Five breach locations in the New Orleans Central polder.

The Tabel 2-1 and Figuur 2-2 show the time of breaching and the accompanying boundary condition. The breaches 2 to 5 are the same as the original, Kok et al, 2007, flood simulations.

Breach	Water height at time of breach	Time of breach
1 (CSX RR)	9ft = 2.74m	06:30
2 (17th street)	7ft = 2.14m	06:00 – 09:00
3 (Orleans canal)	9.4ft = 2.87m	07:30 – 08:00
4 (London east)	8.6ft = 2.61m	07:00 – 09:00
5 (London west)	8.6ft = 2.63m	07:00 – 09:00

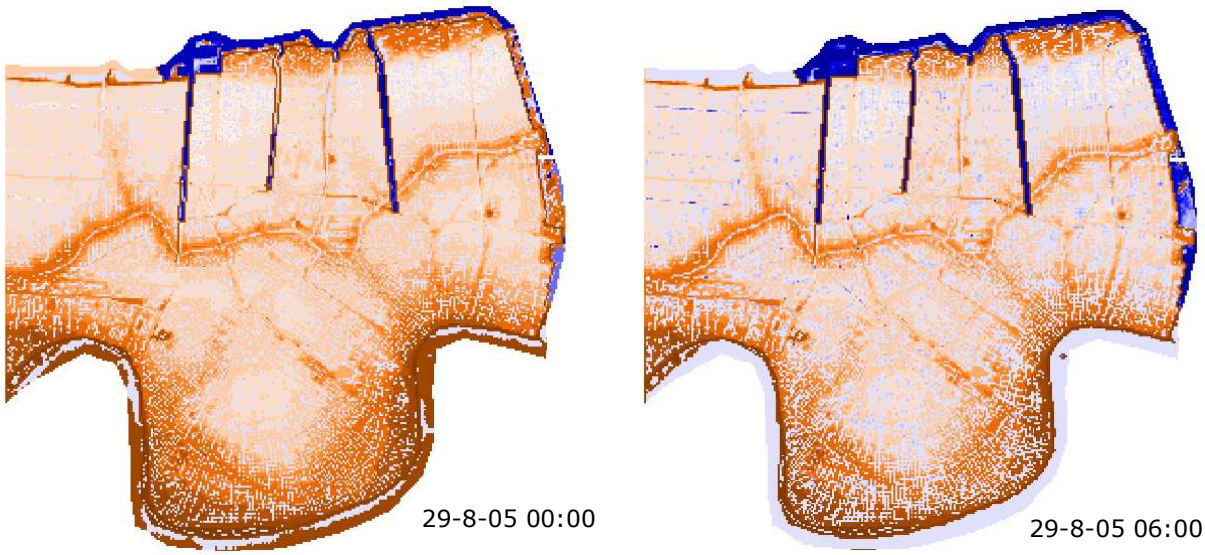
Tabel 2-1: Boundary conditions breaches 1 to 2 New Orleans Central polder.

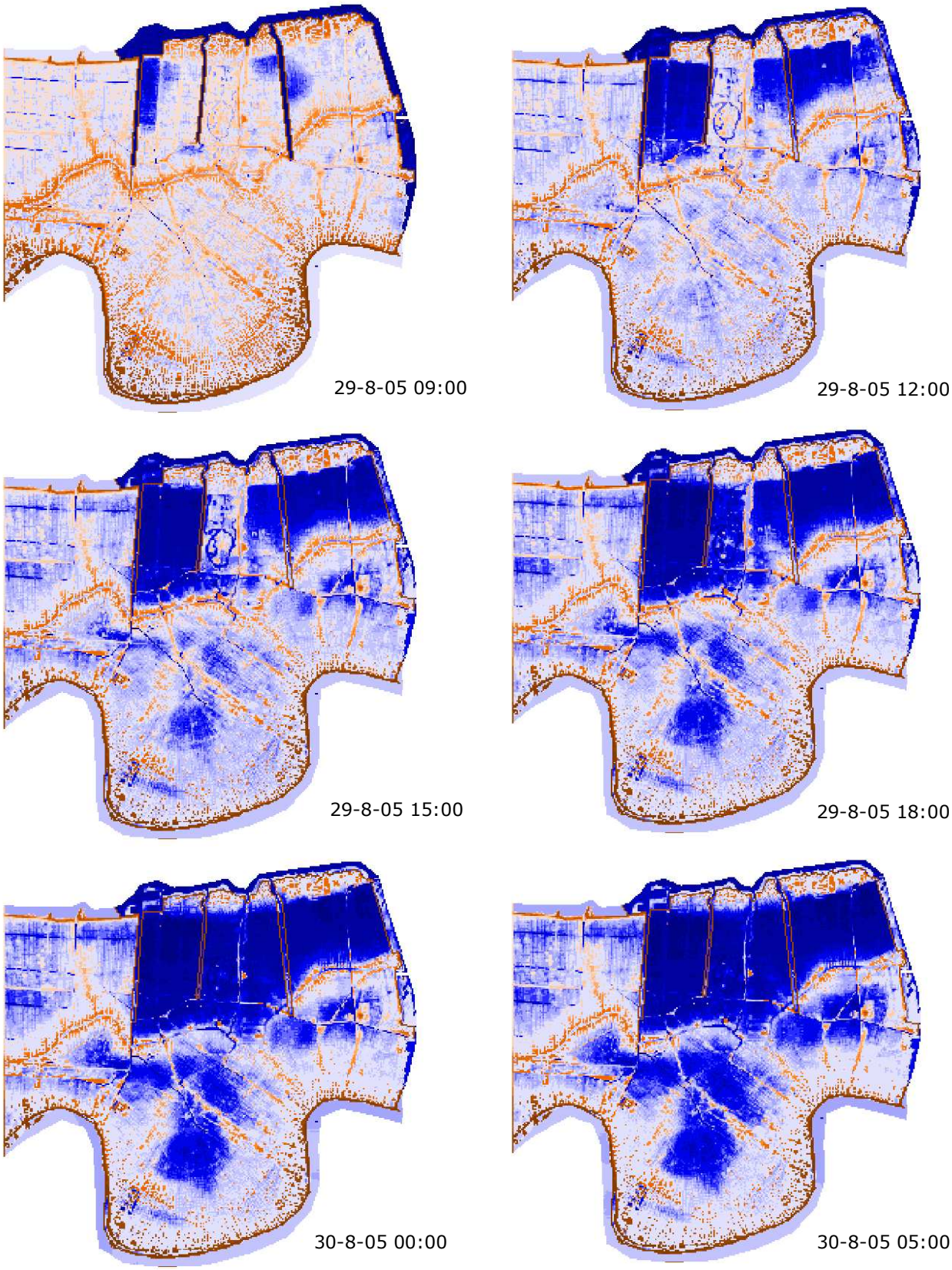


Figuur 2-2: Boundary condition breach 1 New Orleans Central polder.

2.2 Simulation results

The figures below (Figuur 2-3) show the progression of the flooding with the boundary condition in the IHNC from the FINEL scenario 2C results.





Figuur 2-3: Progressive snapshots of the computed water depth inside the New Orleans Central Polder.

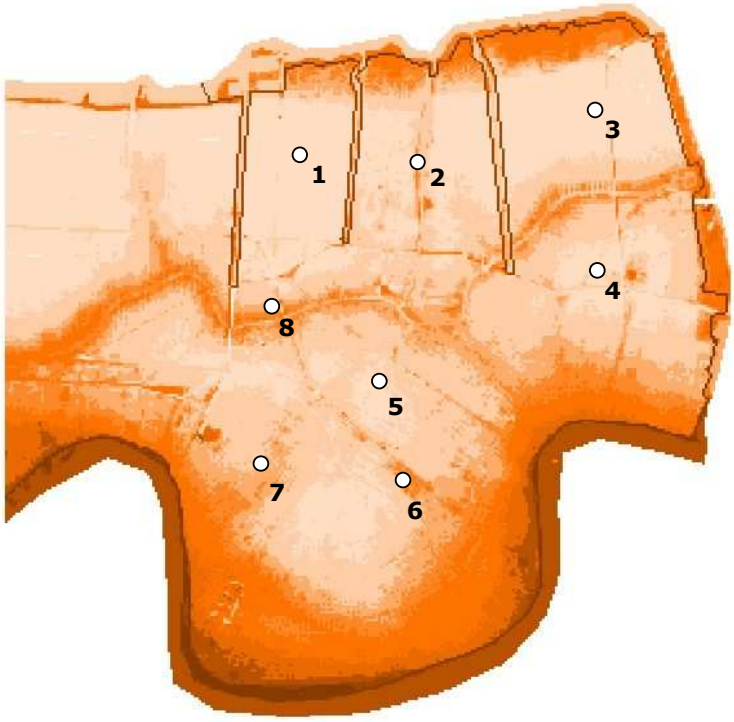
2.3 Results at specified locations

For each location pointed in Figuur 2-4 the water level is given in Figuur 2-5 for three different scenarios.

- Scenario 1 'All causes' (black line) is from the flood simulations done last year (Kok et al, 2007),
- Scenario 2 'Scenario 2C' (green line) is the line which represents the water level line computed with the adjusted boundary conditions in the IHNC.
- Scenario 3 'No breaching' (red line) gives the development of the water level for the situation that there is rainfall, overtopping, a breach near the Railroad and a breach at the end of the Orleans Canal, breach numbers 1 and 3 in Figuur 2-1.

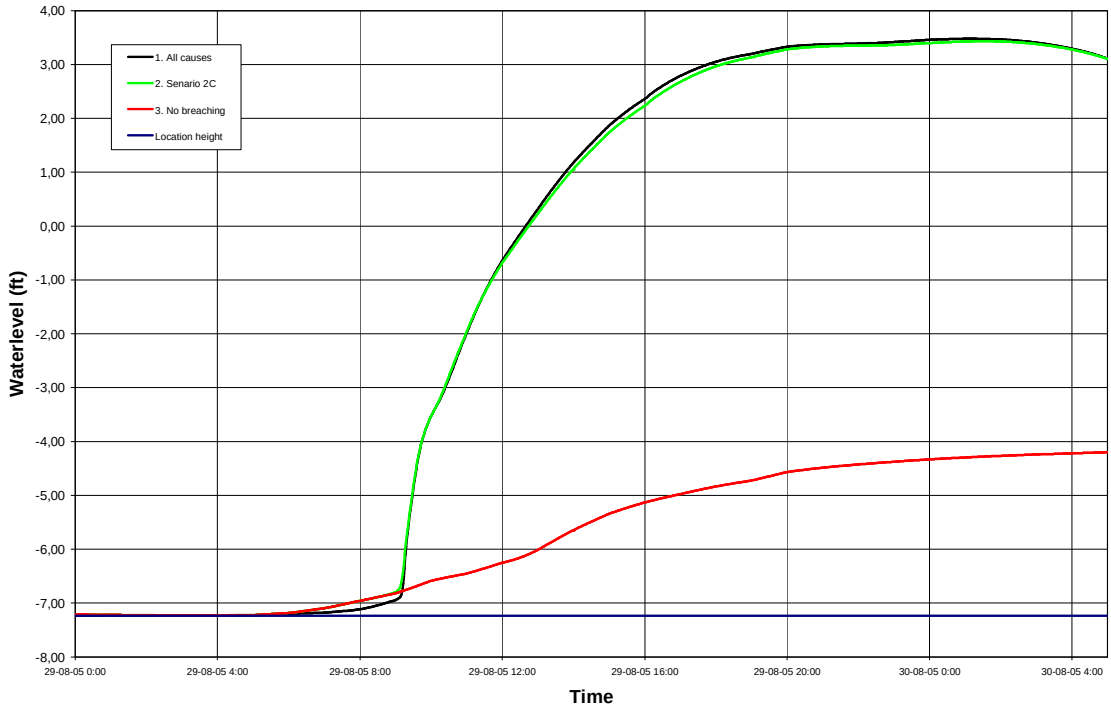
De blue line indicates the height of the location.

Due the changes in the IHNC boundary conditions the water levels in location 4 will change the most. If no breaching would occur the water level at all locations will lower (except for the high situated location 7).

