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2017 Coastal Master Plan

Attachment C4-11: Metrics

Report: Version II

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Coastal Protection and Restoration Authority

This document was prepared in support of the 2017 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 five years) and annual plans. CPRA's mandate is to develop, implement and enforce a comprehensive coastal protection and restoration master plan.

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Executive Summary

This report describes the approach used to develop a set of metrics to reflect expected outcomes of the 2017 Coastal Master Plan that are not specifically addressed by outputs from the various models. The following Decision Criteria developed for the 2012 Coastal Master Plan were refined and re-categorized as Metrics for use in the 2017 Coastal Master Plan: Cultural Heritage, Navigation, Natural Processes, Sustainability of Land, Support for Oil and Gas, and Distribution of Risk Across Socio-Economic Groups. The refinement of the 2012 approach focused on obtaining input from focus groups, utilizing updated data sources for defining community boundaries and important resource areas, capitalizing on model improvements that allowed for the extraction of additional parameters, and reviewing original equations to ensure they adequately reflect the purpose of the metric. The new metrics utilize available outputs from the Integrated Compartment Model (ICM) and the Coastal Louisiana Risk Assessment (CLARA) model at varying temporal frequencies and spatial scales. The metrics now include: Sustainability of Land, Support for Navigation, Traditional Fishing Communities, Support for Oil and Gas Activities and Communities, Support for Agricultural Communities, Use of Natural Processes, Flood Protection of Strategic Assets, Flood Protection of Historic Properties, and a Social Vulnerability Index.

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List of Abbreviations

ACS	American Community Survey
AVT	Lower Atchafalaya/Vermillion/Western Terrebonne
BFD	Bird's Foot Delta
BH	Barrier headland
BRT	Breton
BS	Bankline stabilization
CAS	Calcasieu/Sabine
CLARA	Coastal Louisiana Risk Assessment model
CPRA	Coastal Protection and Restoration Authority
DI	Diversion
EAD	Expected annual damages
EL	Extent of Land value
EWCR	East/West Chenier Ridges
EwE	Ecopath with Ecosim
FEMA	Federal Emergency Management Agency
FWA	Future with Action
FWOA	Future Without Action
HP	Hurricane protection
HR	Hydrologic restoration
HSI	Habitat Suitability Index
HSIP	Homeland Security Infrastructure Program
ICM	Integrated Compartment Model
LBA	Lower Barataria
LDWF	Louisiana Department of Wildlife and Fisheries
LPO	Lower Pontchartrain

LTB	Lower Terrebonne
LULC	USGS National Land Cover Database Land Use Cover
MC	Marsh creation
MEL	Mermentau Lakes
MPDT	Master Plan Delivery Team
NHD	National Hydrography Dataset
NLCD	National Land Cover Database
OR	Oyster reef
PCA	Principal Components Analysis
ppsm	People per square mile
RC	Ridge creation
SHPO	Louisiana State Historic Preservation Office
SP	Shoreline protection
SVI	Social Vulnerability Index
UBA	Upper Barataria
UPO	Upper Pontchartrain
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

1.0 Introduction

1.1 Background and Purpose

Many of the ways in which protection and restoration projects influence the landscape, ecosystems, and risk outcomes are derived directly from the Integrated Compartment Model (ICM), Ecosim with Ecopath (EwE), and the Coastal Louisiana Risk Assessment (CLARA) model. However, some aspects of system change that inform how projects meet the master plan objectives are better derived by further analysis and combinations of model outputs. These additional metrics are described in this report.

For the 2012 Coastal Master Plan, many such metrics were used in addition to the main decision drivers – land area and expected annual damage (EAD) – to rank projects, formulate alternatives, compare alternatives, or improve understanding of the effects of the plan and included projects. While the objectives of the master plan have not changed, modeling has improved and lessons learned in 2012 can be used to refine the derivation of these metrics. For example:

- More detailed models of the effects of river diversions on the Mississippi River flow can be used to more directly attest to changes in cross channel flow during diversion operation.
- The planning process for the 2017 Coastal Master Plan also allows for information regarding projects (e.g., their effect on hydrologic exchange) to be assessed on a project specific basis that considers geographic setting, not simply project type.
- Some of the results of similar metrics in 2012 showed that they did not effectively discriminate amongst projects or alternatives because too many different factors were combined into one metric.

The metric descriptions included here consider the new information and approaches available and reflect input from various groups involved during the 2012 and 2017 master plan processes.

Each of the metrics described here can be used in different ways in the development of the 2017 Coastal Master Plan. Some metrics reflect individual project effects and can be used to rank projects or formulate alternatives (i.e., to select groups of protection and restoration projects using the Planning Tool). Some metrics that assess individual project effects are tailored to either restoration or protection projects as they are based on aspects or outputs from ICM or CLARA modeling. Others, which use information from both the ICM and CLARA models, can only be used to compare alternatives. Metrics are calculated at different scales according to the nature of the input data and the aspect of the system they address. In many cases, even if a single coast wide value is reported in the Planning Tool, more detailed information (e.g., at the community scale) can be used to understand the patterns of change that are combined in the single value. A summary of the application scale, the spatial unit, and potential utility for each of the metrics described here is included in Table 1. Example results from both types of metrics applications are also discussed in this report. Metric values by project type are provided in Attachment C4-11.1.

Table 1: Summary information on the metrics.

