2023 COASTAL MASTER PLAN

# BARRIER ISLAND MODEL SENSITIVITY TESTS ON FUTURE WITHOUT ACTION (FWOA)

SUPPLEMENTAL MATERIAL D4.1

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# COASTAL PROTECTION AND RESTORATION AUTHORITY

This document was developed in support of the 2023 Coastal Master Plan being prepared by the Coastal Protection and Restoration Authority (CPRA). CPRA was established by the Louisiana Legislature in response to Hurricanes Katrina and Rita through Act 8 of the First Extraordinary Session of 2005. Act 8 of the First Extraordinary Session of 2005 expanded the membership, duties, and responsibilities of CPRA and charged the new authority to develop and implement a comprehensive coastal protection plan, consisting of a master plan (revised every six years) and annual plans. CPRA's mandate is to develop, implement, and enforce a comprehensive coastal protection and restoration master plan.

# CITATION

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# LIST OF ABBREVIATIONS

BARSIM ........................................................... BARRIER ISLAND SIMULATION
BIMODE ................................................ BARRIER ISLAND MODEL DEVELOPMENT
BICM ...........................BARRIER ISLAND COMPREHENSIVE MONITORING PROGRAM
BISM .....................................................BARRIER ISLAND SYSTEM MANAGEMENT
CERC ............................................... . COASTAL ENGINEERING RESEARCH CENTER
CPRA ................................. COASTAL PROTECTION AND RESTORATION AUTHORITY
DEM ......................................................................DIGITAL ELEVATION MODEL
ICM ............................................................INTEGRATED COMPARTMENT MODEL
RSLR ....................................................................RELATIVE SEA LEVEL RISE
SLR ..........................................................................................SEA LEVEL RISE

# 1.0 ICM-BI SENSITIVITY TESTING

## 1.1 OVERVIEW OF THE ICM-BI SEDIMENT VOLUME NEEDED FOR RESTORATION AND AUTO-RESTORATION FREQUENCY SENSITIVITY TESTS

Predictions of the sediment volume needed for future restoration of the barrier islands, as well as restoration frequency, will vary depending on the parameterization of the ICM-BI (i.e., choices made in model implementation). Model parameterizations that will impact the results include the choice of restoration templates and auto-restoration thresholds, as well as the applied cross-shore retreat rates. A set of sensitivity tests were conducted for a select set of barrier islands and headlands within the Terrebonne (West Belle Pass, Caminada Headland) and Barataria (West Grand Terre, East Grand Terre, Grand Pierre, Chaland Headland, Shell Island, Pelican Island, Scofield Island) regions to test the influence of these parameters. Results were analyzed to identify how model uncertainties influence calculated sediment volume need and restoration frequency. Based on this analysis, a second set of simulations was conducted for all barrier islands and headlands along the Louisiana coast to provide a range of predictions for future restoration sediment volume needed and restoration frequency.

In all cases, sensitivity tests were conducted using a standalone version of the ICM-BI using a sea level rise (SLR) rate approximately the same as values incorporated in the ICM for S08. Although the standalone version of the ICM-BI will produce similar predictions of barrier island evolution to those produced when coupled to the rest of the ICM, variations in this input water level time series – which cannot be identically replicated in the standalone version – will result in some variation. Results were also benchmarked against sediment volume used in prior restoration projects along the Louisiana cost as a further assessment of uncertainty.

Sensitivity tests run with the model included:

## 1.2 BASELINE

The baseline simulation was of the period of 2018-2070, the same 52-year period simulated with the ICM including the 2-year model initialization period. The ICM-BI was configured using the same settings as for S08 including:

**Baseline:**

- Auto-restoration thresholds:
    - Individual cross-shore profiles flagged as crossing the threshold for restoration when 75% of the subaerial width is lost (for barrier islands).
    - Individual cross-shore profiles flagged as crossing the threshold for restoration when

the shoreline erodes past the dune crest (for headlands).
    - Restoration units are auto-restored when 10% of individual cross-shore associated with that unit are flagged as needing restoration.
- Cross-shore retreat rates at the start of the simulation based on historical values.
- Cross-shore retreat rates increase over the time of period of simulation based on SLR rates.
- Subsidence and eustatic SLR are included.

## 1.3 RELAXATION OF AUTO-RESTORATION THRESHOLDS

A sensitivity test was run to assess the impact of auto-restoration thresholds that varied several model parameters from the base line case (*italics* denote parameters were that were altered from the baseline case).

**Relaxation of auto-restoration thresholds:**

- Auto-restoration thresholds:
    - *Individual cross-shore profiles flagged as crossing the threshold for restoration when 90% of the subaerial width is lost (for barrier islands).*
    - Individual cross-shore profiles flagged as crossing the threshold for restoration when the shoreline erodes past the dune crest (for headlands).
    - *Restoration units are auto-restored when 50% of individual cross-shore associated with that unit are flagged as needing restoration.*
- Cross-shore retreat rates at the start of the simulation based on historical values.
- Cross-shore retreat rates increase over the time of period of simulation based on SLR rates.
- Subsidence and eustatic SLR are included.

## 1.4 RELAXATION OF AUTO-RESTORATION THRESHOLDS FOR HEADLANDS

A sensitivity test was run to assess the impact of auto-restoration thresholds of barrier headlands that varied several model parameters from the base line case (italics denote parameters were that were altered from the baseline case).

**Relaxation of auto-restoration thresholds for headlands:**

- Auto-restoration thresholds:
    - Individual cross-shore profiles flagged as crossing the threshold for restoration when 75% of the subaerial width is lost (for barrier islands).
    - *Individual cross-shore profiles flagged as crossing the threshold for restoration when the shoreline erodes 50 meters past the dune crest (for headlands).*
    - Restoration units are auto-restored when 10% of individual cross-shore associated

    - with that unit are flagged as needing restoration.
- Cross-shore retreat rates at the start of the simulation based on historical values.
- Cross-shore retreat rates increase over the time of period of simulation based on SLR rates.
- Subsidence and eustatic SLR are included.