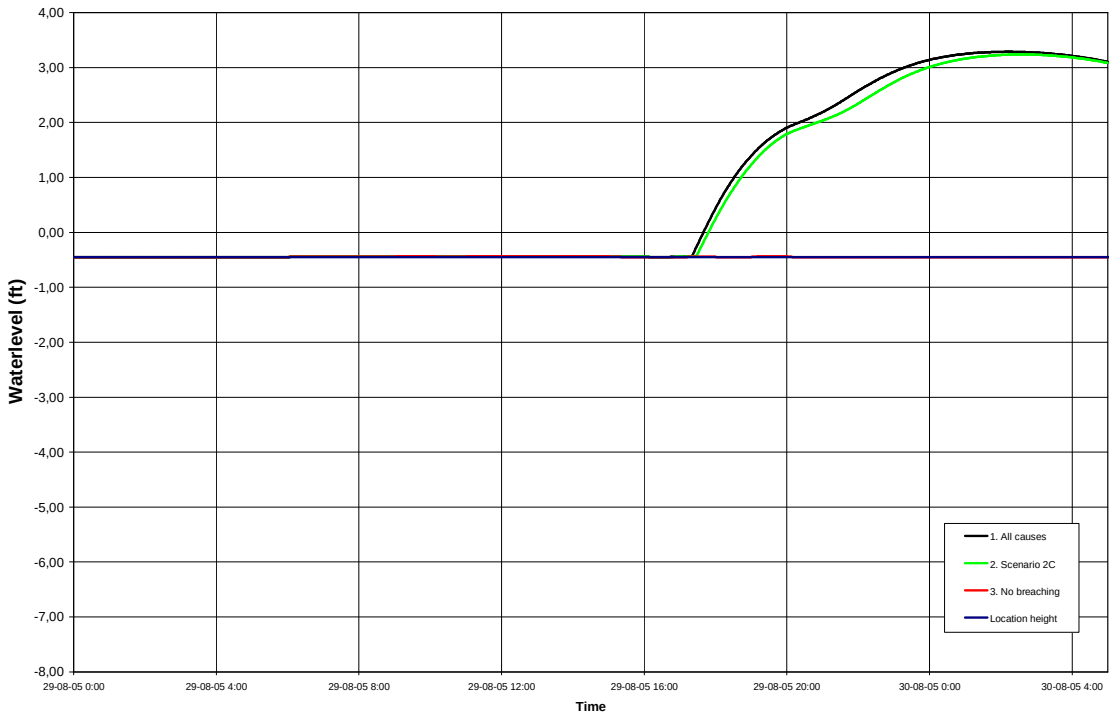


Figuur 2-4: Locations utilized for scenario development Orleans Metro polder.