Metric	Scale for application	Spatial unit for calculation	Utility for 2017 Coastal Master Plan
Sustainability of Land	Project or alternative	Single coast wide value	Alternative formulation and alternative comparison
Support for Navigation	Project or alternative	Single coast wide value	Alternative formulation and alternative comparison
Traditional Fishing Communities	Alternative	Ecoregion and community and community region outputs for discussion purposes	Alternative comparison; Understanding the distribution of change by community
Support for Oil and Gas	Alternative	Ecoregion and community and regional values for discussion purposes	Alternative comparison; Understanding the distribution of change by community
Support for Agricultural Communities	Alternative	Ecoregion and community value for discussion purposes	Alternative comparison; Understanding the distribution of change by ecoregion and community
Use of Natural Processes	Project	Single coast wide value	Alternative formulation
Flood Protection of Historic Properties	Project or alternative	Risk region	Alternative formulation and alternative comparison
Flood Protection of Strategic Assets	Project or alternative	Risk region	Alternative formulation and alternative comparison
Social Vulnerability Index	The results of this analysis are used to interpret the results of other metrics and master plan model outputs in terms of their impact on socially vulnerable communities.		

1.2 Determining Community Boundaries

Several of the metrics consider specific coastal communities. The community boundaries were determined based upon three factors. First, the geographical population center for each community was established. If that community was either legally incorporated with defined boundaries or determined by the U.S. Census Bureau to be a census designated place (an unincorporated, locally recognized, and named population center), the official U.S. Census Bureau boundary was used to determine the core portion of the community. In some cases, small rural settlements do not meet either of these criteria. In these instances, land use and land cover data as well as aerial photography was examined to determine the spatial extent of community development.

Secondly, population density data were used to extend the community boundaries where necessary. A density of 1,000 people per square mile (ppsm) was used to establish the spatial extent of community development. Contiguous census blocks meeting this population density requirement were grouped together into population clusters. Population clusters connected by census blocks with at least 500 ppsm were also considered to be contiguous, provided the overall population cluster maintained the 1,000 ppsm requirement. In several cases, the extent of the population clusters extended beyond the official community boundaries. In these instances, the two datasets were merged to establish a more accurate, inclusive community boundary.

Finally, the National Land Cover Database (NLCD) was used to identify locations within or contiguous to these communities with high, medium, and low density-developed land surface. These impervious layers include commercial and industrial areas, as well as public buildings within the communities, which may not have been included based solely on population count. The developed land layers were merged with the population center layer to establish the final community boundary.

Table 2 lists the communities and community groupings used in the metrics. See the individual metric descriptions for more information on how they are used.

Table 2: Communities and community groupings within the ICM domain used in the metrics.

Communities and Community Groupings	
Alliance	Kraemer
Ama	Lacombe
Amelia	Lafitte/Jean Lafitte/Barataria
Avondale/Waggaman	Lake Arthur
Bayou Blue	Lake Charles/Prien
Bayou Cane	Laplace/Reserve
Bayou Gauche	Larose/Cut Off/Galliano/Golden Meadow
Bayou L'Ourse	Leeville
Belle Chasse	Luling/Boutte
Belle Rose/Paincourtville	Manchac
Boothville	Mandeville/Covington/Madisonville/Abita Springs

Communities and Community Groupings	
Bourg	Mathews/Lockport/Lockport Heights
Buras	Mermentau
Cameron	Montegut
Chackbay	Morgan City/Berwick/Siracusaville
Chalmette/Arabi/Meraux	Napoleonville/Labadieville/Supreme
Chauvin	New Orleans
Choctaw	New Orleans - Algiers
Cocodrie	New Orleans East
Creole	Paradis
Delacroix	Patterson
Des Allemands	Pecan Island
Destrahan/New Sarpy/Norco	Phoenix
Donaldsonville/Lemannville	Pierre Part
Dulac	Pleasure Bend
Edgard/North Vacherie/Wallace	Point aux Chene
Empire	Pointe a la Hache
Franklin	Ponchatoula/Springfield
Garyville	Port Fourchon
Gibson	Port Sulphur
Gonzales/Prairieville	Port Vincent/French Settlement
Gramercy/Lutcher	Poydras/Violet/St. Bernard
Grand Isle	Presquille
Grand Lake	Raceland
Gray	Schriever
Hackberry	Slidell/Eden Isle/Pearl River

Communities and Community Groupings	
Hahnville	South Vacherie
Houma	St. James/Welcome
Intracoastal City	St. Rose
Isle de Jean Charles	Sulphur/Carlyss
Jefferson Parish (Eastbank)	Thibodaux/Lafourche Crossing/Bayou Country Club
Jefferson Parish (Westbank)	Triumph
Johnson's Bayou	Venice
Killian	Yscloskey
Killona/Taft	

2.0 Sustainability of Land

2.1 Overview

This metric is designed to reflect Master Plan Objective #2: "Promote a sustainable coastal ecosystem by harnessing the processes of the natural system." The metric considers both 1) the progress towards building land (SI_1) and 2) the long-term trajectory of land building (SI_2) and is calculated at the project level and at the coast wide scale. Higher values are achieved when more land is built under future with action (FWA) than would have been lost under the future without action (FWOA) and when the rate of land building in the long-term (i.e., years 40 to 50) is increasing or stable.

2.2 Inputs

The metric requires total land area within each 500 m x 500 m ICM grid cell summed across the coast at years 0 (initial condition), 40, and 50 under FWOA and FWA conditions for each project. The same inputs are required for use in alternative comparison.

2.3 Equations

The metric consists of two suitability indices that reflect the progress towards building land (SI_1) and the trajectory of land building (SI_2).