## 1.5 REDUCTION OF THE BASELINE CROSS-SHORE RETREAT RATES

A sensitivity test was run to assess the impact of cross-shore retreat rates that varied several model parameters from the base line case (italics denote parameters were that were altered from the base-line case).

**Reduction of the baseline cross-shore retreat rates:**

- Auto-restoration thresholds:
    - Individual cross-shore profiles flagged as crossing the threshold for restoration when 75% of the subaerial width is lost (for barrier islands).
    - Individual cross-shore profiles flagged as crossing the threshold for restoration when the shoreline erodes past the dune crest (for headlands).
    - Restoration units are auto-restored when 10% of individual cross-shore associated with that unit are flagged as needing restoration.
- *Cross-shore retreat rates at the start of the simulation are reduced 10% from the baseline values.*
- Cross-shore retreat rates increase over the time of period of simulation based on SLR rates.
- Subsidence and eustatic SLR are included.

## 1.6 NO MODULATION OF CROSS-SHORE RETREAT RATES WITH SLR

A sensitivity test was run to assess the impact of SLR on cross-shore retreat rates that varied several model parameters from the base line case (italics denote parameters were that were altered from the baseline case).

**No modulation of cross-shore retreat rates with SLR:**

- Auto-restoration thresholds:
    - Individual cross-shore profiles flagged as crossing the threshold for restoration when 75% of the subaerial width is lost (for barrier islands).
    - Individual cross-shore profiles flagged as crossing the threshold for restoration when the shoreline erodes past the dune crest (for headlands).
    - Restoration units are auto-restored when 10% of individual cross-shore associated with that unit are flagged as needing restoration.
- Cross-shore retreat rates at the start of the simulation based on historical values.

- *Cross-shore retreat rates are held constant over the entire period of simulation, with no increase with SLR.*
- Subsidence and eustatic SLR are included.

For the restoration units within the Barataria Region of the coast, all sensitivity test runs had a lower overall sediment volume placement over the 52-year model simulation period compared to the baseline case (Figure 1). The largest decrease was associated with relaxation of the auto-restoration threshold for barrier islands (Test Case 2), which reduced the total sediment volume placement across all restoration units by 28%. For the restoration units within the Terrebonne Region of the coast, however, several of the sensitivity tests had a higher overall sediment volume placement compared to the baseline case (Figure 2). Both test cases in which auto-restoration thresholds were relaxed (Test Cases 2 and 3), as well as the test case in which the cross-shore retreat rate was held fixed in time (Test Case 5), increased the placed sediment volume. Reducing the baseline cross-shore retreat rate by 10% (Test Case 4) was the only sensitivity test resulting in a reduced sediment volume placement compared to the baseline.

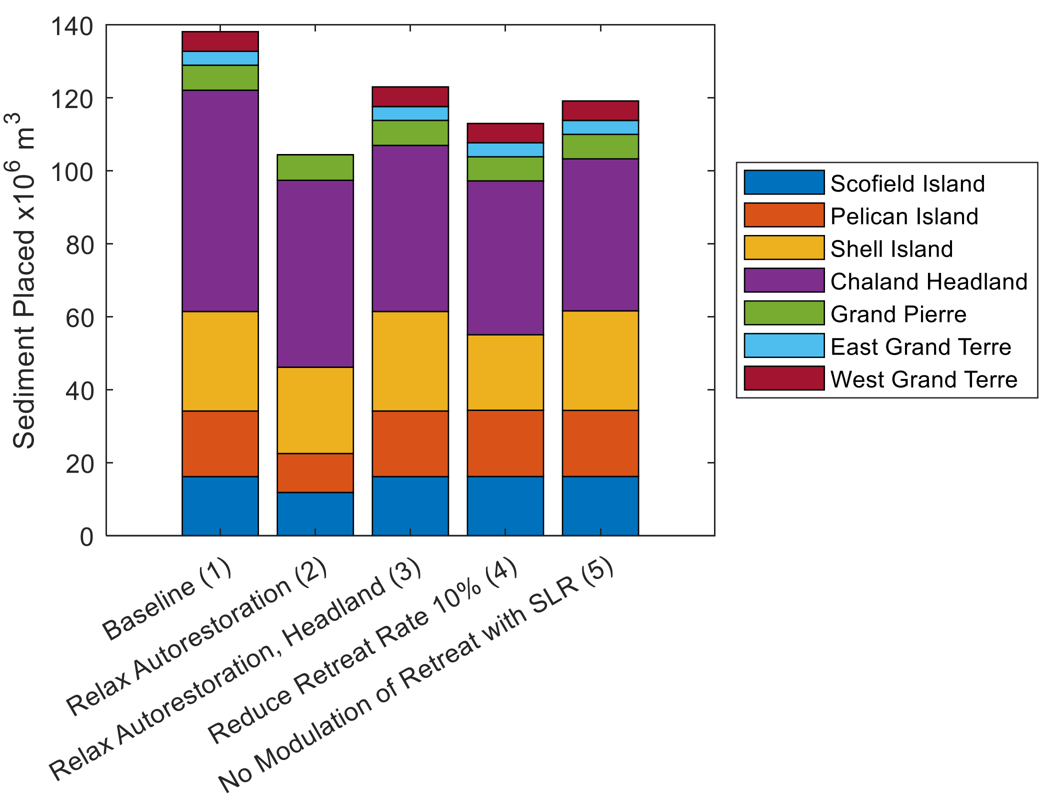


Figure 1. Sediment volume placed at island and headland units in the Barataria Region of the coast over the 52-year model period for five sensitivity test cases.