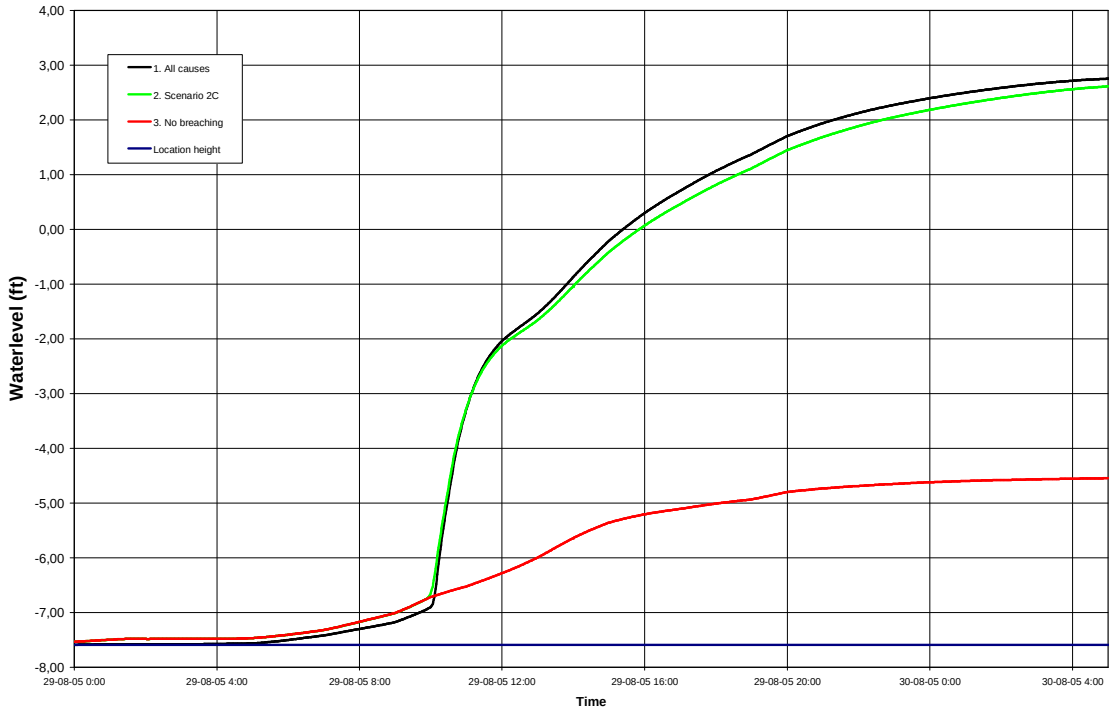
Water level location 1



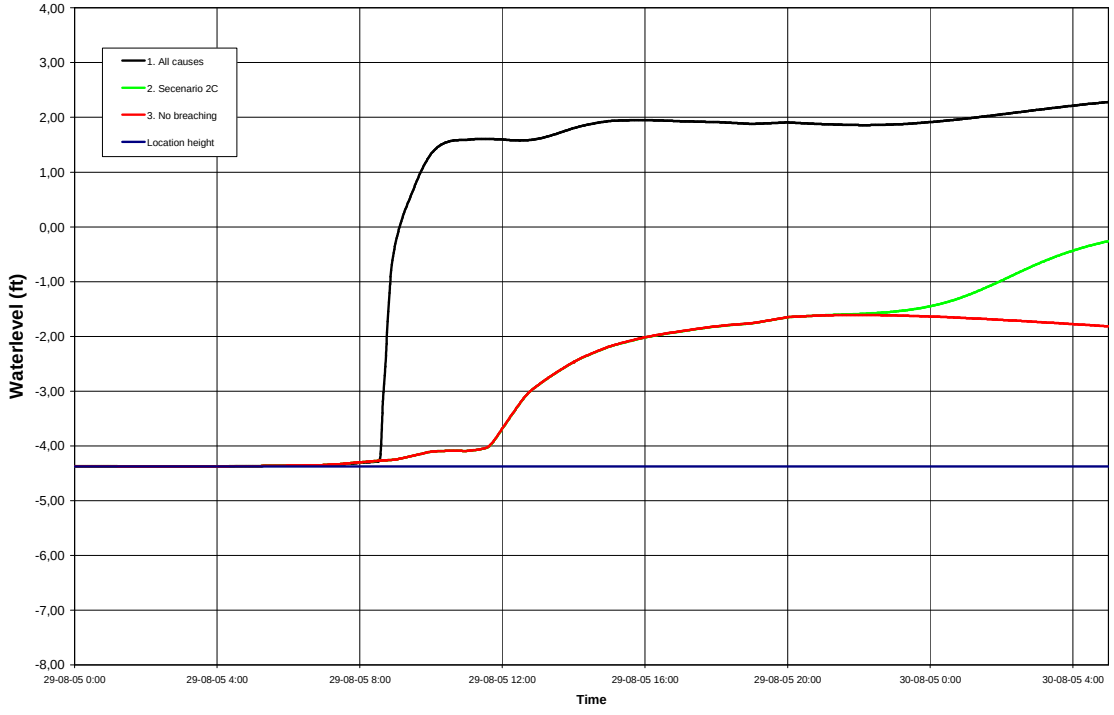
Water level location 2



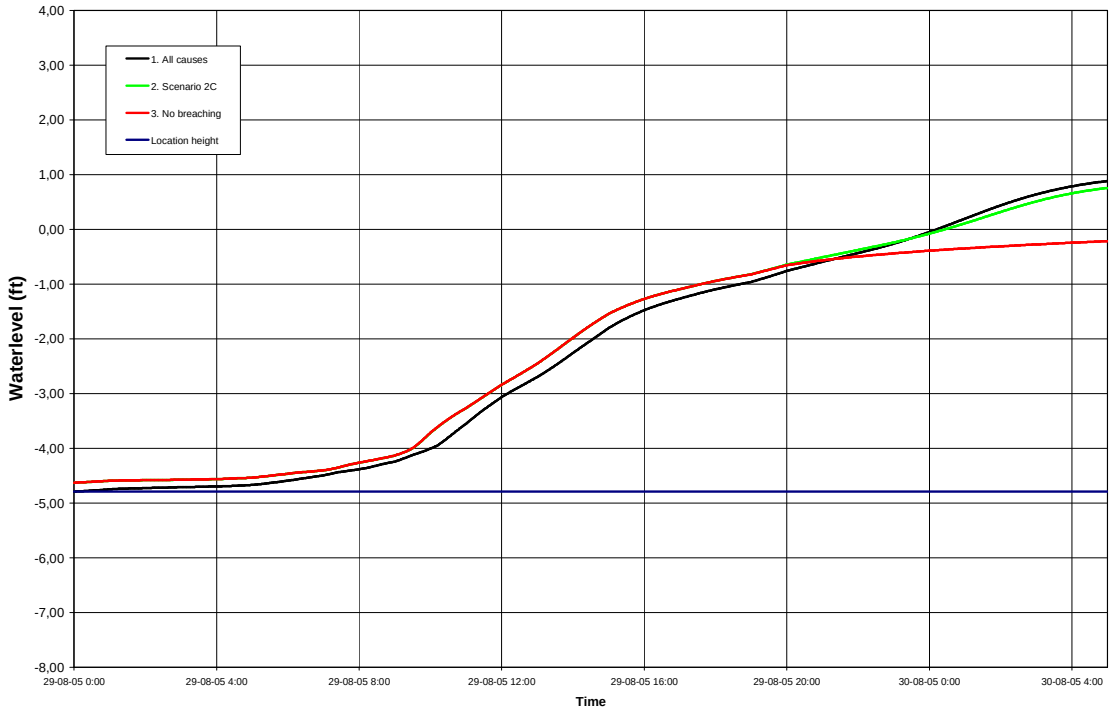
Water level location 3



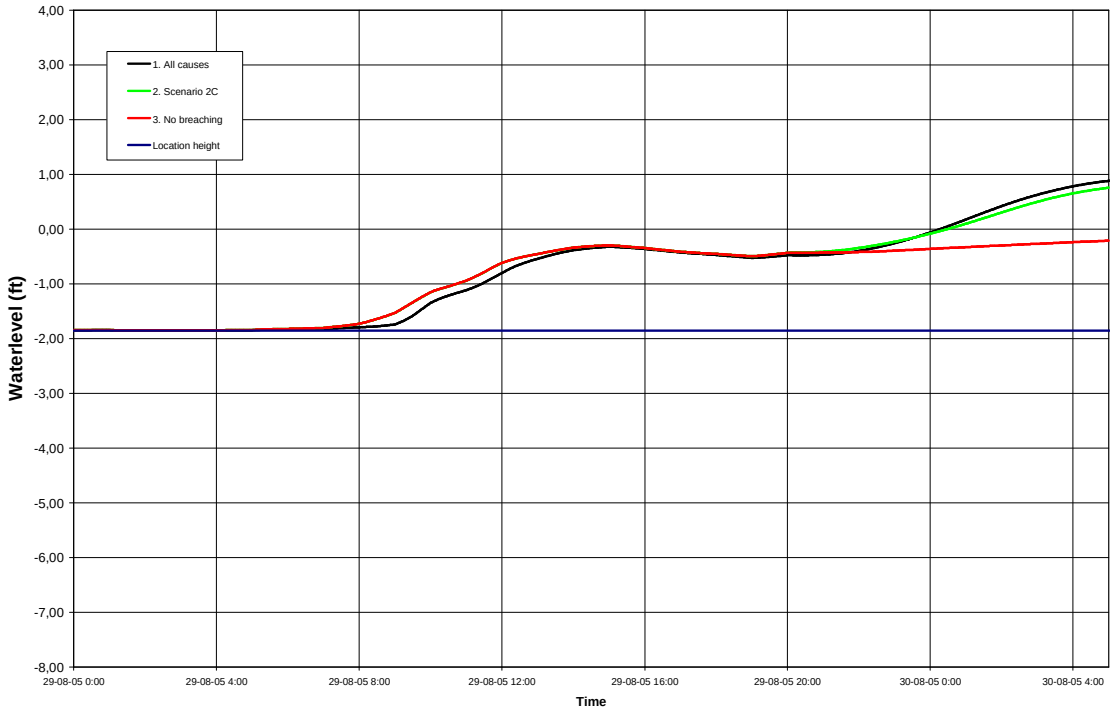
Water level location 4

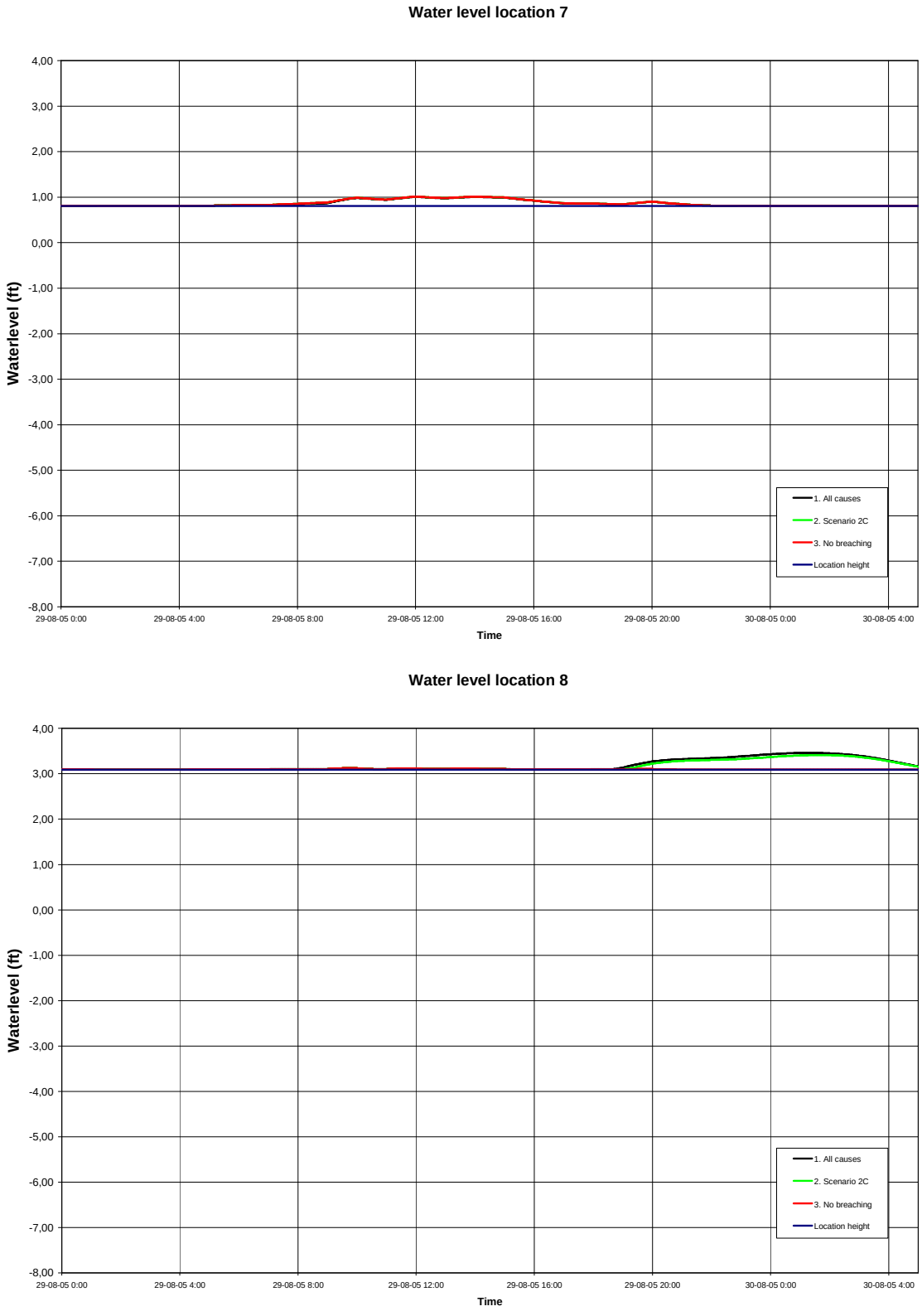


Water level location 5



Water level location 6





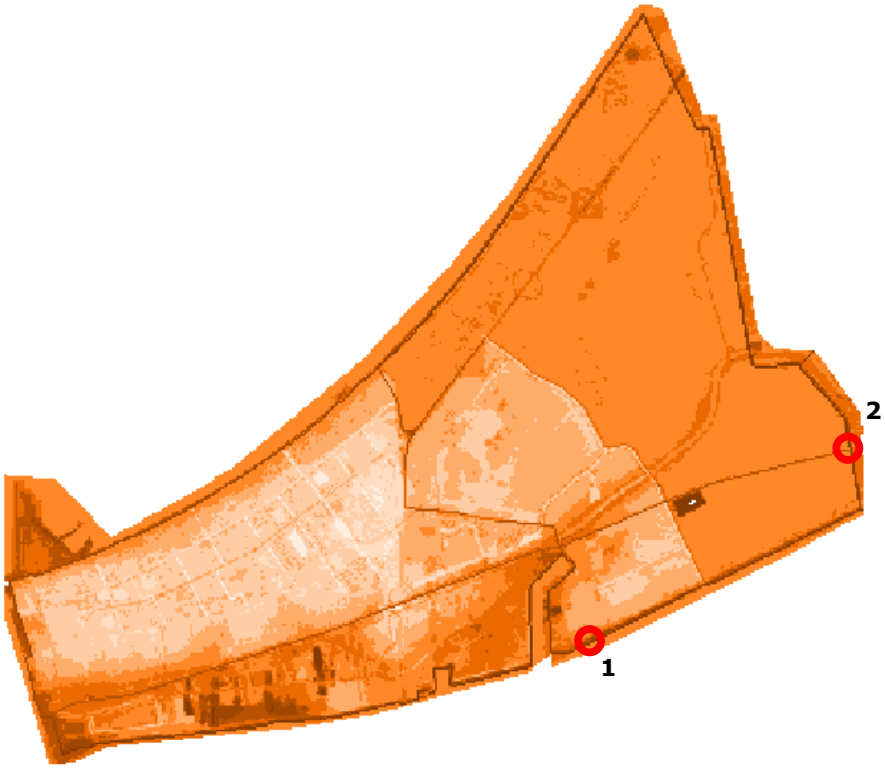
Figuur 2-5: Water level per scenario location Orleans Metro polder.

3 New Orleans East

3.1 Breach locations and boundary conditions

In the modelling of the New Orleans East polder, the boundary conditions at the North side have not been changed. These boundary conditions are the same as in the previous simulations of the hurricane Katrina event (Kok et al, 2007). The boundary conditions on southern part of New Orleans East have been changed using the FINEL results from scenario 2C.

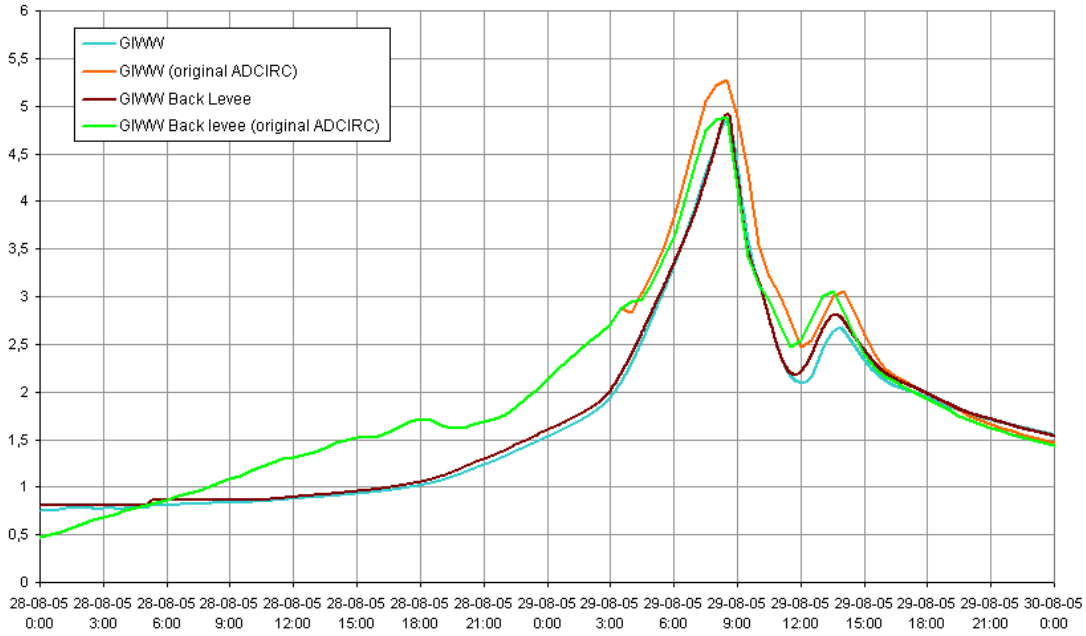
There are two breaches defined in the New Orleans East polder, numbered one and two (see Figuur 3-1). The time of breaching and the accompanying boundary condition are given in the Tabel 3-1 and Figuur 3-2.



Figuur 3-1: Two breach locations in the New Orleans East polder.

Breach	Water height at time of breach	Time of breach
1 (Air Products Plant)	10.89 ft (3.32m)	6:00
2 (Railroad)	9.39 ft (2.86m)	5:00

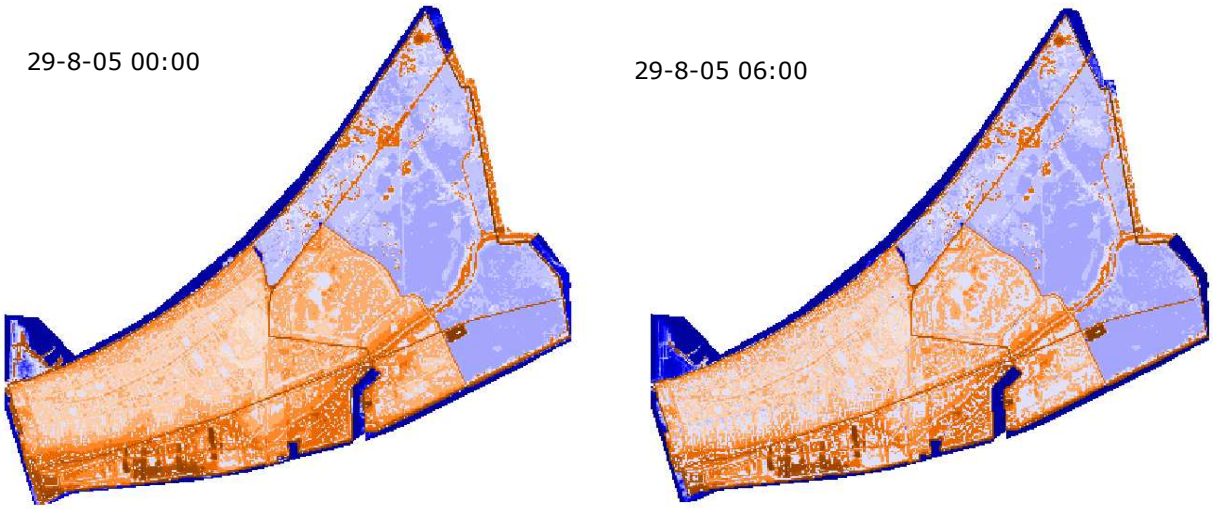
Tabel 3-1: Boundary conditions breaches 1 and 2 New Orleans East polder.

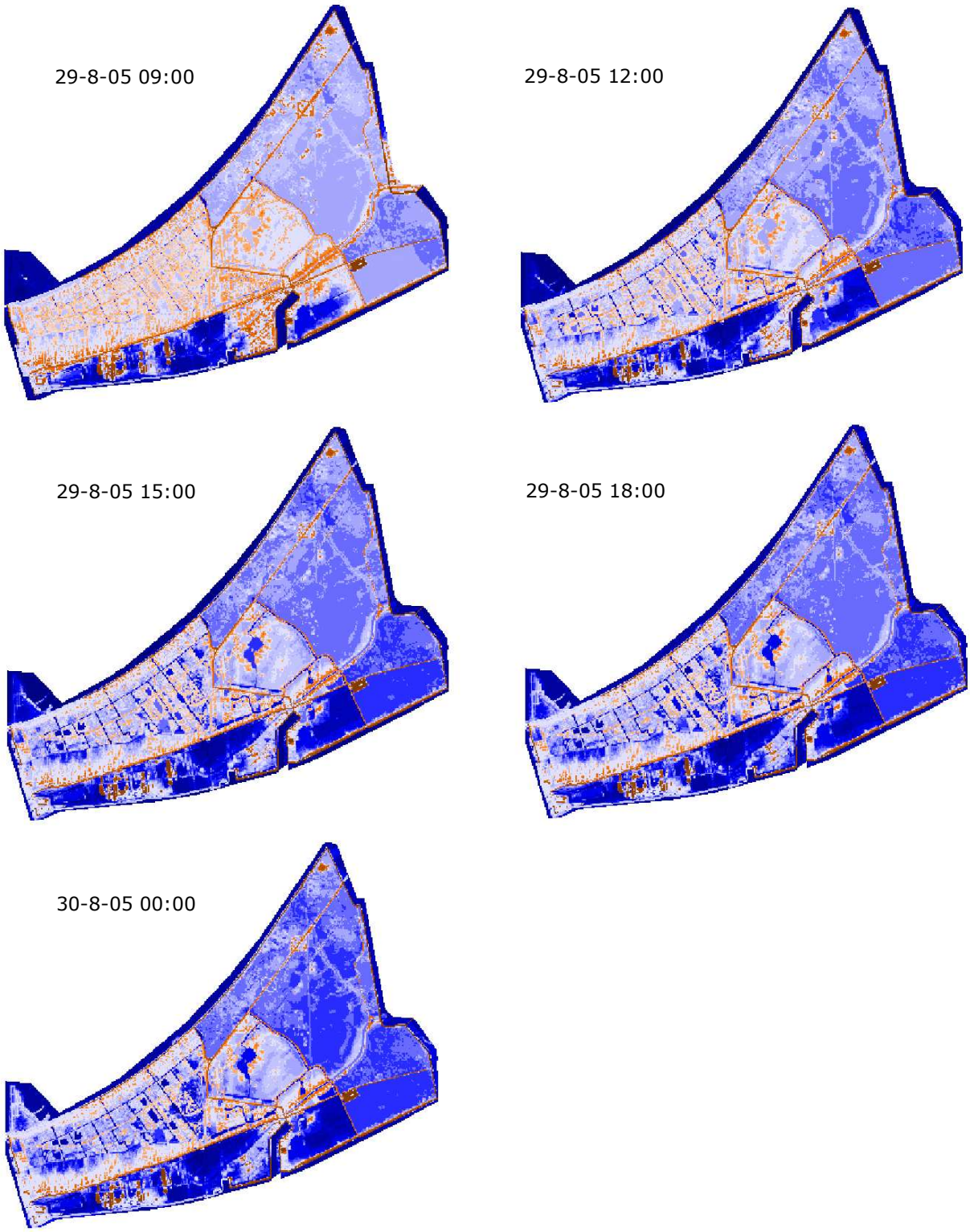


Figuur 3-2: Boundary conditions breaches 1 and 2 New Orleans East polder.