2.3.1 Progress Towards Building Land

Progress towards building land, *P*, measures the difference between FWOA and FWA at a coast wide, project, or alternative level and scales the difference relative to the land change that occurred from year 0 to year 50 under FWOA (1). The variable scales from positive to negative, where positive values indicate more land is built under FWA than FWOA, and negative indicates less land is built under FWA than FWOA:

$$\begin{aligned}&\boldsymbol{If\ Land_{FWOA50} \geq Land_0, Then}\\&\qquad \boldsymbol{P = \frac{Land_{FWA50} - Land_{FWOA50}}{Land_{FWOA50} - Land_0}}\\&\boldsymbol{Else\ if\ Land_{FWOA50} < Land_0, Then}\\&\qquad \boldsymbol{P = \frac{Land_{FWA50} - Land_{FWOA50}}{Land_0 - Land_{FWOA50}}}\end{aligned} \tag{1}$$

Where:

$Land_{FWA50}$	=	total coast wide land area under future with action at year 50
$Land_{FWOA50}$	=	total coast wide land area under future without action at year 50
$Land_0$	=	total coast wide land area under initial conditions

2.3.2 Trajectory of Land Building

Trajectory of land building, *T*, measures the slope of land building (or loss) from year 40 to year 50 coast wide at the project or alternative level and scales the slope relative to the slope of the land change that occurred from year 40 to year 50 under FWOA (2). The variable is an indication of whether the project has long term land building potential.

$$\boldsymbol{T = (Land_{FWA50} - Land_{FWA40}) - (Land_{FWOA50} - Land_{FWOA40})} \tag{2}$$

Where:

$Land_{FWA40}$	=	total coast wide land area under future with action at year 40
$Land_{FWOA40}$	=	total coast wide land area under future without action at year 40

2.3.3 Metric Value

2.3.3.1 Project Effects

The sustainability metric is calculated coast wide as the geometric mean of the SI_1 and SI_2 measures (3). To ensure the correct sign is applied, if either (or both) measures are less than 0, the metric defaults to a negative value.

$$\begin{aligned}&\boldsymbol{If\ P < 0\ or\ T\ < 0\ then\ X = -1}\\&\qquad \boldsymbol{Else\ X = 1}\\&\boldsymbol{Sustainability\ of\ Land\ Metric = X * (|P * T|)^{\frac{1}{2}}}\end{aligned} \tag{3}$$

Where:

X = positive or negative integer used to ensure the correct sign is applied to the final metric value

2.3.3.2 Alternatives

To assess the sustainability of alternatives, the same calculations can be made for the net effect of projects on the landscape (4).

$$\begin{aligned} &\boldsymbol{If\ P < 0\ or\ T\ < 0\ then\ X = -1} \\ &\qquad\qquad \boldsymbol{Else\ X = 1} \\ &\boldsymbol{Sustainability\ of\ Land\ Metric = X * (|P * T|)^{\frac{1}{2}}} \end{aligned} \quad (4)$$

2.4 Output

For each project run, the Sustainability of Land metric is calculated for the entire coast and used by the Planning Tool to formulate alternatives. The metric scales are directionally from negative to positive. A modified version of the trajectory of change component of the metric, based on the trajectory between year 20 and year 30) is used as a constraint (e.g., only include projects with values >0.01) in the Planning Tool analysis. Further detail can be found in Appendix D. The alternatives calculation could be used as a way of simply representing the same information shown in plots of the amount of land over time for the alternative verses FWOA.

2.5 Example Results

Table 3 includes average values for each type of master plan restoration project for the Progress Towards Building Land component of the metric. Positive values indicate more land is built under FWA than FWOA, and negative indicates less land is built under FWA than FWOA. There is substantial difference among scenarios within a project type reflecting the complex landscape dynamics that occur in both FWA and FWOA. All project types except bankline stabilization, ridge creation, and shoreline protection have lower values for the high scenario than for the low scenario. This shows the challenge of building or sustaining land in the face of the conditions represented in the high scenario. The most negative score for any project type is sediment diversions under the high scenario, especially in the Barataria Basin, where diversions keep marsh fresh, but the fresh marsh is lost to salinity intrusion during times when the diversion flow is turned off due to low Mississippi River discharge (see Chapter 4 for more information). Marsh creation and barrier headland projects retain positive values across all scenarios as they directly turn water to land and generally have less effect on marsh type.

Table 3: Average values by restoration project type[1] for each environmental scenario for Progress Towards Building Land. Values are presented x1000 for ease of comparison in the table.

Project Type	Low	Medium	High
BH	1.51	0.72	0.40
BS	-0.06	0.04	-0.01
DI	8.51	0.54	-2.65
HR	4.35	1.48	0.80
MC	5.20	2.11	1.11
OR	-0.02	-0.01	0.00
RC	-0.04	0.21	-0.03
SP	0.00	-0.22	0.19

Inspection of project level metric values (Attachment C4-11.1) indicates that Upper Breton Diversion (001.DI.17; 7079 cms) has the highest value (most positive) for Progress Towards Building Land under the high environmental scenario and Ama Sediment Diversion (001.DI.101; 1416 cms) has the lowest value. The Ama sediment diversion actually discharges into the Barataria Basin and the negative effect is a result of the effects described above for sediment diversions in general.

For comparison, the value of Progress Towards Building Land for the draft master plan is 0.28 for the medium scenario and 0.36 for the high scenario.

3.0 Support for Navigation

3.1 Overview

This metric is designed to reflect Master Plan Objective #5: "Promote a viable working coast to support businesses and industries." The aim of this metric is to reflect the potential effects of projects on navigability of shallow and deep draft channels in coastal Louisiana. The focus is on federally-authorized navigation channels. Higher values are achieved when land is sustained on either side of the channel, bed elevation in the channel decreases or does not change, changes in transverse velocities at diversions are minimal, and when no new obstacles to navigation are imposed.

3.2 Inputs

The calculation required identifying the grid cells that contain the navigation channels and defining a 3 km buffer on either side of the navigation channels (0.5 km for the Mississippi River) to assess the impacts of "windage" on barge traffic. Land area change is calculated within these areas. In navigation channels (other than the Mississippi River), land elevation is calculated

[1] BH (barrier headland); BS (bankline stabilization); DI (diversion); HR (hydrologic restoration); MC (marsh creation); OR (oyster reef); RC (ridge creation); SP (shoreline protection)

within the grid cells that contain the channel plus one adjacent grid cell. For the Mississippi River diversions, the transverse component of velocity is obtained from external models. The characteristics of new structures, such as locks and floodgates, that will have an impact on navigability of navigation channels is also needed. This includes information about the type of structure and how frequently it is expected to be operated, e.g., seasonal control of salinity or gates which only close during storms.