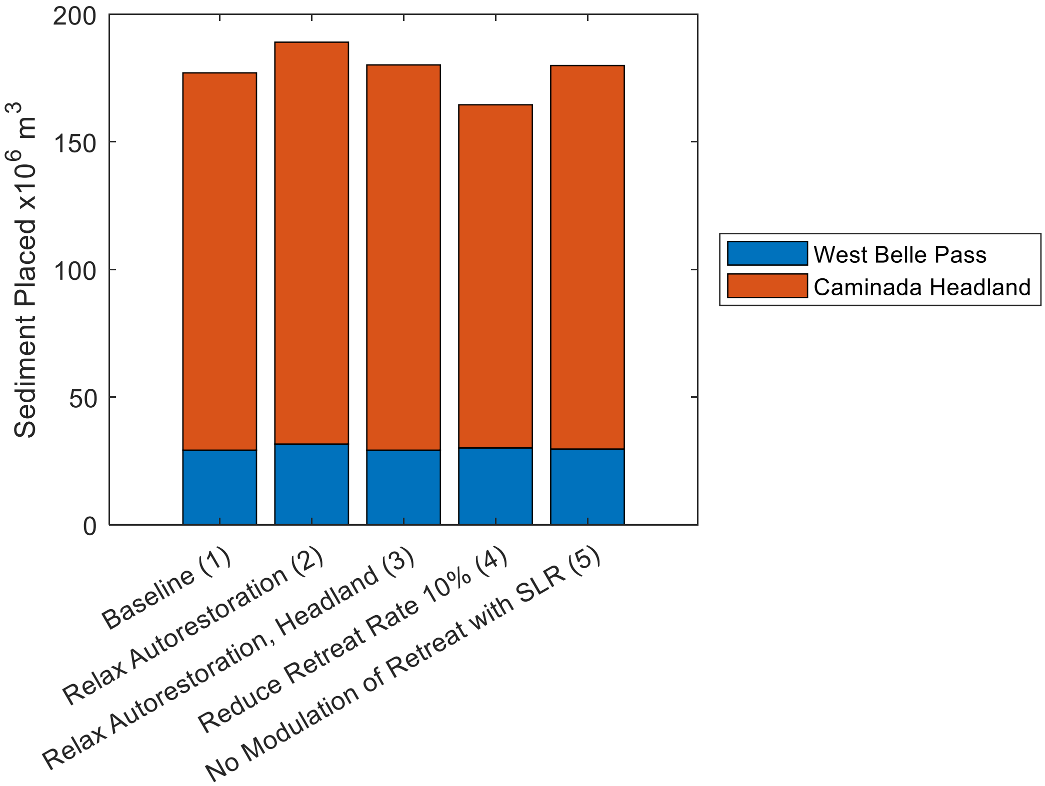


Figure 2. Sediment volume placed at island and headland units in the Terrebonne Region of the coast over the 52-year model period for five sensitivity test cases.

Several analyses were conducted to evaluate the cause of the observed variability in sediment volume placements for the sensitivity tests. First, we evaluated the time series of individual auto-restoration events (Figure 3, Figure 4). Two factors identified as important in controlling the total sediment volume placed in the 52-year simulation period are frequency of auto-restoration and the timing of the last auto-restoration. Relaxing the auto-restoration threshold, for example, reduces the frequency of restoration and for some restoration units results in one (or more) less individual sediment placement events (e.g., baseline Test Case 1 for Chaland Headland includes a total of four auto-restoration events with the last placement occurring just prior to the end of simulation, whereas the four sensitivity test cases auto-restore at a slightly lower frequency and incur a total of three auto-restoration events over the simulation period). The total sediment volume placed — particularly for larger units where the sediment volume placed in each individual auto-restoration even is high — can increase substantially through one additional auto-restoration event just prior to the end of the simulation, even if the overall trajectory and magnitude of auto-restoration sediment volumes between simulation events is similar for the first 50+ years of the simulations. For Caminada Headland, the total sediment volume placed in all sensitivity test cases except the reduction of the cross-shore retreat rate (Test Case 4) is higher than the baseline case because the final auto-restoration occurs just prior to the end of the simulation. In contrast, Caminada Headland is degraded at the end of the baseline simulation (i.e., is approaching the threshold for auto-restoration).

For virtually all restoration units, there is a trend wherein the amount of sediment volume placed in each individual auto-restoration event increases with time (Figure 3, Figure 4). The slope of this trend varies with each sensitivity test and influences the total sediment volume placed. This trend is driven by multiple factors. Cross-shore retreat and marsh edge (bayside) retreat is associated with steepening of the Gulf and Bay shorelines over time. This steepening leads to the restoration template intersecting the cross-shore profile in progressively deeper water (Figure 5); as a result, the volume of sediment placement during each auto-restoration event increases. Analysis of the sediment volume placed in the first auto-restoration of the baseline case (Test Case 1) of Chaland Headland, for example, indicates that the percentage of the total restoration sand volume that was placed between depths of 2-4 m NAVD88 increased from 3% to 18% between the first auto-restoration (in model Year 7) and the last auto-restoration (in model year 15). Increasing the cross-shore retreat rate with SLR further accelerates shoreline and upper shoreface retreat, amplifying this effect. Relative sea level rise (RSLR) also directly influences the volume of sediment needed for restoration by increasing the depth and accommodation space.