3.2 Simulation results

The figures below (Figuur 3-3) show the flood development in the New Orleans East polder. The flooding differs significantly from the original New Orleans East flooding in Kok et al, 2007. This is mainly because in this flood simulation the breaching in the Back levee does not occur. This was the main entry point for the floodwater in the original flood simulation (Kok et al, 2007). Two other originally modelled breaches that contributed significantly to the flooding occurred in the Citrus Back levee, these two breaches are also excluded in this simulation. Breaches in the IHNC levee are also excluded from the simulation.





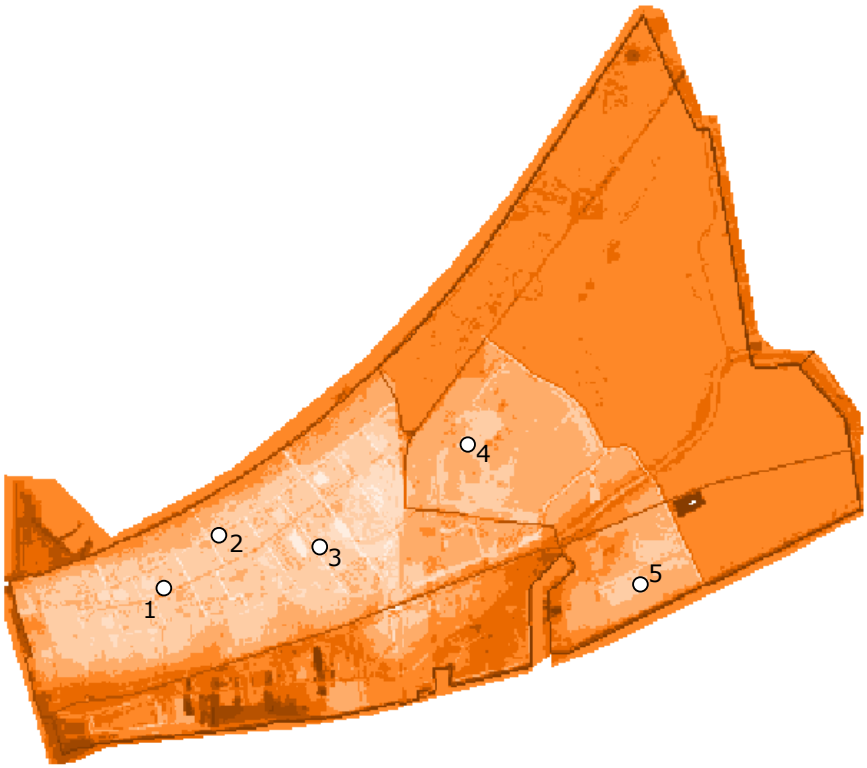
Figuur 3-3: Progressive snapshots of the computed water depth inside the New Orleans East polder.

3.3 Results at specified locations

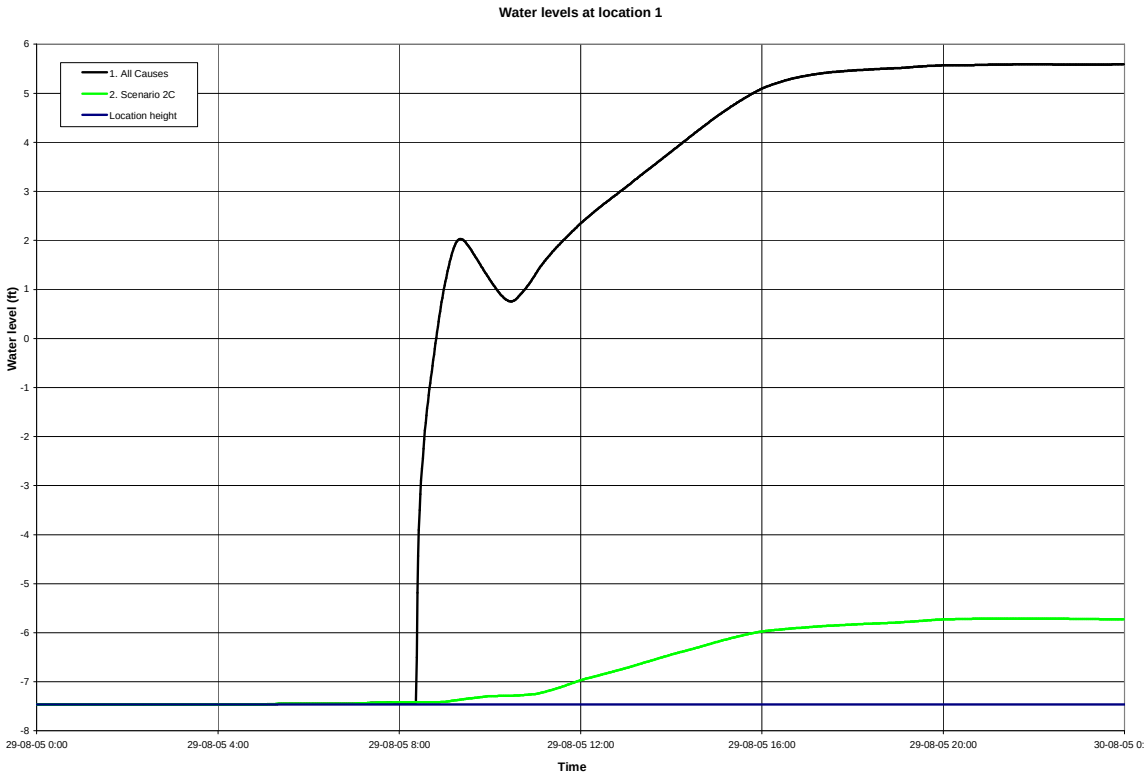
For each location pointed in Figuur 3-4 the water level is given in Figuur 3-5. Figuur 3-5 gives two water level lines each representing one scenario.

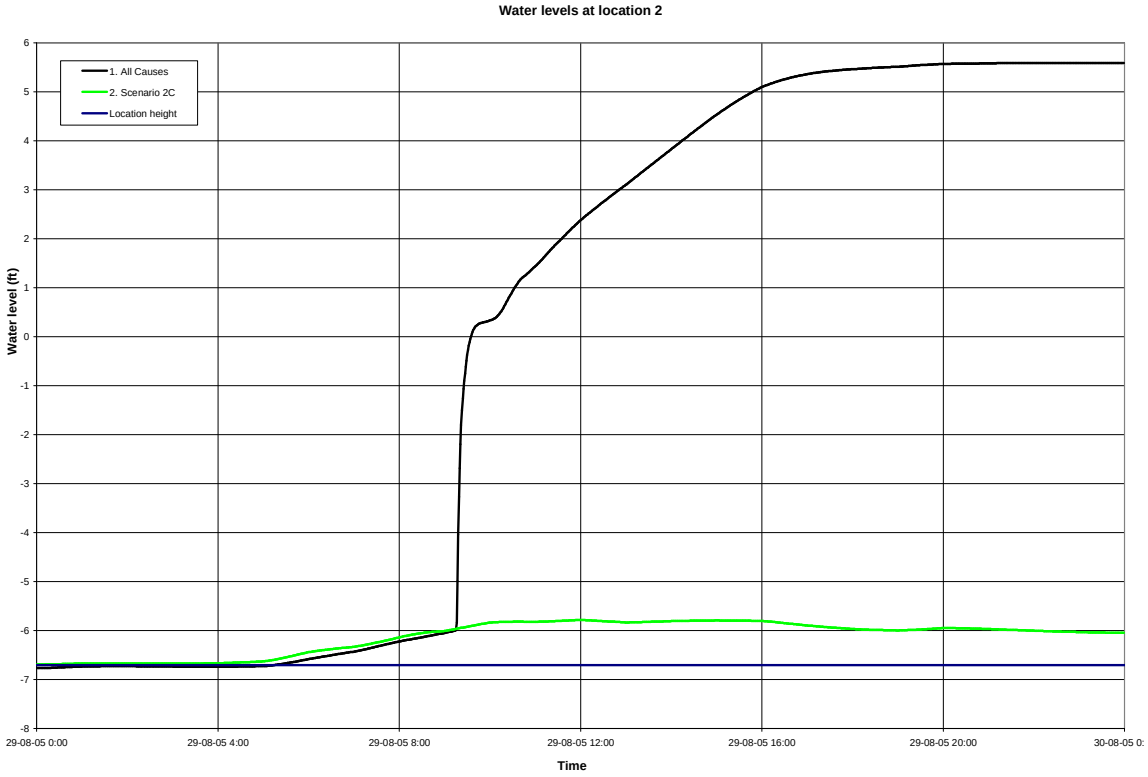
- Scenario 1 'All causes' (black line) is from the flood simulations done last year (Kok et al, 2007),
- Scenario 2 'Scenario 2C' (green line) is the line which represents the water level line computed with the adjusted boundary conditions in the IHNC and GIWW.

The blue line gives the height of the location.

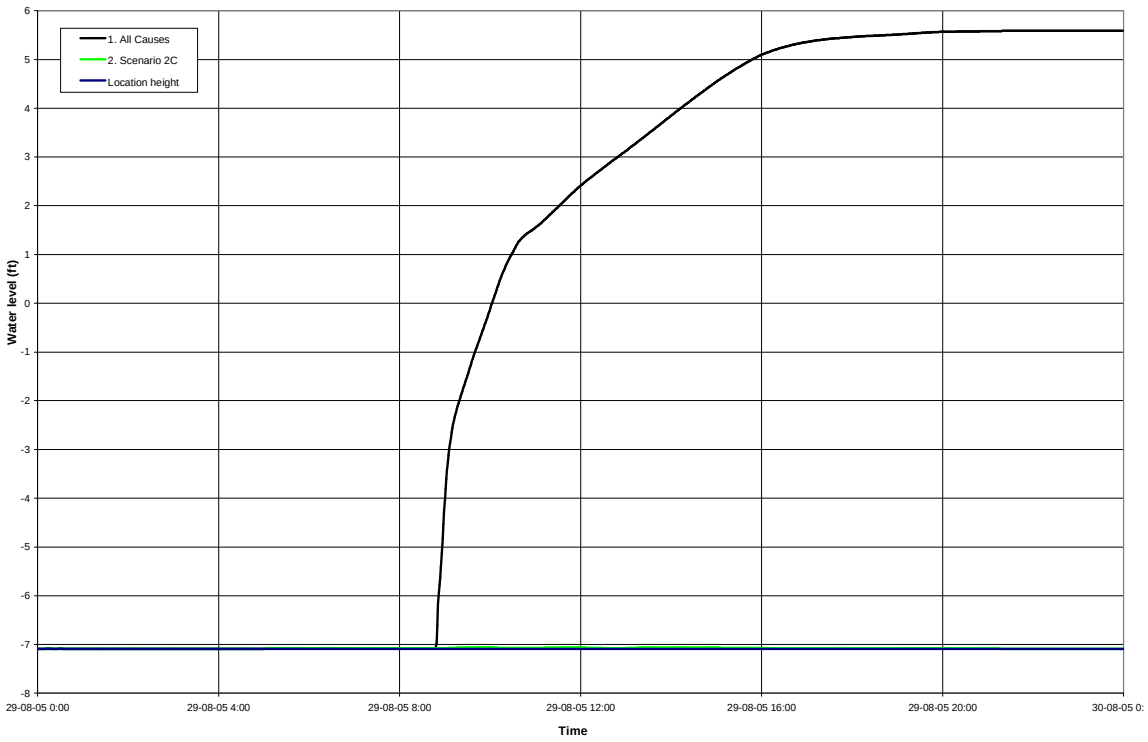


Figuur 3-4: Locations utilized for scenario development New Orleans East.