3.3 Equations

The metrics consist of a series of suitability indices that reflect the degree to which projects affect the sustainability of the channel and surrounding area, impedance to navigation through shoaling or steerage, and impedance to navigation through new structures.

3.3.1 Extent of Land Adjacent to Channels

This variable estimates the degree to which project effects that are in close proximity to channels may affect the overall sustainability of the area and channel. The amount of open water is an important factor for "windage" that impairs navigation for barge traffic and impacts the ability to maintain the channel into the future. It is assumed that projects which build or maintain land within 3 km of a navigation channel will benefit navigation. Each relevant project will receive an Extent of Land value (*EL)*, for extent of land in coastal cells. Specific projects which seek to maintain the banks of navigable channels (e.g., bank stabilization or shore protection projects) receive an *EL* value of 1.0.

<u>Step 1</u>

Projects that change land area within 3 km of a navigation channel (except the Mississippi River) will affect navigation according to the following formula, *L*, that is calculated for each individual grid cell, *i*, within the 3 km buffer (5). Due to the extensive levee system on the Mississippi River that provides some protection to the channel and the lesser effect of windage on deep draft vessels using the river in the areas without levees, the maximum L_i value was reduced to 0.5 within 3 km of the Mississippi River using the NC factor described in the formula above. The U.S. Geological Survey (USGS) National Hydrography Dataset (NHD) was used in defining the Mississippi River channel for this purpose. In addition, the calculation is made only for sections of the Mississippi River which are not confined by levees (e.g., the Bohemia Spillway and downstream on the eastbank, and Venice and downstream on the westbank). However, as the NHD does not include the Southwest Pass, this section of the channel is also not included. The formula is calculated as follows:

$$
\begin{aligned}
&\textbf{If } Land_{FWA50,i} \leq Land_{FWOA50,i}, \textbf{ then} \\
&\qquad L_i = 0, \textbf{ else} \\
&\textbf{If } Land_{FWOA50,i} > Land_{0,i}, \textbf{ then} \\
&\qquad L_i = \frac{(Land_{FWA50,i} - Land_{FWOA50,i})}{(Land_{FWOA50,i} - Land_{0,i})} * NC, \textbf{ else} \\
&\textbf{If } Land_{FWOA50,i} < Land_{0,i}, \textbf{ then} \\
&\qquad L_i = \frac{(Land_{FWA50,i} - Land_{FWOA50,i})}{(Land_{0,i} - Land_{FWOA50,i})} * NC, \textbf{ else} \\
&\qquad L_i = NC
\end{aligned}
\tag{5}
$$

Where:

L_i = value for grid cells within 3 km of a navigation channel

$Land_{FWA50}$ = land area within grid cell *i* under future with action at year 50

$Land_{FWOA50}$ = and area within grid cell *i* under future without action at year 50

$Land_0$ = total land area under initial conditions at year 0

NC = 0.5 for Mississippi River or 1 for all other navigable channels

<u>Step 2</u>

EL is calculated separately for the Mississippi River navigation channel (MSR) and all other federal navigation channels within the coastal zone (FNC). *EL* the average of all L_i values within each region. (6)

$$\boldsymbol{EL_{FC}} = \frac{\sum \boldsymbol{L_i}}{\boldsymbol{n_{FC}}} \tag{6}$$

$$EL_{MSR} = \frac{\sum L_i}{n_{MSR}}$$

Where:

n_{FC} = count of all grid cells within 3 km of a federal navigation channel that is not the Mississippi River

n_{MSR} = count of all grid cells within 3 km of the Mississippi River navigation channel