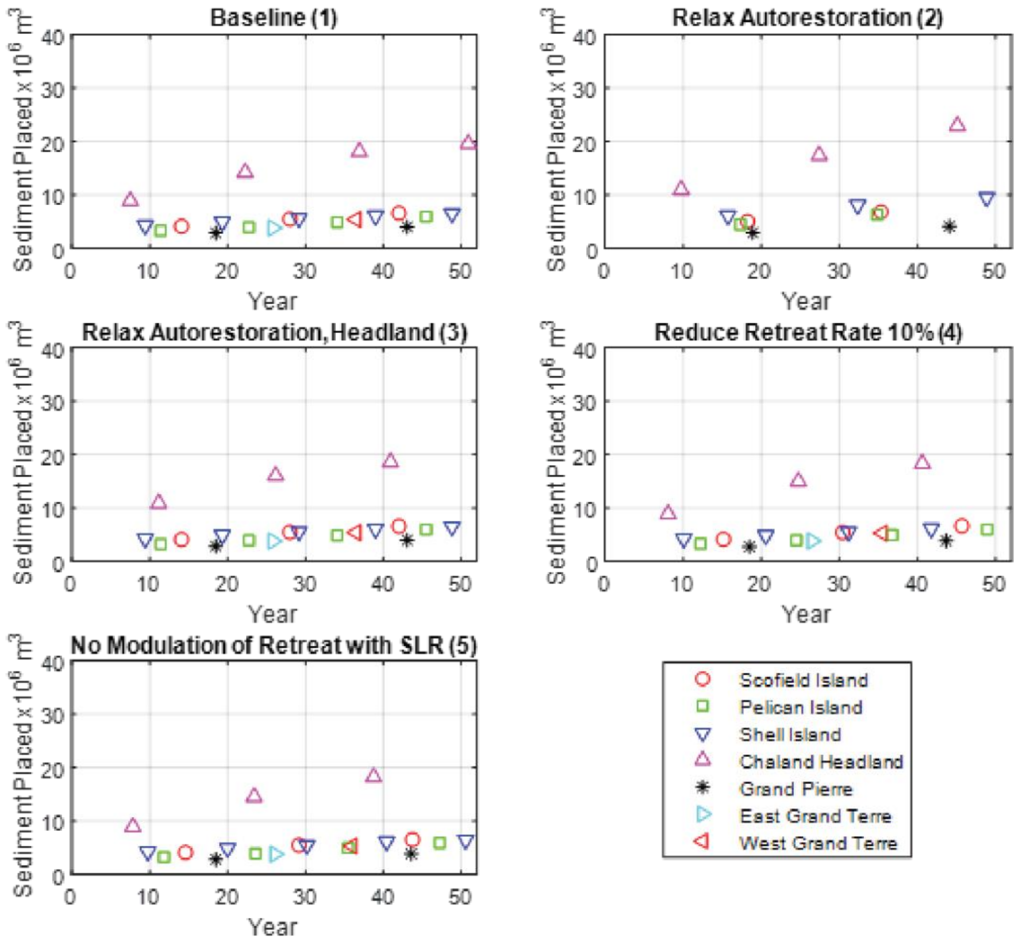


Figure 3. Sediment volume placed over time at island and headland units in the Terrebonne Region of the coast for five sensitivity test cases.

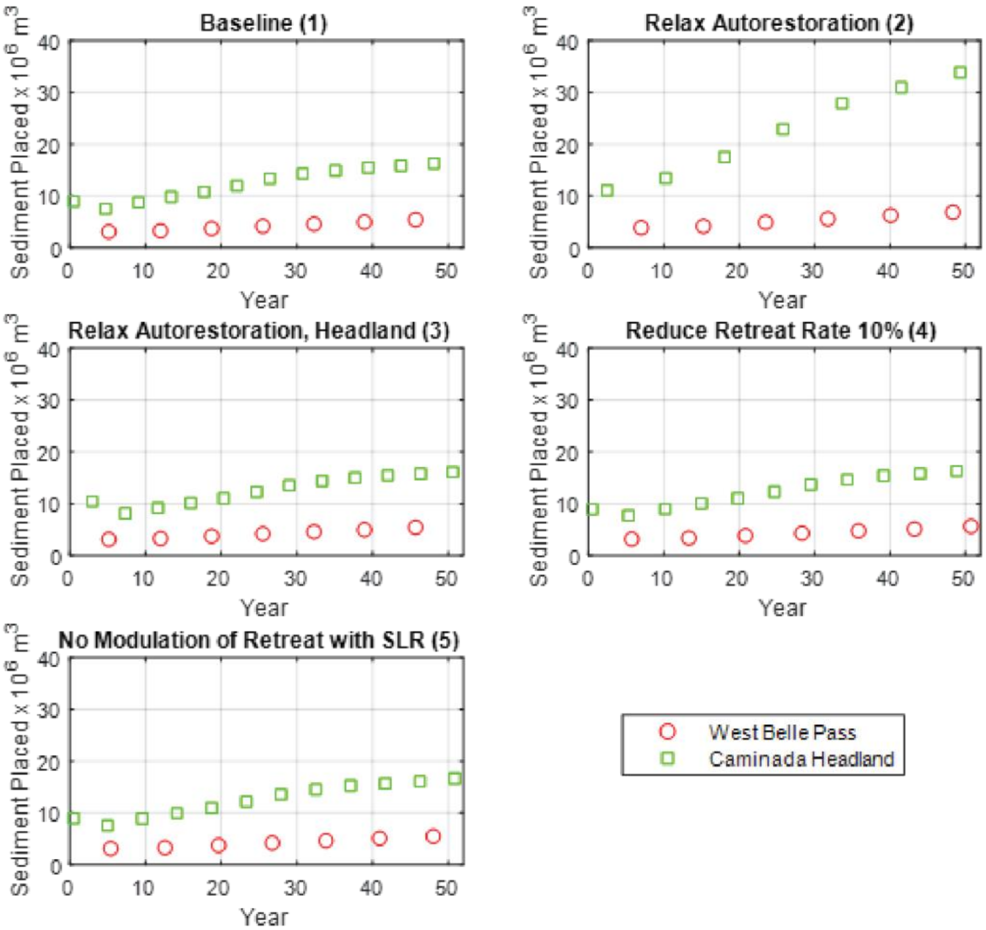


Figure 4. Sediment volume placed over time at island and headland units in the Terrebonne Region of the coast for five sensitivity test cases.