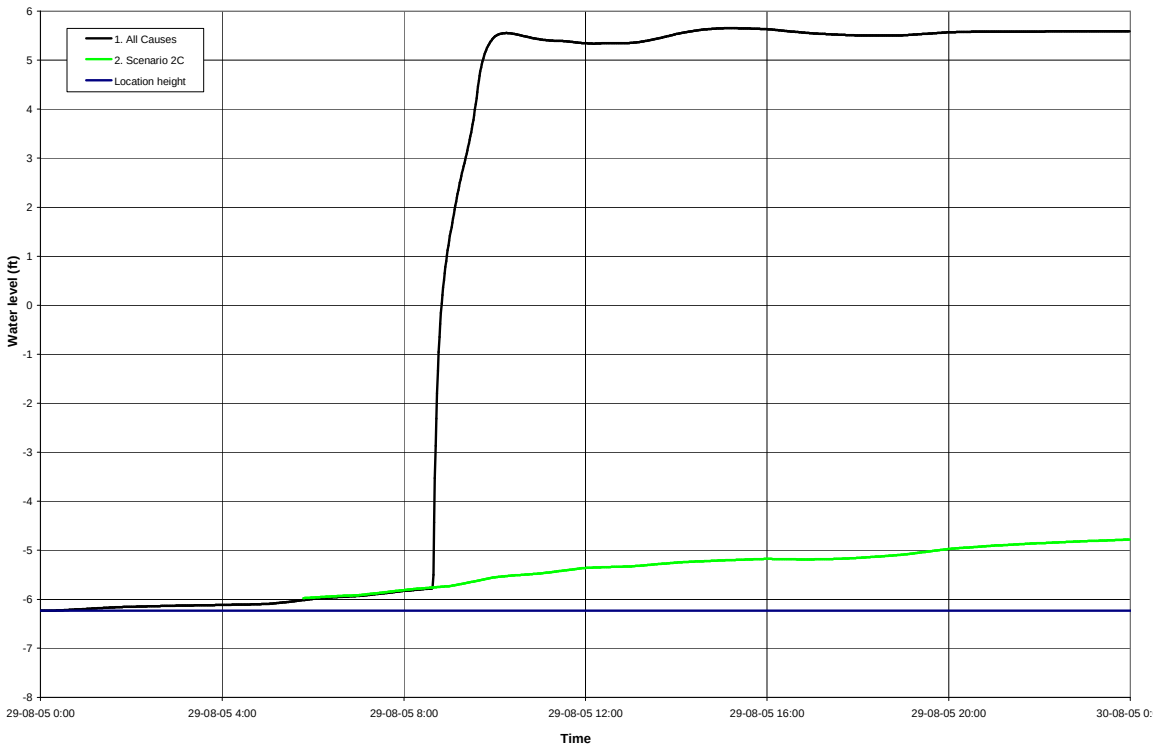

Water levels at location 1
1. All Causes
2. Scenario 2C
Location height
Water level (ft)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
29-08-05 0:00
29-08-05 4:00
29-08-05 8:00
29-08-05 12:00
29-08-05 16:00
29-08-05 20:00
30-08-05 0:
Time

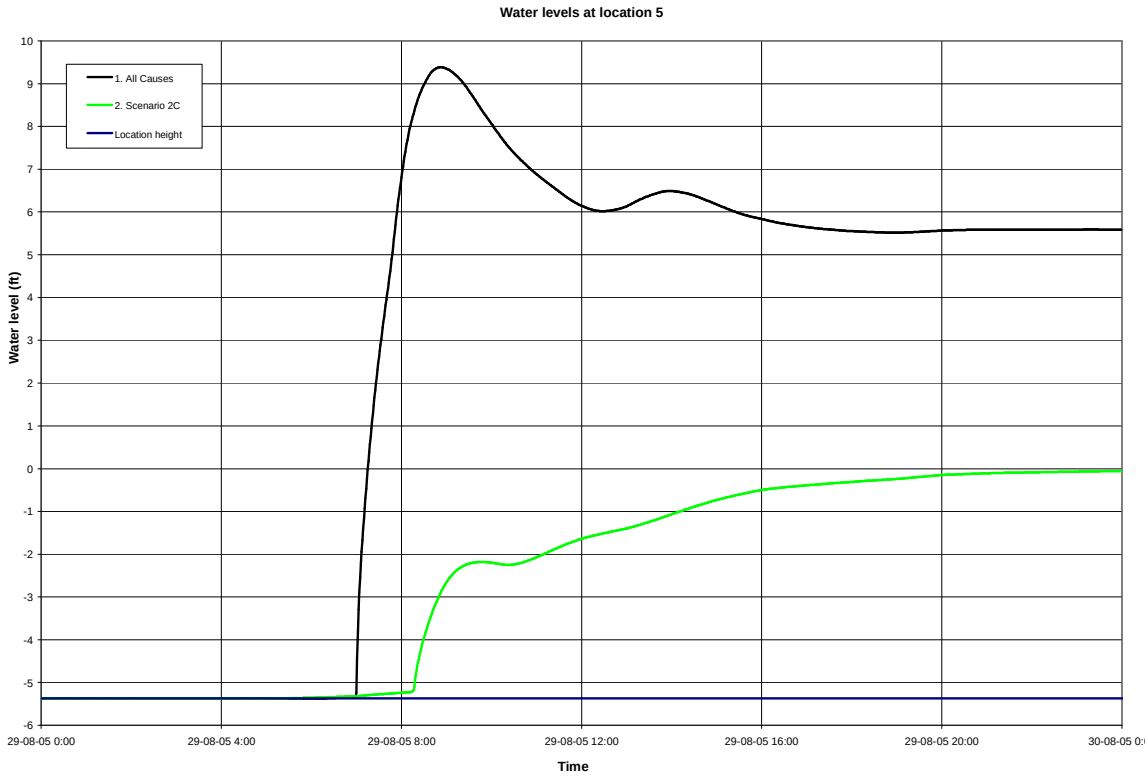

Water levels at location 2
1. All Causes
2. Scenario 2C
Location height
Water level (ft)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
29-08-05 0:00
29-08-05 4:00
29-08-05 8:00
29-08-05 12:00
29-08-05 16:00
29-08-05 20:00
30-08-05 0:
Time

Water levels at location 3



Water levels at location 4



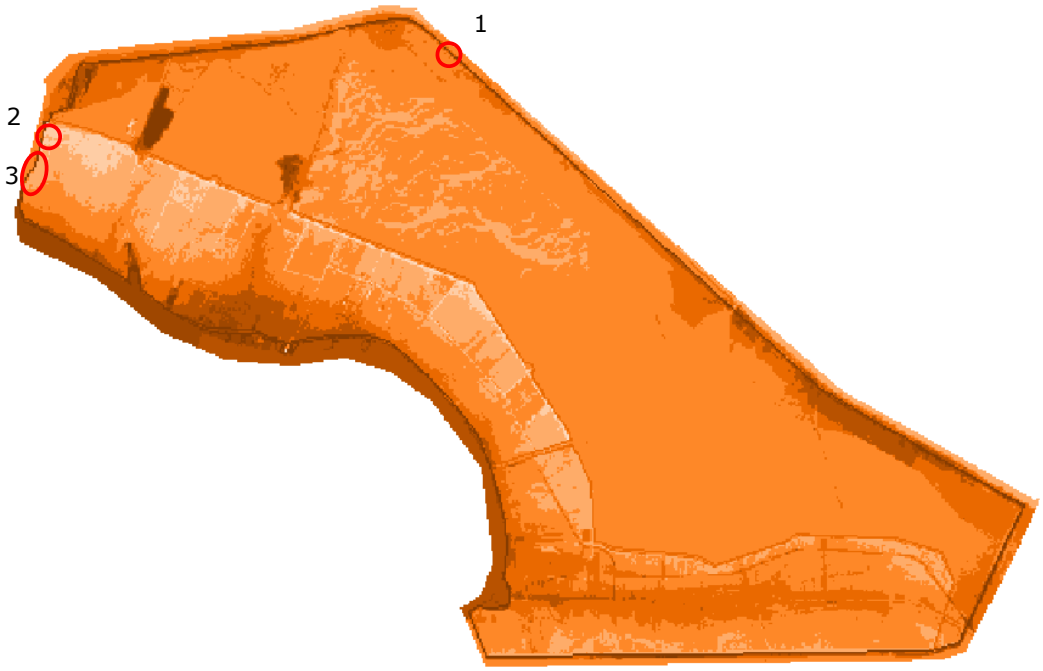


Figuur 3-5: Water level per scenario for 6 locations in the New Orleans East polder.

4 St Bernard polder

4.1 Breach locations and boundary conditions

In Figuur 4-1 the three breach locations in the St. Bernard polder are shown, one breach along the MRGO levee near Bienvenue and two in the IHNC near Lower Ninth Ward.



Figuur 4-1: Four breach locations in the St. Bernard polder.

The boundary conditions used in the flood simulations are the results of the FINEL scenario 2C calculations. Tabel 4-1 and Figuur 4-2 show the boundary conditions and moment of breaching of breach number one.

Breach	Water height at time of breach	Time of breach
1 (Bienvenue)	15.5ft = 4.72m	09:00

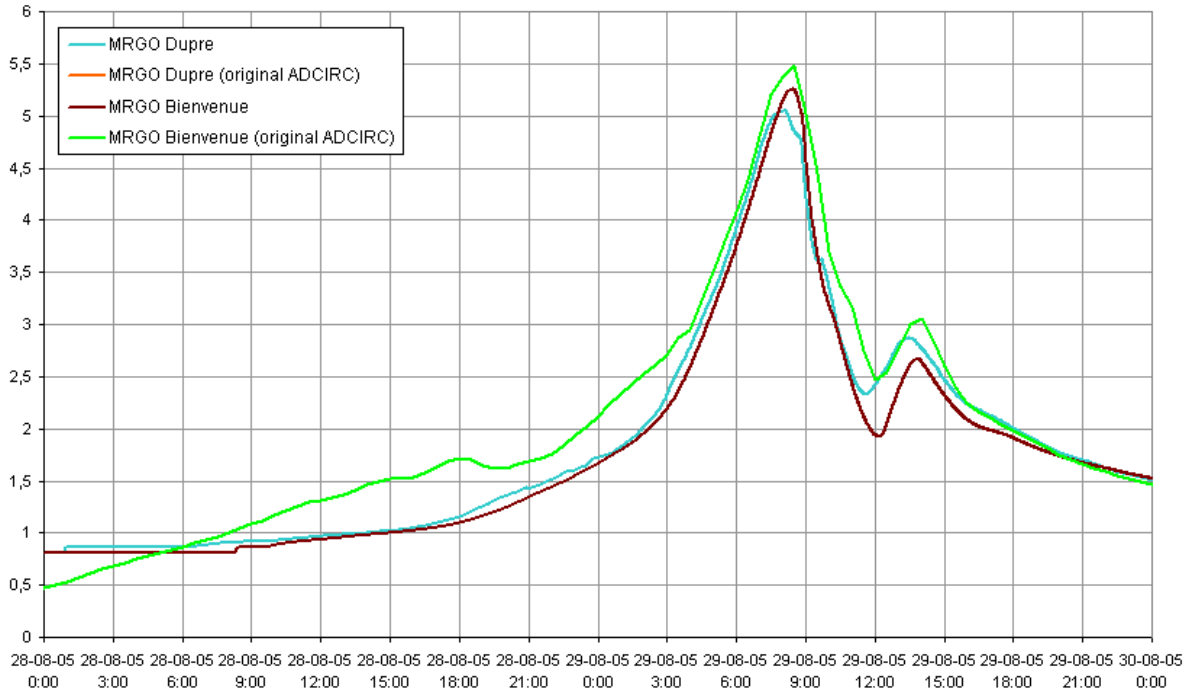
Tabel 4-1: Boundary conditions breaches 1 and 2 St. Bernard polder.

The time of breaching is after the peak of the storm surge, according to Bob Bea this is because of the overtopping that causes erosion.

Tabel 4-2and Figuur 4-3 show the boundary conditions and moment of breaching of breaches number two and three.

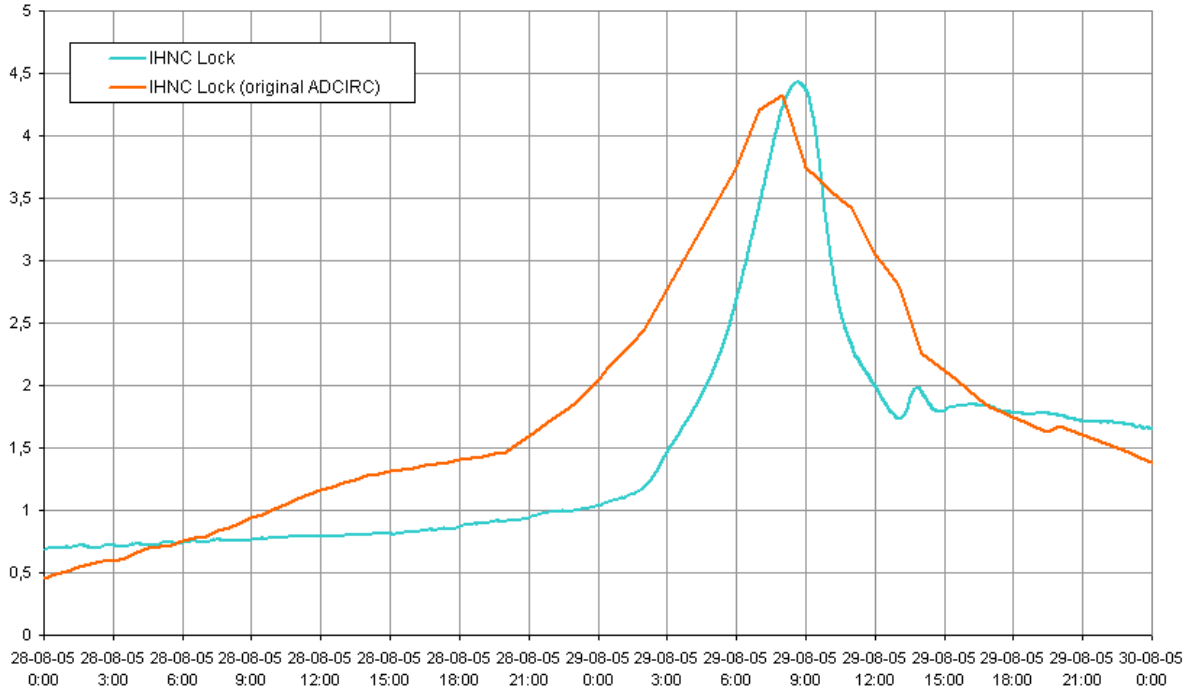
Breach	Water height at time of breach	Time of breach
2 (North)	12.5ft = 3.81m	07:30
3 (South)	12.5ft = 3.81m	09:00

Tabel 4-2: Boundary conditions breaches 3 and 4 St. Bernard polder.