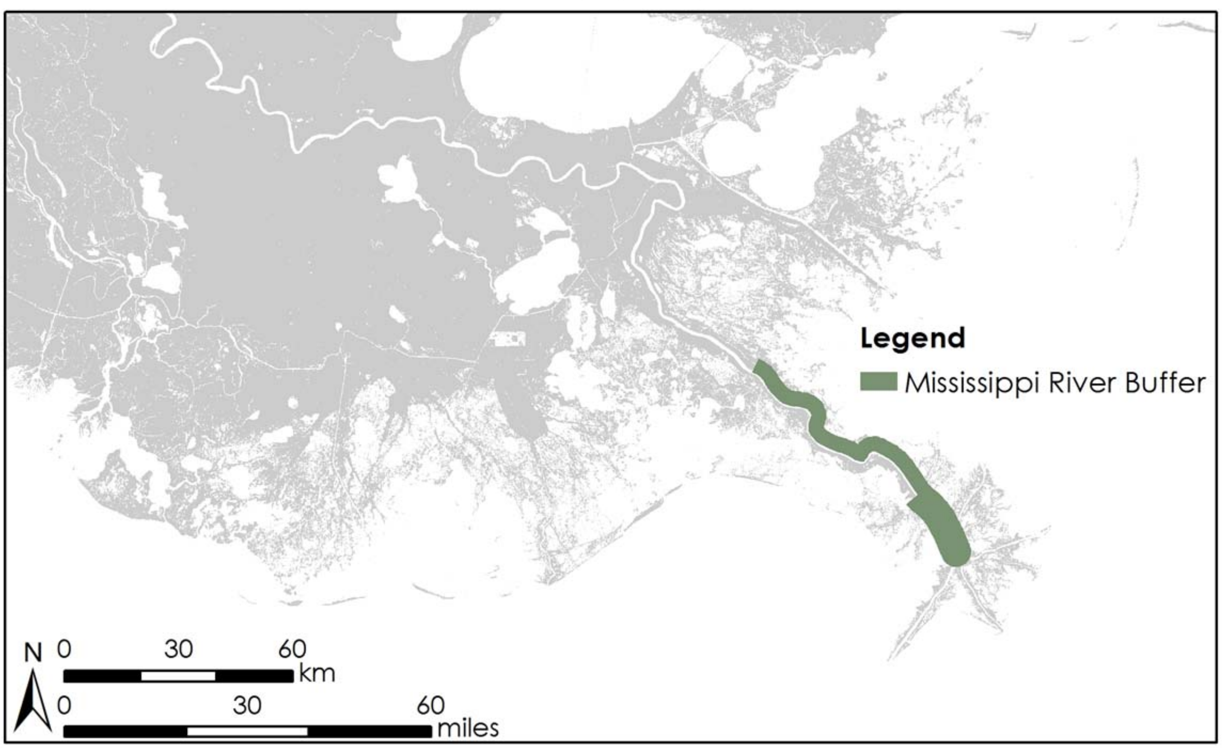


Figure 1: Portions of the Mississippi River used in the extent of land calculation.

3.3.2 Potential for Steerage and Shoaling

The Mississippi River Steerage is only calculated for master plan projects that divert flow from the Mississippi River, while Shoaling in Navigation Channels is calculated for all other projects.

3.3.2.1 Mississippi River Steerage

The variable reflects the effects of projects that divert flow from the main channel on transverse velocities (i.e., cross channel, associated with river diversions) for navigability in the Mississippi River. The transverse velocity at the diversion location at maximum discharge is scaled from 0 to -1, with 0 being no change to channel velocity and -1 being substantial increases in channel velocity (7). The values used to scale the cross channel velocity are the FWOA cross channel velocity (used to scale to 0) and cross channel velocity obtained from model output from the 2011 opening of the Bonnet Carre Spillway (used to scale to -1). Transverse velocity values are obtained from the Delft 3D river model that is used to conduct detailed evaluations of master plan sediment diversions. For the Mississippi River diversion locations, which have not been subject to the detailed modeling, transverse velocities have been estimated from modeled diversion locations based on diversion flow rates that reflect the project being considered. The formula, S_{MSR}, is calculated as follows:

$$\boldsymbol{If\ V_I \le V_{FWOA}, Then} \qquad (7)$$
$$\boldsymbol{S_{MSR} = 0, else}$$
$$\boldsymbol{If\ V_I < V_{BC}, Then}$$
$$\boldsymbol{S_{MSR} = \frac{V_I - V_{FWOA}}{V_{BC}} * -1, else}$$
$$\boldsymbol{If\ V_I > V_{BC}, Then}$$
$$\boldsymbol{S_{MSR} = -1}$$

Where:

V_I	=	magnitude of cross channel velocity at diversion location at maximum discharge
V_{BC}	=	magnitude of cross channel velocity at the Bonnet Carre Spillway
V_{FWOA}	=	magnitude of cross channel velocity at diversion location at high diversion discharge (i.e., time discharge at which maximum diversion discharge is expected) during FWOA

3.3.2.2 Shoaling in Navigation Channels apart from the Mississippi River

Step 1

Each relevant project receives a value for potential shoaling in federal navigation channels, S_{FC}, other than the Mississippi River (8). This variable reflects the way in which some projects can introduce sediments to open waters which can cause shoaling and impede navigation if dredging is not conducted. The change in mean bed elevation within the channel is calculated within each individual grid cell within a navigation channel at years 10, 30, and 50 to track the change in elevation over time as follows:

$$\boldsymbol{If\ Elev_{FWA,YR,i} - Elev_{FWOA,YR,i} \le 0, \quad Then\ S_{FC,YR} = 0}$$

$$If\ 0 < Elev_{FWA,YR,i} - Elev_{FWOA,YR,i} \le 0.15, \quad Then\ S_{FC,YR,i} = \left(\frac{-0.5}{0.15}\right) * (Elev_{FWA,YR,i} - Elev_{FWOA,YR,i})$$

$$If\ 0.15 < Elev_{FWA,YR,i} - Elev_{FWOA,YR,i} \leq 0.3, \quad Then\ S_{FC,YR,i} = -0.7 \tag{8}$$
$$If\ 0.3 < Elev_{FWA,YR,i} - Elev_{FWOA,YR,i} \leq 0.6, \quad Then\ S_{FC,YR,i} = -0.9$$
$$If\ Elev_{FWA,YR,i} - Elev_{FWOA,YR,i} > 0.6, \quad Then\ S_{FC,YR,i} = -1.0$$

Where:

i	=	grid cell within a navigation channel
$Elev_{FWA,YR}$	=	mean bed elevation (m) in cell that contains channel and adjacent 500 m x 500 m cells under future with action at years 10, 30, and 50
$Elev_{FWOA,YR}$	=	mean bed elevation in cell that contains channel and adjacent 500 m x 500 m cells under future without action at years 10, 30, and 50
$S_{FC,YR}$	=	index value for shoaling in federal navigation channels calculated separately at years 10, 30, and 50

<u>Step 2</u>

The potential shoaling value, $S_{FC,YR}$, is then calculated coast wide as the average of all $S_{FC,YR,i}$ values (9).

$$\boldsymbol{S_{FC,YR}} = \frac{\sum \boldsymbol{S_{FC,YR,i}}}{\boldsymbol{n}} \tag{9}$$

Where:

n	=	count of all grid cells within a navigation channel coast wide

<u>Step 3</u>

S_{FC} is a measure of the arithmetic mean of $S_{FC,YR}$ calculated for each year set weighted unequally as change that happens immediately (i.e., year 10) is worse than change that happens gradually (10).