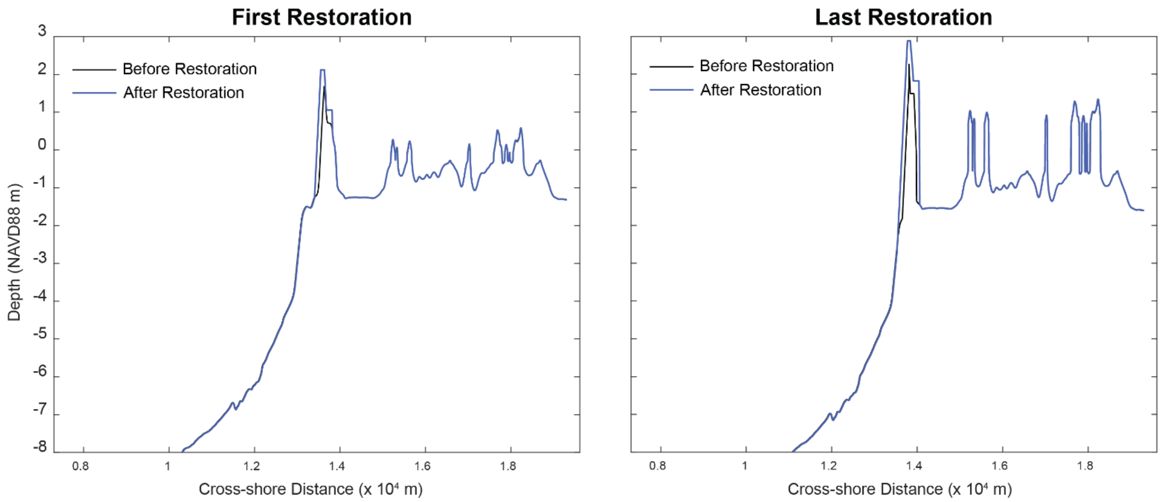


Figure 5. Illustration of the placement of the restoration template for the first (left) and last (right) auto-restoration in the baseline simulation for a transect along the Chaland Headland. As the Gulf and marsh shorefaces erode, the template intersects the existing profile in deeper water, increasing the volume of sediment needed to rebuild the template.

Although restoration sediment volume needs are likely to increase over time due real-world trends that are captured by the simulations (e.g., increased depth, accommodation space, and cross-shore retreat rate with relative SLR), there are some natural processes and restoration engineering factors not included in the model that will likely mitigate this effect. First, the slope of the uppermost shoreface — particularly in the highly dynamic surf zone — adjusts and equilibrates to incident wave forcing and SLR due to longshore transport processes that are not captured in the model. As a result, the upper shoreface is unlikely to be as steep as predicted by the model. In addition, the cross-shore placement of the restoration template in the model is hard-wired to align the berm or dune in the template with the highest point in the residual island profile. This cross-shore placement location can lead to the restoration template intersecting the residual profile at progressive deeper depths (up to 2-3 m). In practice, coastal engineers will design and place the restoration template based on the needs of the project and surveys of the pre-restoration bathymetry and topography. The planned template may be adjusted as needed to avoid placing excessive sediment volumes in the deeper portions of the surf zone.

There is one exception to the observed trend of increasing sediment volume placed with each restoration over time. The first auto-restoration at Caminada Headland required slightly higher sediment volume than the second auto-restoration for all test cases except when the auto-restoration thresholds are relaxed (Test Case 2). The first auto-restoration also occurs in the first year of the simulation, in comparison to other units where the first auto-restoration occurs later in the simulation time series. This indicates that the current condition of Caminada Headland meets the threshold for auto-restoration as defined in ICM-BI, and may suggest that the restoration template is more substantial and/or the auto-restoration thresholds for this headland are lower in the model than what has been used in real-world management practice.

## 1.7 HYBRID SENSITIVITY TESTS

Based on the result of the initial round of sensitivity tests for the Terrebonne and Barataria regions, sensitivity tests 1-5 were replicated for all regions to develop ranges of sediment volume need and auto-restoration frequency. In addition, a hybrid sensitivity test was run that varied several model parameters from the base line case (*italics* denote parameters were that were altered from the baseline case).

**Hybrid Sensitivity Test:**

- Auto-restoration thresholds:
    - *Individual cross-shore profiles flagged as crossing the threshold for restoration when 90% of the subaerial width is lost (for barrier islands).*
    - Individual cross-shore profiles flagged as crossing the threshold for restoration when the shoreline erodes past the dune crest (for headlands).
    - *Restoration units are auto-restored when 50% of individual cross-shore associated with that unit are flagged as needing restoration.*
- *Cross-shore retreat rates at the start of the simulation are reduced 10% from baseline values.*
- *Cross-shore retreat rates are held constant over the entire period of simulation, with no increase with SLR.*
- Subsidence and eustatic SLR are included.

## 1.8 RSLR SENSITIVITY TEST

A seventh test was run wherein all processes related to RSLR (change in water level, subsidence, and variation of the cross-shore retreat rate) were inactivated in the model. This test is intended to provide benchmark values for comparison to historical sediment volume placements only and is not intended to produce a realistic forecast of future conditions (*italics* denote parameters were that were altered from the baseline case).

**RSLR Sensitivity Test:**

- Auto-restoration thresholds:
    - Individual cross-shore profiles flagged as crossing the threshold for restoration when 75% of the subaerial width is lost (for barrier islands).
    - Individual cross-shore profiles flagged as crossing the threshold for restoration when the shoreline erodes past the dune crest (for headlands).