*The orange line MRGO Dupre (original ADCIRC) is the same as the green line MRGO Bienvenue (original ADCIRC).

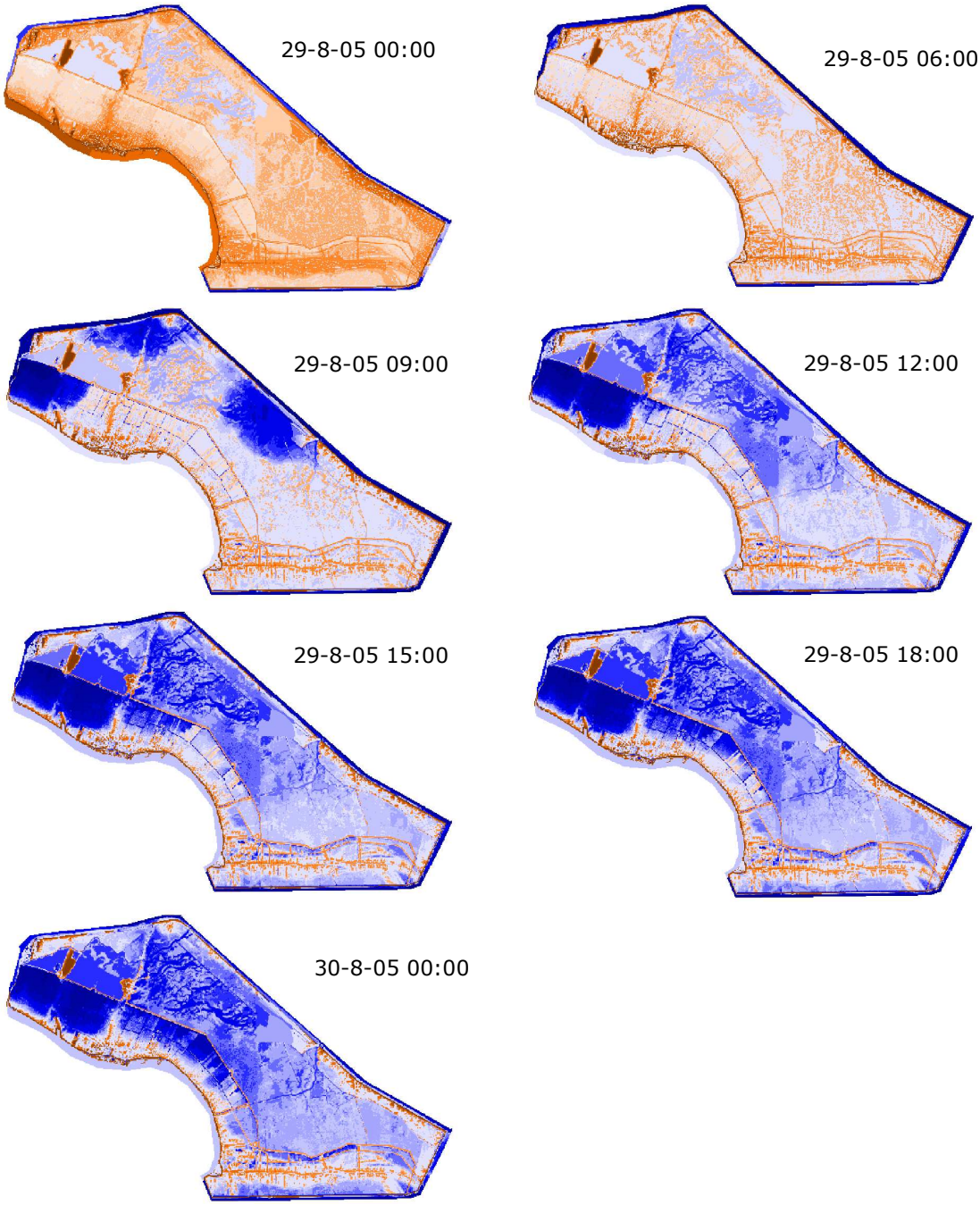
Figuur 4-2: Boundary conditions breach 1 St. Bernard polder.



Figuur 4-3: Boundary conditions breaches 2 and 3 St. Bernard polder.

4.2 Simulation results

The flood simulation shows (Figuur 4-4) that the wetlands between the 40-Arpent levee and the MRGO are filled with water mainly due to overtopping of the MRGO levee. The water height at the 40-Arpent levee is approximately 0.6 meter (= 2 ft) under the crest of the levee. This is consistent with the FINEL results. The water in the Saint Bernard residential area originates from the two breaches in the IHNC. The most southern part of the residential area has only minor flooding due to rainfall.



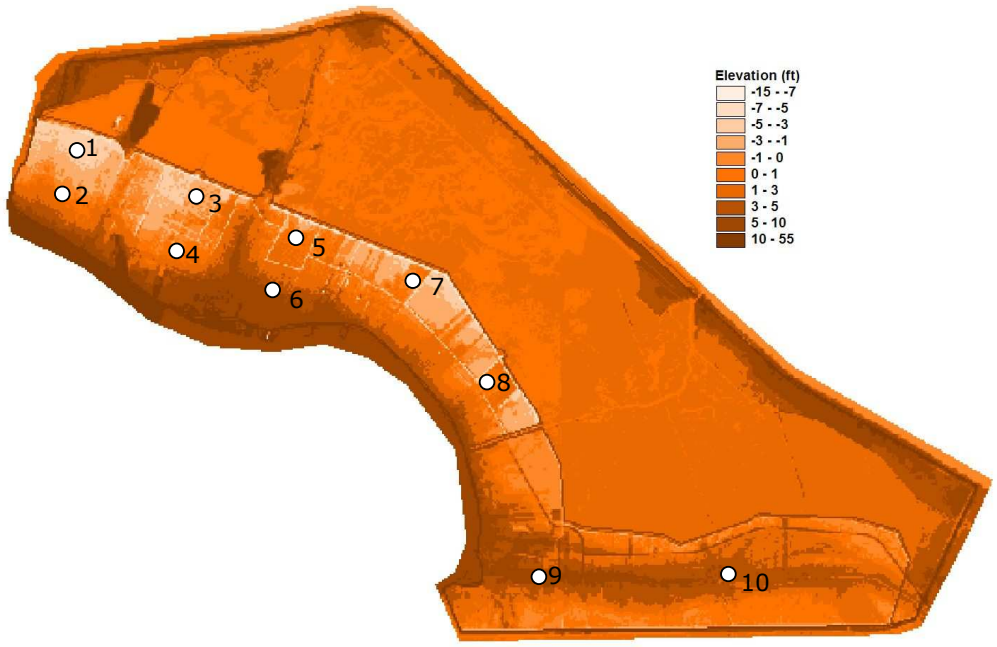
Figuur 4-4: Progressive snapshots of the computed water depth inside the St. Bernard polder.

4.3 Results at specified locations

For each location pointed in Figuur 4-5 the water levels are given in Figuur 4-6. The lines indicate the computed water levels for four scenarios and the height of the location.

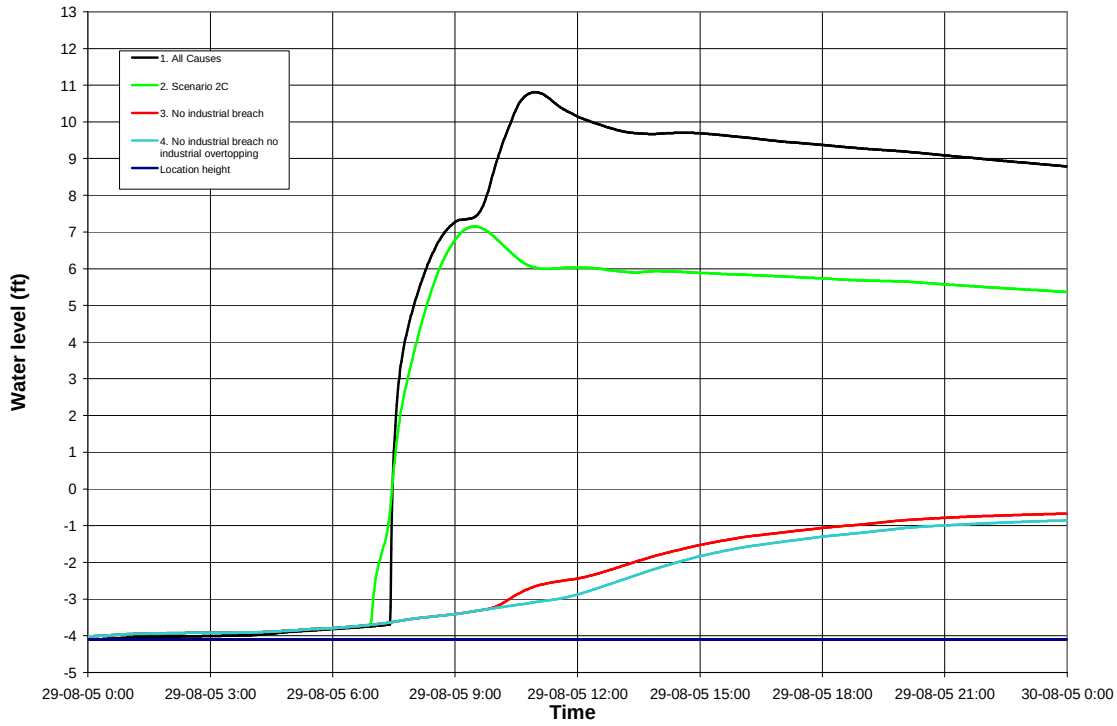
- Scenario 1 'All causes' (black line) is from the flood simulations done last year (Kok et al, 2007),
- Scenario 2 'Scenario 2C' (green line) is the line which represents the water level line computed with the adjusted boundary conditions in the IHNC, GIWW and MRGO
- Scenario 3 'No industrial breach' (red line) gives the development of the water level for the situation that there is rainfall, overtopping and only one breach near MRGO Bienvenue.
- Scenario 4 'No industrial breach no industrial overtopping' (light blue line) gives the water level line for the situation that there is rainfall, a breach near MRGO Bienvenue and only overtopping along the MRGO and GIWW levees. There is no breaching or overtopping along the IHNC levees.

The blue line gives the height of the location.

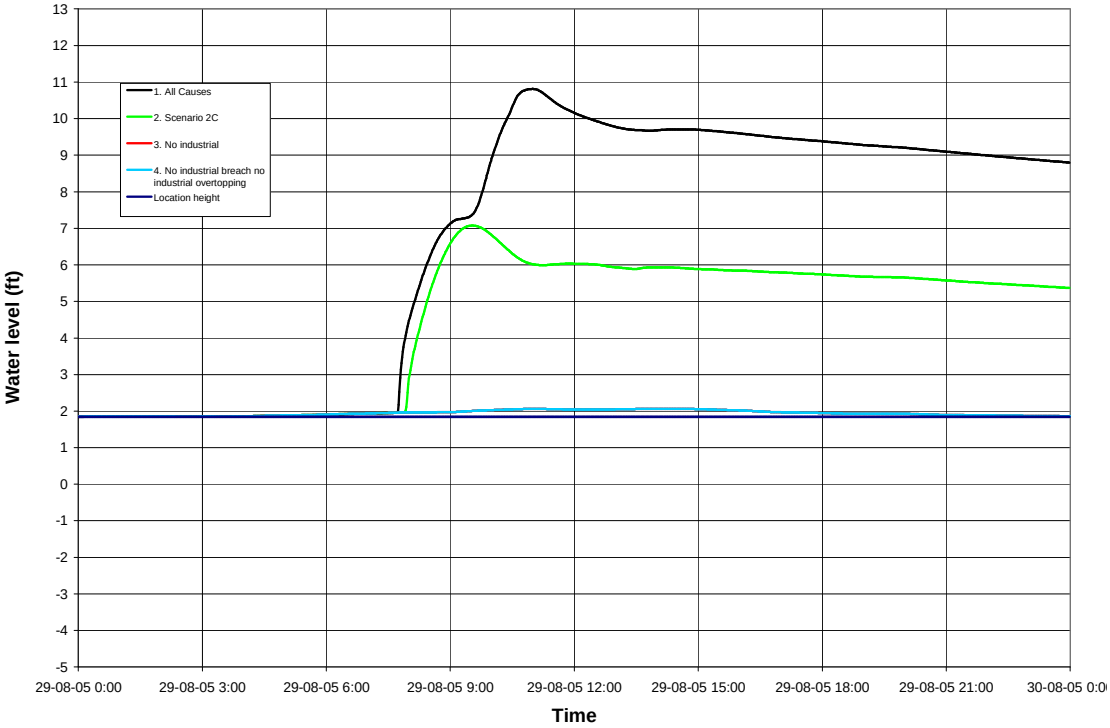


Figuur 4-5: Locations utilized for scenario development St. Bernard polder.