$$\boldsymbol{S_{FC}} = (\boldsymbol{S_{FC,10}} * \boldsymbol{0.5}) + (\boldsymbol{S_{FC,30}} * \boldsymbol{0.25}) + (\boldsymbol{S_{FC,50}} * \boldsymbol{0.25}) \tag{10}$$

3.3.3 New Structures

This variable reflects the effects of structures such as locks, floodgates, etc. on navigation. Each project is assigned an attribute for this variable using the attributes for the projects (11).

$$\begin{aligned}
&\boldsymbol{IF\ no\ new\ structures\ are\ added\ by\ the\ alternative,} \\
&\qquad \boldsymbol{THEN\ NS = 0.0} \\
&IF\ 1\ or\ more\ new\ storm\ surge\ floodgate\ is\ added, \\
&\qquad THEN\ NS = -0.2 \\
&IF\ \geq 1\ new\ lock\ (continuous\ operation) is\ added, \\
&\qquad THEN\ NS = -0.7 \\
&IF\ channel\ is\ permanently\ blocked\ with\ an\ alternative\ route\ provided, \\
&\qquad THEN\ NS = -0.9 \\
&IF\ channel\ is\ permanently\ blocked\ with\ no\ alternative\ route\ provided, \\
&\qquad THEN\ NS = -1.0
\end{aligned} \tag{11}$$

3.3.4 Metric Value

3.3.4.1 Project Effects

The following equations are used to calculate a total value for each project's effect on the coast wide scale, depending on the project type (12).

$$Nav_{MSR} = \frac{EL_{MSR} + S_{MSR}}{2} \tag{12}$$

$$Nav_{FC} = \frac{EL_{FC} + S_{FC}}{2}$$

$$Nav_{HP} = NS$$

Where:

Nav_{MSR} = Mississippi River diversions
Nav_{FC} = all other restoration project types
Nav_{HP}= all structural protection project types

3.3.4.2 Alternatives

To assess the sustainability of alternatives, the same calculations for EL_{MSR}, EL_{FC}, S_{FC}, and NS can be made for the net effect of projects on the landscape (13). The term representing steerage in the Mississippi River, S_{MSR}, is calculated differently than in project-level calculations; the project that impacts the steerage the greatest (e.g. the minimum S_{MSR} value) is used as the S_{MSR} term for the entire alternative. Variables should only be included in the equation below if the alternative includes project types reflected in the variable. Otherwise, the variable should be removed and the denominator adjusted to reflect the number of variables in the numerator. Thus, the equation shown below is an example which would be adjusted based on the alternatives considered.

$$Nav_{ALT} = \frac{EL_{MSR} + EL_{FC} + Min(S_{MSR}) + S_{FC} + \sum NS}{5} \tag{13}$$

Where:

Nav_{ALT} = all projects implemented in an alternative
$Min(S_{MSR})$= minimum S_{MSR} score of all projects implemented in an alternative

3.4 Output

For each project analyzed, the Navigation metric is calculated for the entire coast and used by the Planning Tool to help formulate alternatives. The metric scales directionally from negative to positive. It can also be used as a constraint in alternative formulation (e.g., only include projects with positive values). For comparison of alternatives, a value can be derived by adding all of the project values (which assumes they are additive and there are no interactions among project effects). Alternatively, a value could be calculated using the net effect of all the projects on the variables as described above.

3.5 Example Results

Table 4 includes average values for each master plan project type for each of the environmental scenarios. As one of the factors in the metric is associated with the effect of the project on land adjacent to the navigation channels, there is substantial difference among scenarios, and some project types which have positive scores under the low scenario switch to slightly negative scores under the high scenario (e.g., marsh creation). The most negative score for any project type is sediment diversions where the metric value includes the effect of diversion flow on cross channel flow in the Mississippi River. Hurricane protection projects show no change among environmental scenarios as the metric value is driven by structural characteristics.

Table 4: Average values by project type for each environmental scenario for the Support for Navigation Metric.

Project Type	Low	Medium	High
BH	-0.023	-0.037	-0.04
BS	-0.016	-0.018	-0.034
DI	-0.21	-0.211	-0.212
HP[2]	-0.118	-0.118	-0.118
HR	-0.014	-0.025	-0.029
MC	0.004	-0.009	-0.024
OR	0.013	-0.006	-0.016
RC	-0.001	-0.016	-0.026
SP	-0.001	-0.021	-0.026

Inspection of project level metric values (Attachment C4-11.1) indicates that Freshwater Bayou Canal Shoreline Protection (004.SP.03) has the highest value (most positive) for the Support for Navigation metric under the High environmental scenario and Mid-Barataria Diversion (002.DI.03a), which has a capacity of 7079 cms has the lowest value.

For comparison the value for Support for Navigation for the draft master plan is -0.02 for the medium scenario and -0.05 for the high scenario.

[2] HP (hurricane protection) project type

4.0 Support for Traditional Fishing Communities

4.1 Overview

The metric is designed to reflect Master Plan Objective #3: "Provide habitats suitable to support an array of commercial and recreational activities coast wide" and Master Plan Objective #4: "Sustain, to the extent practicable, the unique cultural heritage of coastal Louisiana, by protecting historic properties and traditional living cultures and their ties and relationships to the natural environment." This metric considers 1) damages to commercial, residential, and infrastructure assets within a traditional fishing community and 2) the availability of habitat for the representative species needed by the community (defined by community resource areas). High values are achieved when high levels of protection are accompanied by high resource (i.e., habitat) availability.

The calculation first requires defining communities and their respective community resource-use areas Table 5. These are natural resource areas, which include coastal communities that are in close proximity to one another and share similar natural resources of cultural importance. To identify a community's use of traditional fish resources, data were examined from the Louisiana Department of Wildlife and Fisheries (LDWF) Gulf-Wide Information System, Environmental Sensitivity Index Crawfish Database, and by obtaining input from the 2012 Coastal Master Plan Cultural Heritage Technical Advisory Committee (Figure 2).