    - Restoration units are auto-restored when 10% of individual cross-shore associated with that unit are flagged as needing restoration.
- Cross-shore retreat rates at the start of the simulation based on historical values.
- *Cross-shore retreat rates are held constant over the entire period of simulation, with no increase with SLR.*
- *Subsidence and eustatic SLR are not included in the simulation.*

## 1.9 CAMINADA HEADLAND RESTORATION UNITS

In addition to the sensitivity tests, an additional modification was made in how Caminada Headland is simulated in the model. In coupled simulations with the ICM and in the initial round of sensitivity tests, Caminada Headland was treated as a single restoration unit. However, doing so may unrealistically inflate the restoration sediment volume estimates because the entire headland is auto-restored when the western end — which has among the highest retreat rates anywhere in the coast — crosses the restoration threshold. In addition, the criteria to "hold the line" at Port Fourchon results in frequent auto-restoration and increases estimates of restoration sediment volume. The same set of seven sensitivity tests was run with Caminada Headland split into three units (Port Fourchon, central Caminada, and Elmer's Island) and the criteria at Port Fourchon relaxed to allow for managed retreat.

## 1.10 RESULTS AND DISCUSSION

The range of total sediment volume placed, number of auto-restoration events, and sediment volumes used in the first and last individual auto-restoration events are summarized in Tables 4-7. There is significant variation across the sensitivity tests in the total sediment volume placed; as previously mentioned, the number of restoration events occurring during the modeled time and the volume of sediment placed during each restoration are significant drivers of the total sediment volume placed during the simulation period. The northern Chandeleur Islands, for example, has an almost threefold increase between the minimum (35.30 x 106 m$^3$) and maximum (90.61 x 106 m$^3$) sediment volume placed in restoration, reflecting the range of 1-3 auto-restoration events occurring in tests for this unit as well as the substantial sediment volume needed for each restoration of this large barrier island. The smallest range in sediment volume placement values is found for barrier islands and headlands requiring less sediment for each restoration, and for which the variability in the number of auto-restorations during the modeled time period is small. For example, a total of two auto-restoration events occur for Trinity/East in each sensitivity test, and the range of total sediment volume required only varies from 51.12 x 106 m$^3$ to 56.08 x 106 m$^3$.

Table 1. Range of sediment volumes placed over 52 years and number of auto-restorations occurring under varying sensitivity tests. Caminada Headland is treated as a single restoration unit; see Table 3 for values if Caminada Headland is split into three restoration units. The number of placements and volume for a case with no RSLR is also given to benchmark volumes against values used in historical, real-world projects. Caminada Headland is treated as a single restoration unit; see Table 4 for values if Caminada Headland is split into three restoration units.

| RESTORATION SENSITIVITY TESTING, CASES 1-6 (ALL VOLUMES X $10^6$ $M^3$) | | | | | FOR BENCHMARK AGAINST HISTORICAL | |
|---|---|---|---|---|---|---|
| UNIT | MINIMUM 52-YEAR SEDIMENT VOLUME | MAXIMUM 52-YEAR SEDIMENT VOLUME | MINIMUM # OF PLACEMENTS IN 52 YEARS | MAXIMUM # OF PLACEMENTS IN 52 YEARS | 52-YEAR VOLUME, NO RSLR | # PLACEMENTS, NO RSLR |
| WHISKEY ISLAND | 21.69 | 52.43 | 1 | 2 | 17.86 | 1 |
| TRINITY/EAST | 51.12 | 56.08 | 2 | 2 | 38.82 | 2 |
| TIMBALIER ISLAND | 16.14 | 34.74 | 1 | 2 | 10.82 | 1 |
| WEST BELLE PASS | 25.37 | 31.60 | 5 | 7 | 21.93 | 7 |
| CAMINADA HEADLAND | 122.59 | 157.49 | 6 | 12 | 119.92 | 11 |
| WEST GRAND TERRE | 0.00 | 5.40 | 0 | 1 | 0.00 | 0 |
| EAST GRAND TERRE | 0.00 | 3.84 | 0 | 1 | 0.00 | 0 |
| GRAND PIERRE | 6.61 | 7.00 | 2 | 2 | 2.17 | 1 |
| CHALAND HEADLAND | 41.68 | 60.65 | 3 | 4 | 32.45 | 3 |
| SHELL ISLAND | 14.68 | 27.28 | 2 | 5 | 15.02 | 4 |
| PELICAN ISLAND | 10.69 | 18.16 | 2 | 4 | 11.28 | 4 |
| SCOFIELD ISLAND | 11.80 | 16.18 | 2 | 3 | 10.71 | 3 |
| NORTH CHANDELEURS | 35.30 | 90.61 | 1 | 3 | 31.19 | 2 |
| SOUTH CHANDELEURS | 21.21 | 49.37 | 2 | 5 | 15.27 | 3 |
| BRETON ISLAND | 7.13 | 8.29 | 1 | 1 | 0.00 | 0 |

Table 2. Range of sediment volume placed during the first and last restoration placements in the 52-year simulation period under varying sensitivity tests