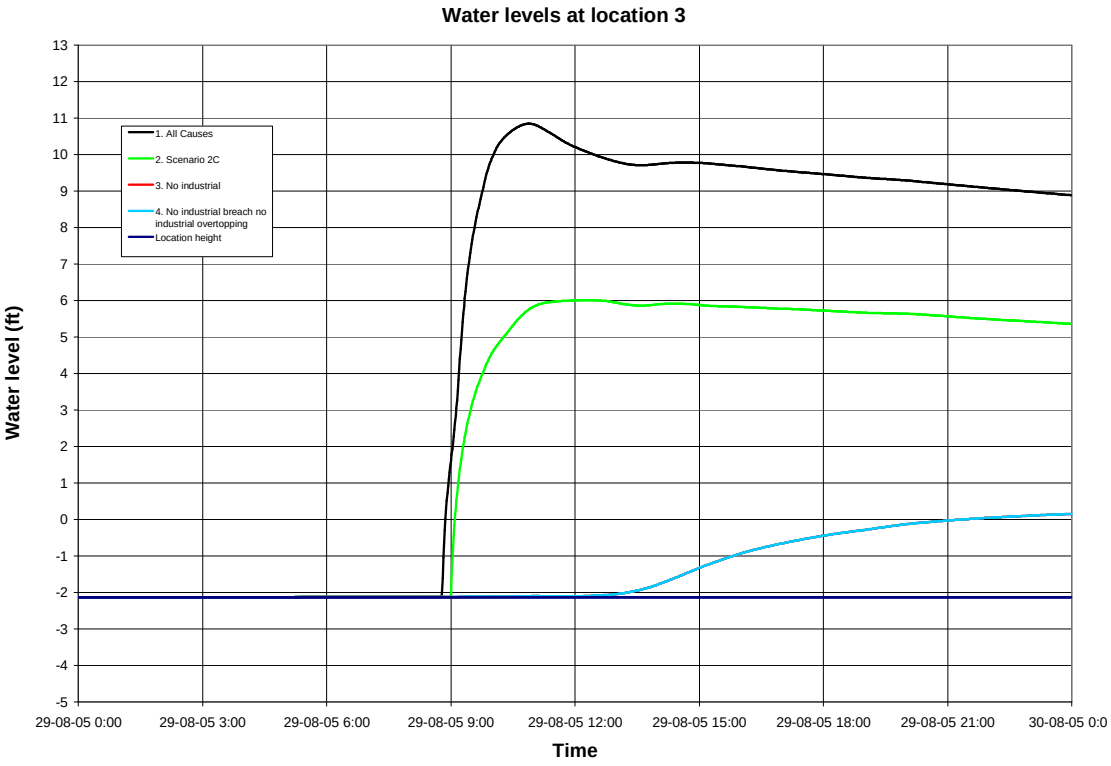
Water levels at location 1



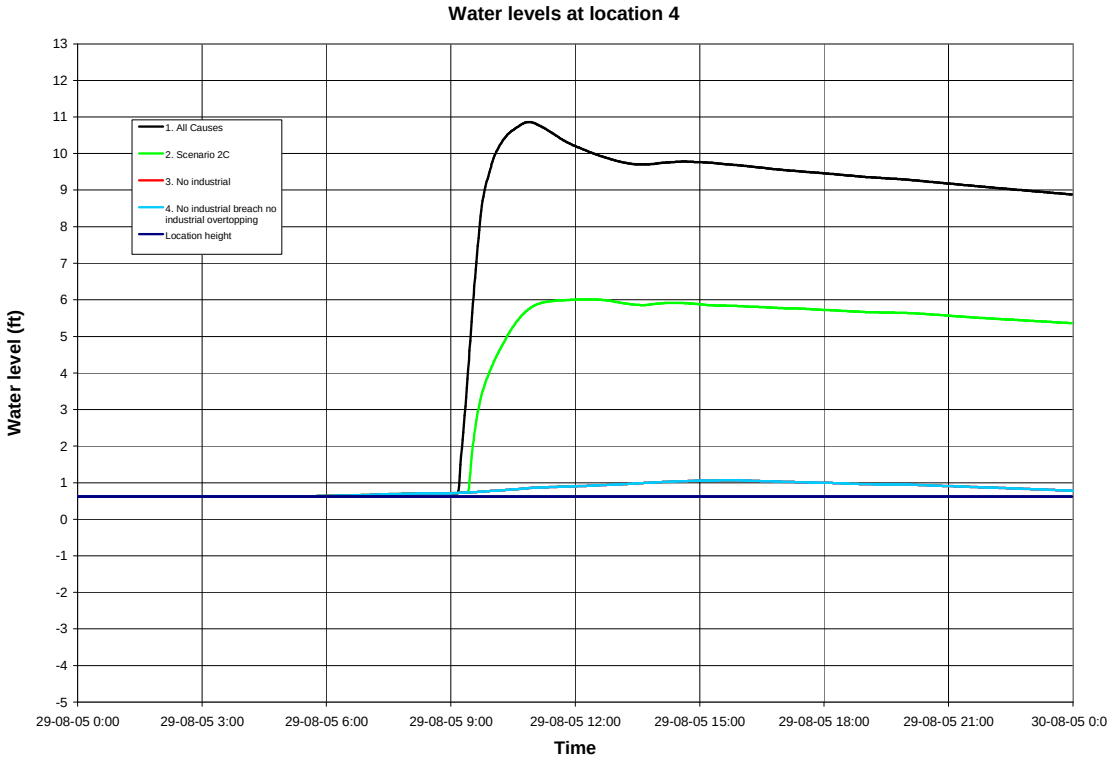
Water levels at location 2



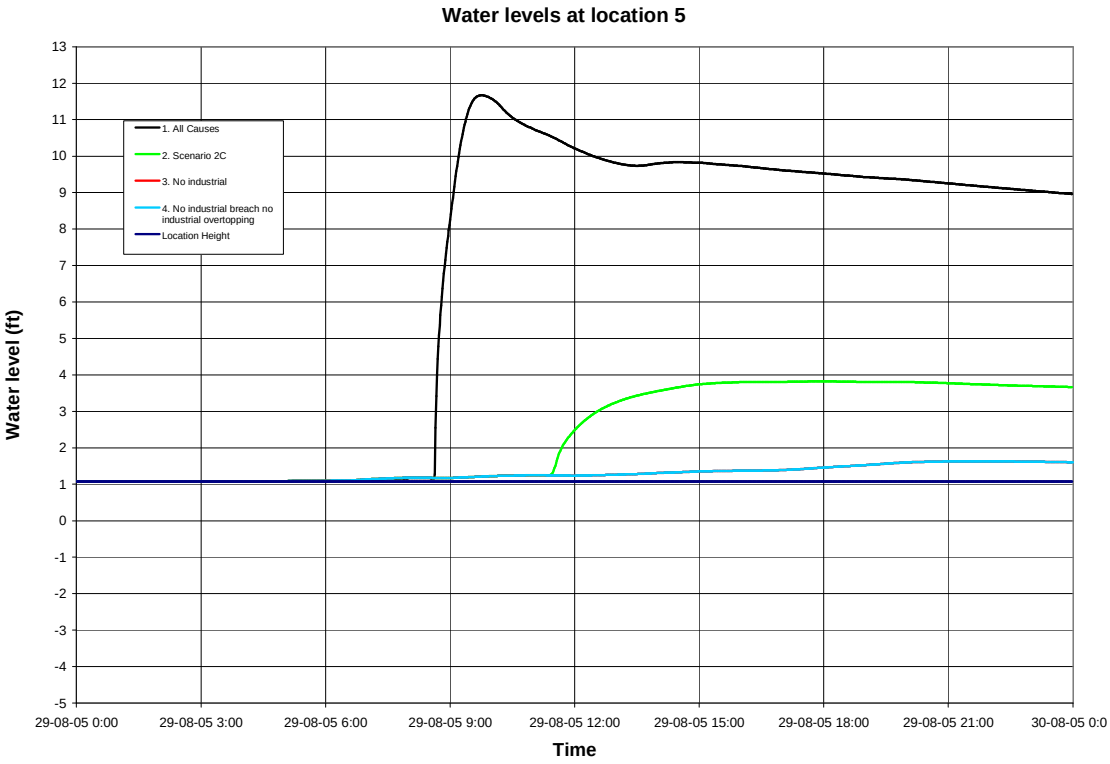
* The light blue line is on top of the red line



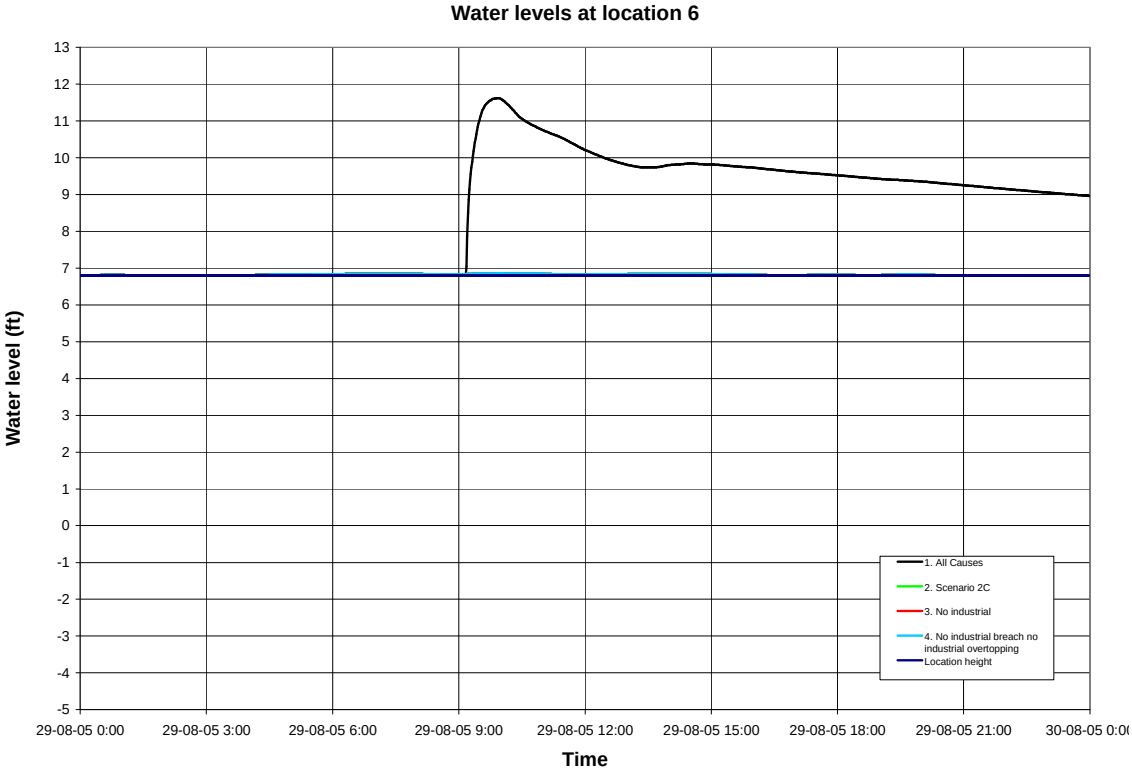
* The light blue line is on top of the red line