4.2 Inputs

The calculation requires combining model output from both the ICM and CLARA modeling domains. Within each community, EAD (in dollars) to commercial, residential, and infrastructure assets are summed at initial conditions (year 0), FWOA year 50, and FWA year 50. More specifically, the 50th percentile of EAD for the 1% exceedance probability (i.e., 100-year flood depth) is used in the EAD calculation. Within each community resource-use area, habitat suitability index (HSI) values derived from the ICM are summed by species at initial conditions (averaged over years 1-3), FWOA (averaged over years 48-50), and FWA (averaged over years 48-50). The HSI values are an indication of the relative suitability of a given area to support a particular species and are strictly based on environmental conditions (e.g., salinity and temperature). Habitat suitability values are calculated by the ICM at the end of a simulation year and are not directly measurable in the landscape, in contrast to key parameters like land area or vegetation cover. Thus, the earliest available information on habitat suitability from a 50-year model run is from the end of year 1. In addition, most habitat suitability indices are sensitive to variables like salinity, which have potentially high inter-annual variability. Thus "initial conditions" for suitability values are based on the average of the first three years of the model run while year 50 is based on an average of years 48-50 so as not to overly bias the results by conditions in an extreme drought/flood year. See Attachment C3-26 for more information on the boundary conditions used to drive the ICM and how they change over time. The HSI values are then applied to the communities that fall within the resource-use area and used with the EAD value to calculate the traditional fishing metric value for the community.

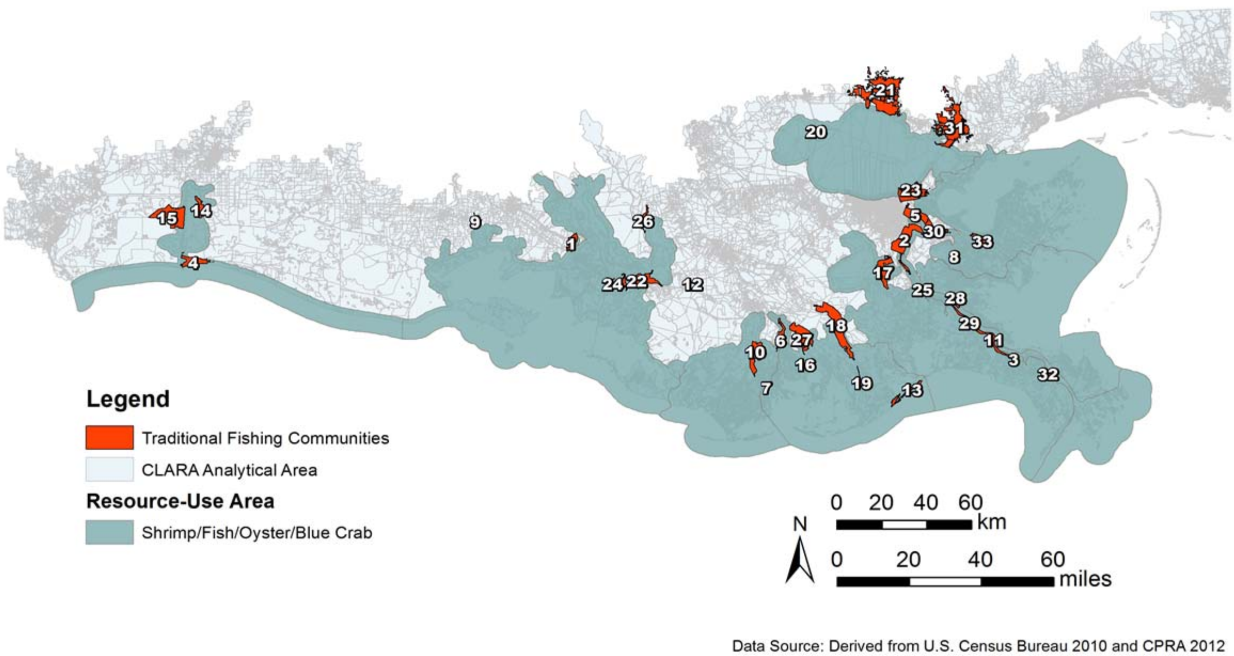


Figure 2: Traditional fishing communities and their resource-use areas. Communities are labeled as numbers which correspond to those listed in Table **5**5.

Table 5: Communities associated with traditional fishing activities and their affiliated resource-use areas. Fish =adult spotted seatrout and largemouth bass; Shrimp = juvenile brown and white shrimp; Oyster = eastern oyster; and Blue Crab = juvenile blue crab.

Map Label	**Community**	**Resource-Use Area**	**Resource**
1	Baldwin/Charenton	South Central/South West (St. Mary, Iberia, and Vermillion)	Shrimp, Fish, and Blue Crab
2	Belle Chasse	Plaquemines (West Bank)	Shrimp, Fish, Oysters, and Blue Crab
3	Buras	Plaquemines (West Bank)	Shrimp, Fish, Oysters, and Blue Crab
4	Cameron	Cameron/ Hackberry	Shrimp, Fish, and Blue Crab
5	Chalmette/Arabi/Meraux	St. Bernard and Orleans	Shrimp, Oysters, and Blue Crab
6	Chauvin	South Terrebonne	Shrimp, Fish, Oysters, and Blue Crab