| RESTORATION SENSITIVITY TESTING, CASES 1-6 (ALL VOLUMES X $10^6$ $M^3$) | | | | | FOR BENCHMARK AGAINST HISTORICAL | |
|---|---|---|---|---|---|---|
| UNIT | MINIMUM VOLUME, FIRST PLACEMENT | MAXIMUM VOLUME, FIRST PLACEMENT | MINIMUM VOLUME, LAST PLACEMENT | MAXIMUM VOLUME, LAST PLACEMENT | SEDIMENT VOLUME, FIRST PLACEMENT | SEDIMENT VOLUME, LAST PLACEMENT |
| WHISKEY ISLAND | 21.69 | 23.45 | 21.69 | 30.42 | 17.86 | N/A |
| TRINITY/EAST | 20.71 | 22.39 | 30.20 | 33.68 | 18.26 | 20.57 |
| TIMBALIER ISLAND | 11.24 | 16.14 | 16.14 | 18.69 | 10.82 | N/A |
| WEST BELLE PASS | 3.11 | 4.00 | 5.42 | 6.86 | 2.59 | 3.84 |
| CAMINADA HEADLAND | 8.91 | 11.12 | 16.08 | 33.84 | 8.81 | 13.99 |
| WEST GRAND TERRE | 0.00 | 5.40 | 0.00 | 5.40 | N/A | N/A |
| EAST GRAND TERRE | 0.00 | 3.84 | 0.00 | 3.84 | N/A | N/A |
| GRAND PIERRE | 2.74 | 2.96 | 3.75 | 4.09 | 2.17 | N/A |
| CHALAND HEADLAND | 8.87 | 11.31 | 18.22 | 23.56 | 7.81 | 13.36 |
| SHELL ISLAND | 4.23 | 6.13 | 6.11 | 9.50 | 3.52 | 3.95 |
| PELICAN ISLAND | 3.25 | 4.51 | 5.93 | 6.38 | 2.20 | 3.39 |
| SCOFIELD ISLAND | 4.11 | 5.12 | 6.55 | 7.09 | 2.93 | 4.31 |
| NORTH CHANDELEURS | 26.66 | 37.66 | 32.40 | 37.66 | 15.76 | 15.42 |
| SOUTH CHANDELEURS | 7.31 | 9.28 | 11.48 | 14.37 | 4.66 | 5.53 |
| BRETON ISLAND | 7.13 | 8.29 | 7.13 | 8.29 | N/A | N/A |

Table 3. Range of sediment volumes placed over 52 years and number of auto-restorations occurring under varying sensitivity tests for Caminada Headland if split into three separate restoration units. In addition, the criteria to hold-the-line at Port Fourchon is relaxed to allow for managed retreat.

| RESTORATION SENSITIVITY TESTING, CASES 1-6 (ALL VOLUMES X $10^6$ $M^3$) | | | | | FOR BENCHMARK AGAINST HISTORICAL | |
|---|---|---|---|---|---|---|
| UNIT | MINIMUM 52-YEAR SEDIMENT VOLUME | MAXIMUM 52-YEAR SEDIMENT VOLUME | MINIMUM # OF PLACEMENTS IN 52 YEARS | MAXIMUM # OF PLACEMENTS IN 52 YEARS | 52-YEAR VOLUME, NO RSLR | # PLACEMENTS, NO RSLR |
| PORT FOURCHON | 28.93 | 40.31 | 6 | 8 | 28.44 | 7 |
| CENTRAL CAMINADA | 55.61 | 71.75 | 6 | 8 | 56.99 | 8 |
| ELMER'S ISLAND | 11.17 | 17.67 | 3 | 5 | 9.41 | 4 |
| CAMINADA HEADLAND, ALL | 95.71 | 129.72 | N/A | N/A | 94.84 | N/A |

Table 4. Range of sediment volume placed during the first and last restoration placements in the 52-year simulation period under varying sensitivity tests for Caminada Headland if split into three separate restoration units. In addition, the criteria to hold-the-line at Port Fourchon is relaxed to allow for managed retreat. The number of placements and volume for a case with no relative sea-level rise (RSLR) is also given to benchmark volumes against values used in historical, real-world projects.

| RESTORATION SENSITIVITY TESTING, CASES 1-6 (ALL VOLUMES X 106 M3) | | | | | FOR BENCHMARK AGAINST HISTORICAL | |
|---|---|---|---|---|---|---|
| UNIT | MINIMUM VOLUME, FIRST PLACEMENT | MAXIMUM VOLUME, FIRST PLACEMENT | MINIMUM VOLUME, LAST PLACEMENT | MAXIMUM VOLUME, LAST PLACEMENT | SEDIMENT VOLUME, FIRST PLACEMENT | SEDIMENT VOLUME, LAST PLACEMENT |
| PORT FOURCHON | 2.17 | 2.52 | 7.31 | 7.96 | 2.09 | 6.22 |
| CENTRAL CAMINADA | 4.90 | 5.80 | 12.56 | 16.26 | 4.91 | 10.16 |
| ELMER'S ISLAND | 2.33 | 2.87 | 3.65 | 6.63 | 2.30 | 2.57 |

The sensitivity tests also illustrate the influence of dividing Caminada Headland into multiple restoration units. When Caminada is treated as a single restoration unit, the total sediment volume required is between 122.59 x 106 $m^3$ and 157.49 x 106 $m^3$. When the headland is divided into three separate restoration units, the total sediment volume combined across those three units is substantially reduced and varies from 95.71 x 106 $m^3$ to 129.72 x 106 $m^3$. This decrease is a result of each section of Caminada headland (Port Fourchon, Central Caminada, and Elmer's Island) only auto-restoring when needed, which is more aligned with how management action would be taken and thus a better representation of future sediment volume need.

As an additional benchmark capturing the uncertainty in the restoration placement sediment volumes, values from the sensitivity test in in which SLR was inactivated (Test Case 7) were compared to historical sediment volumes used in real-world restoration (Table 5). The results indicate that the auto-restoration sediment volumes are comparable to, and in some cases lower, than the volumes used historically in restoring most of the barrier islands and headlands. This finding suggests that the templates used in restoration, and the alongshore extent over which they are applied, is reasonable when benchmarked against historical management action. The exceptions are Whiskey Island, Timbalier Island, and Trinity/East Island. In each of these cases, the modeled restoration sediment volume is higher than has been previously used at these islands. In all cases, this discrepancy between the modeled and historical sediment volume placement can be explained by the choice of restoration template. For Whiskey Island, Template C from TE-100 — which includes a wide back-barrier marsh restoration — was chosen as the ICM-BI template across the entire alongshore extent of the unit by The Water Institute/CPRA team under the assumption that future restoration would include maintenance of a marsh of this size. Other templates used in the historical restoration of Whiskey Island did not include as extensive of a marsh platform, and therefore required less sediment. Similarly, the team chose the Terrebonne Basin template designed under TE-143 for East/Trinity and Timbalier for use in the ICM-BI. This template is wider than the templates used at these islands during historical restoration activities and was chosen because The Water Institute/CPRA team determined that future restoration activity at these locations would use templates similar to the (more recently designed) TE-143 template.