* The light blue line is on top of the red line

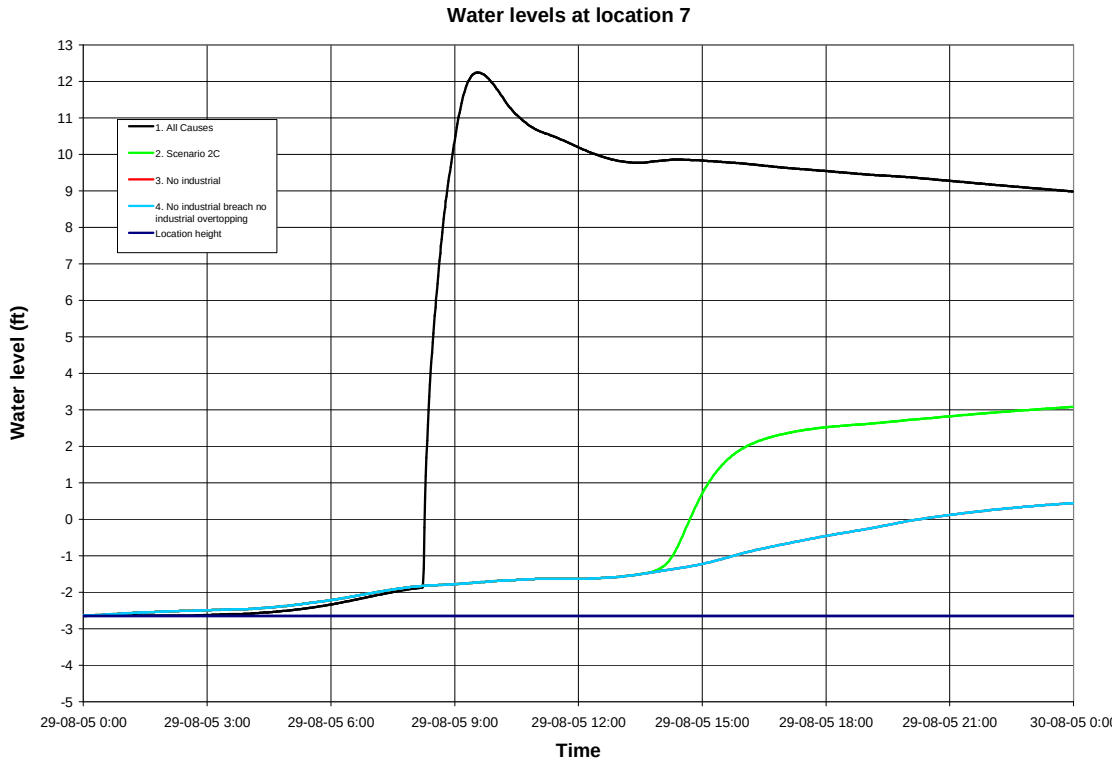


* The light blue line is on top of the red line

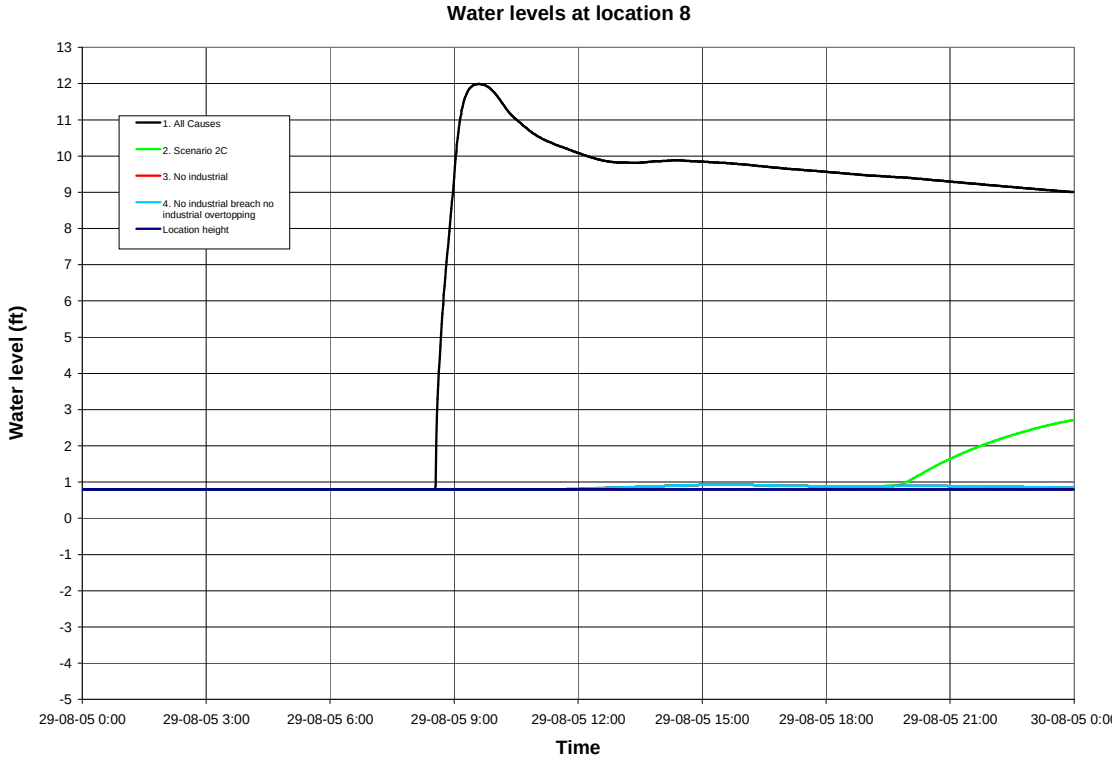


*The blue line is on top of the green line

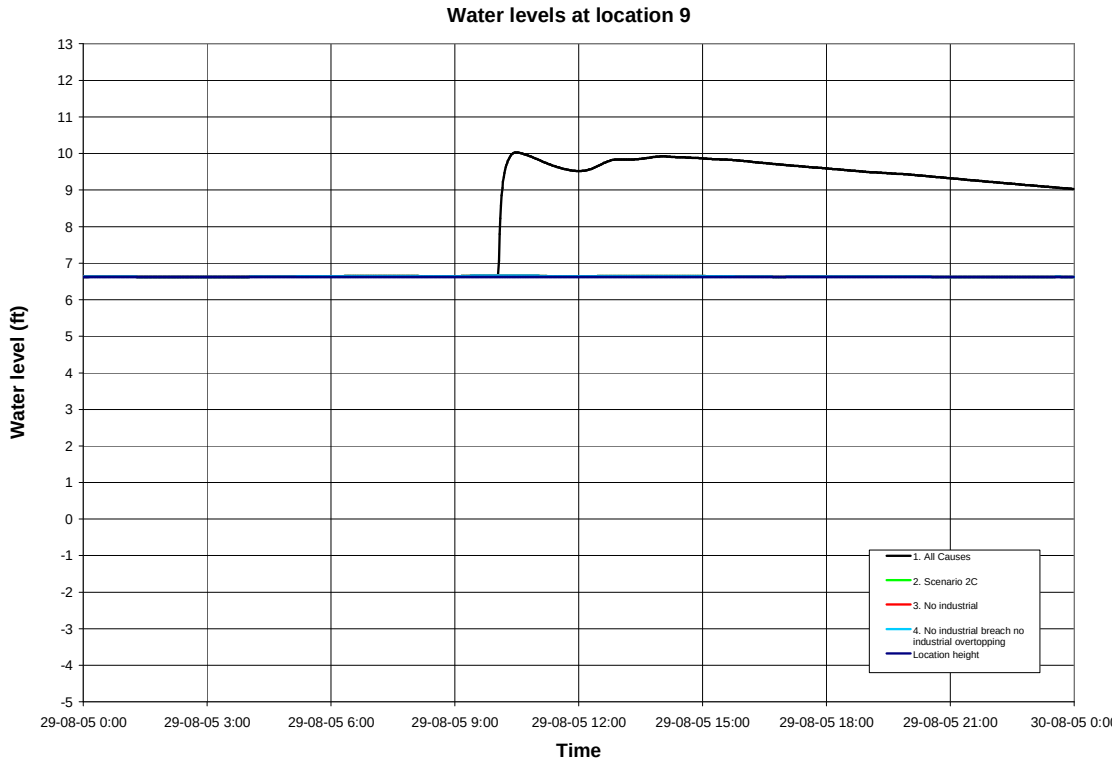
* The light blue line is on top of the red line



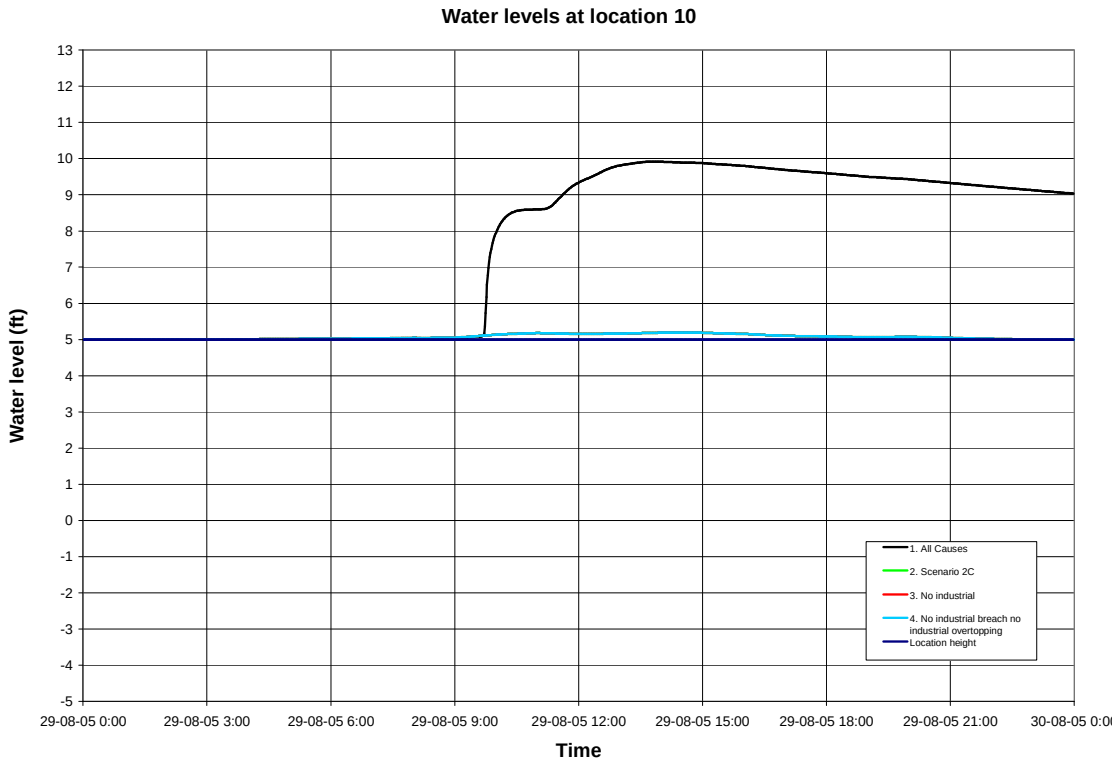
* The light blue line is on top of the red line



* The light blue line is on top of the red line



*The blue line is on top of the green, red and light blue line



*The blue line is on top of the green line

* The light blue line is on top of the red line

Figuur 4-6: Water level per scenario location St. Bernard polder.

5 Conclusions

In this report we used the SOBEK flooding model of the three New Orleans polders (see Kok et al, 2007). We added a new scenario, the 'neutral MRGO scenario' we assessed the influence of this scenario on the flooding of New Orleans.
The conclusion is that a neutral MRGO scenario has serious impact on the flooding of New Orleans. Still, the damage of rainfall and some overtopping will have occurred, but it might be expected that the impact of the flood would be less than in the Katrina event.

6 References

Kok, M. et al, (2007) Polder Flood Simulations for Greater New Orleans, Hurricane Katrina August 2005

Appendix: Overview failure modes for scenario 2c

Overview of the failure modes during scenario 2C in the GIWW, MRGO and IHNC, by R.G. Bea and P. Kemp.

The outcomes in the table below have been used in the flood simulations scenario 2C.

Location	Maximum Surge (Scenario 1, ft)	Maximum Surge (Scenario 2C, ft)	Elevation range (NGVD88+ ft)	Primary failure modes Scenario 1	Primary failure modes Scenario 2c
GIWWW NO East Back Levee	17.0	16.0	15.5-18.0	wave and surge breaching. main point of entry of floodwater into NOE polder	**no breaching** – limited surge overtopping. waves insufficient height to breach (vegetation effects–outboard protection & grass).
GIWW Paris Road Area	16.2	15.5	14.5-16.5	overtopping	**no breaching except at Air Products Plant** flood wall to levee sheet pile connection due to sheet pile interlock failure.
GIWW Bulk Terminal	16.2	14.5	14.0-15.0	overtopping	**no breaching** of floodwalls or levees
IHNC Junction Port of New Orleans	17.0	14.0	14.0-15.4	overtopping	**no breaching of floodwalls. through seepage breach of two roadway sections behind Port of New Orleans.**
IHNC I10 CSX Railroad	14.0	13.0	13.0-14.0	sand bags blew out at 9 ft surge elevation	**breaching -** sand bags would blow out again. no breach if CSX Railroad flood gate was in place.
IHNC Seabrook NOE Area	12.0	12.0	13.0-14.0	overtopping	**no breaching**
Lower 9th Ward	17.5	14.5	12.0-12.5	seepage, overtopping, lateral instability breaching	**breaching at North and South Breaches** due to seepage, limited overtopping, lateral instability breaching
MRGO Dupre	17.6	16.5	14.5	overtopping breaching at wingwall	**no breaching**
MRGO Reach 2 EBSBs	18.0	17.0	15.0 – 20.0	wave and surge breaching, overtopping, failure of some sheet pile repair inerlocks.	**no breaching** (good turf – ground cover conditions). where surge elevation exceeds crest elevation for more than 1 hour (good grass cover), breaching can develop. **breaching** at sheet pile repairs interlock failure locations
MRGO Bievenue	17.8	17.2	15.5	seepage, lateral instability breaching	**breaching after overtopping (after peak surge when surge at 15.5 ft)** due to seepage and lateral stability at wing wall to EBSB interface.