Table 5. Comparison of the sediment volume used in the first restoration of the sensitivity test wherein all processes related to relative sea level are inactivated (Test Case 7) to the historical volume of sediment used in restoration.

| UNIT | SEDIMENT VOLUME PLACED IN 1ST RESTORATION , NO RSLR (X $10^6$ $M^3$) | HISTORICAL SED VOL (X $10^6$ $M^3$) | HISTORICAL PROJECTS USED IN ESTIMATE |
|---|---|---|---|
| WHISKEY ISLAND | 17.86 | 11.1 | TE27 + TE50+ TE100 |
| TRINITY/EAST | 18.26 | 6.7 | TE20 + TE24 |
| TIMBALIER ISLAND | 10.82 | 3.5 | TE40 |
| WEST BELLE PASS | 2.59 | 3.2 | TE52 |
| CAMINADA HEADLAND (CENTRAL PORTION) | 4.91 | 6.0 | BA45 + BA143 |
| CHALAND HEADLAND | 7.81 | 7.8 | BA35 + BA38(2) + BA76 |
| SHELL ISLAND (EAST/WEST) | 3.52 | 5.4 | BA 110 + BA 111 |
| PELICAN ISLAND | 2.20 | 2.8 | BA-38(1) |
| SCOFIELD ISLAND | 2.93 | 2.7 | BA40 |

| UNIT | SEDIMENT VOLUME PLACED IN 1ST RESTORATION , NO RSLR (X $10^6$ $M^3$) | HISTORICAL SED VOL (X $10^6$ $M^3$) | HISTORICAL PROJECTS USED IN ESTIMATE |
|---|---|---|---|
| SEDIMENT VOLUMES FOR HISTORICAL PROJECTS TAKEN FROM TABLE 5 IN: *CAFFEY RH, PETROLIA D, GEORGIOU IY, MINER M, WANG H, KIME B. 2020. ECONOMIC AND GEOMORPHIC COMPARISON OF OUTER CONTINENTAL SHELF SAND AND NEARSHORE SAND FOR COASTAL RESTORATION PROJECTS. NEW ORLEANS (LA): US DEPARTMENT OF THE INTERIOR, BUREAU OF OCEAN ENERGY MANAGEMENT. 54 P. CONTRACT NO.: M15AC00013. REPORT NO.: OCS STUDY BOEM 2020-035.*<br><br>VOLUMES FROM WITHIN THE FOOTPRINT OF EACH RESTORATION UNIT WERE TOTALED AFTER CONVERSION FROM CUBIC YARDS TO CUBIC YARDS TO CUBIC METERS. | | | |

The comparison of the sediment volume placed during the first application of the restoration template in the sensitivity test case where there is no SLR (Test Case 7) suggests that the templates in use in the ICM-BI are reasonable approximations for what have been (and would continue to be) used in management practice. Real-world processes that are captured within the model will likely increase the sediment volume necessary to restore a barrier island over time; these include SLR and resulting increase in accommodation space; steepening of the upper shoreface due to cross-shore retreat; and acceleration of cross-shore retreat with SLR. There are, however, processes not included in the model that will influence the sediment volume needed for restoration, which include: the effect that adding sediment volume to the system through restoration will have on cross-shore retreat rates; changes in the cross-shore retreat rate that may occur as the morphology of the coast evolves and impacts wave and alongshore current patterns; and the frequency and intensity of storm events. Similarly, the model cannot account for project-scale decisions that will impact the sediment volume required for restoration, such as use of an alongshore-variable restoration template that is designed to accommodate and build from the pre-restoration barrier island morphology. The sensitivity tests described above vary the input parameters of the ICM-BI model to estimate a range of sediment volumes needed for barrier island restoration projects that account for these factors where possible. However, actual sediment volume need may vary outside of these ranges depending on storm frequency and intensity, as well as the total volume of sediment added to the system and its influence on cross-shore retreat rates.

# 2.0 ICM-BITI SENSITIVITY TESTING

It is important to understand the sensitivity of the ICM to the inlet sizes, particularly the impact capping the amount of change that occurs. The following describes the anticipated changes to the model results.

## 2.1 TERREBONNE BASIN

The largest change would be in Link 906, which is the western-most link. It reaches the maximum size in the spin-up and does not change over the model years for either scenario. Allowing this link to expand could increase the conveyance in the area north of Whiskey Island, possibly increasing the land loss. Additional land loss in turn could cause other inlets to expand faster. Removing the minimum cap would allow Link 907 and 909 to further constrict. This change would likely have little to no impact because the size relative to the other inlets is already small.

## 2.2 BARATARIA BASIN

The largest changes would be to Caminada and Barataria Passes. If the set width was left in place, the depth of these inlets would become unrealistically large, 30 m for Caminada Pass and 15 m for Barataria Pass in S08. Other caps are not reached until the last two decades for both scenarios, and therefore, changing the caps would not have an impact until that time. With larger inlets, the conveyance could increase, possibly increasing land loss in the interior of the basin.

## 2.3 PONTCHARTRAIN BASIN

Changing the caps would have a minimal impact, even in S08. The max depth is reached for one inlet, Link 350, in the last few years of the simulation, and the max width is reached for two of the inlets, Link 350 and 141, in last 15 years. Both of these links are already quite large, and increasing their size in the final portions of the simulation will not likely cause other impacts.

We considered three options for implementing sensitivity testing:

1. Remove the maximum and minimum caps
2. Use inlet sizes after the spin-up period to set the maximum and minimum sizes
3. Change the caps to increase the amount of change allowed

We recommend Option 2. Using the ICM-year 2 data to set the maximum and minimum sizes would prevent most caps from ever being reached, while also preventing the most extreme changes from occurring (e.g., deepening of Caminada Pass described above).