Map Label	Community	Resource-Use Area	Resource
7	Cocodrie	South Terrebonne	Shrimp, Fish, Oysters, and Blue Crab
8	Delacroix	St. Bernard and Orleans	Shrimp, Oysters, and Blue Crab
9	Delcambre	South Central/South West (St. Mary, Iberia, and Vermillion)	Shrimp, Fish, and Blue Crab
10	Dulac	South Terrebonne	Shrimp, Fish, Oysters, and Blue Crab
11	Empire	Plaquemines (West Bank)	Shrimp, Fish, Oysters, and Blue Crab
12	Gibson	Atchafalaya Basin	Wild Caught Crawfish
13	Grand Isle	West Bank Jefferson	Shrimp, Fish, and Blue Crab
14	Grand Lake	Cameron/ Hackberry	Shrimp, Fish
15	Hackberry	Cameron/ Hackberry	Shrimp, Fish, and Blue Crab
16	Isle de Jean Charles	South Terrebonne	Shrimp, Fish, Oysters, and Blue Crab
17	Lafitte/Jean Lafitte/Barataria	West Bank Jefferson	Shrimp, Fish, and Blue Crab
18	Larose/Cut Off/Galliano/ Golden Meadow	South Lafourche	Shrimp, Fish, Oysters, and Blue Crab
19	Leeville	South Lafourche	Shrimp, Fish, Oysters, and Blue Crab
20	Manchac	St. Tammany/Tangipahoa	Fish and Blue Crab
21	Mandeville/Covington/ Madisonville/Abita Springs	St. Tammany/Tangipahoa	Fish and Blue Crab
22	Morgan City/Berwick/Siracusaville	South Central/South West	Shrimp, Fish, and Blue Crab

Map Label	Community	Resource-Use Area	Resource
		(St. Mary, Iberia, and Vermillion)	
23	New Orleans East	St. Bernard and Orleans	Shrimp, Oysters, and Blue Crab
24	Patterson	Atchafalaya Basin	Wild Caught Crawfish
25	Phoenix	Plaquemines (East Bank)	Shrimp, Fish, Oysters, and Blue Crab
26	Pierre Part	Atchafalaya Basin	Wild Caught Crawfish
27	Point aux Chene	South Lafourche	Shrimp, Fish, Oysters, and Blue Crab
28	Pointe a la Hache	Plaquemines (East Bank)	Shrimp, Fish, Oysters, and Blue Crab
29	Port Sulphur	Plaquemines (West Bank)	Shrimp, Fish, Oysters, and Blue Crab
30	Poydras/Violet/St. Bernard	St. Bernard and Orleans	Shrimp, Oysters, and Blue Crab
31	Slidell/Eden Isle/Pearl River	St. Tammany/Tangipahoa	Fish, Blue Crab
32	Venice	Plaquemines (West Bank)	Shrimp, Fish, Oysters, and Blue Crab
33	Yscloskey	St. Bernard and Orleans	Shrimp, Oysters, and Blue Crab

4.3 Equations

The metric consists of two suitability index values that represent the use of resources and the EAD from storm surge based flooding. The suitability index values are calculated under FWOA and FWA at the alternative level. The metric value combines the suitability index values and takes the difference between FWOA and FWA as the final value.

4.3.1 Use of Resource

Step 1

H is a measure of future total habitat units for a particular species, s, within a community resource-use area, c, relative to initial conditions. *H* is calculated by averaging HSI values for years 48-50 (calculated for both FWOA and FWA) and dividing by the initial habitat units averaged for years 1-3 for that species (14).

FWOA

$$H_{s,c,FWOA} = \frac{HSI_{s,c,FWOA50}}{HSI_{s,c,1}}$$

FWA

$$H_{s,c,FWA} = \frac{HSI_{s,c,FWA50}}{HSI_{s,c,1}} \qquad (14)$$

Where:

s	=	species of interest for a community
c	=	community resource-use area
HSI_{FWOA50}	=	total habitat suitability index value under future without action averaged over years 48-50
HSI_{FWA50}	=	total habitat suitability index value under future with action averaged over years 48-50
HSI_1	=	total habitat suitability index value averaged over years 1-3

Step 2

P is a measure of the proportion of total habitat units for a particular species, s, in a community resource area, *c*, divided by the total habitat units for all species in a community resource area under initial conditions (15).

$$\boldsymbol{P_{s,c}} = \frac{\boldsymbol{HSI_{s,c\,1}}}{\sum_s \boldsymbol{HSI_{s,c,1}}} \qquad (15)$$

Step 3

The results from Step 1 and Step 2 are used together to generate the value, SI_1, for both FWOA and FWA (16). The geometric mean of H_s, sum of habitat unit index value within a community resource use area for a species, is calculated across all species, but is weighted by the relative proportion of each species, $P_{s,c}$. This assumes that resource availability (i.e., habitat units) at initial conditions are representative of the needs of the community and that the community will not switch from one species to another in the future. This assumption was also made in the analyses supporting the 2012 Coastal Master Plan. As a result, species with lower habitat units at initial conditions generate a lower $P_{s,c}$, value than those with higher habitat units and, thus, contributes less to the overall $SI_{1,c}$ value. This value will then be used for each community within the community resource use area for the calculation of the overall traditional fishing metric.

FWOA

$$SI_{1,c,FWOA} = \prod_s H_{s,c,FWOA}{}^{P_{s,c}}$$

FWA

$$SI_{1,c,FWA} = \prod_s H_{s,c,FWA}{}^{P_{s,c}} \qquad (16)$$

Step 4

The FWOA and FWA results from Step 3 are combined together into a single value, *Fisheries*$_C$, for each community

$$Fisheries_c = 1 - \frac{SI_{1,c,FWOA}}{SI_{1,c,FWA}}$$

(17). This value ranges from -1 to 1, with positive values indicating an increase in a community's fisheries resource under FWA as compared to FWOA. Negative values indicate that a community's fishery resource would increase under FWOA while decreasing under FWA.

$$Fisheries_c = 1 - \frac{SI_{1,c,FWOA}}{SI_{1,c,FWA}} \quad (17)$$

4.3.2 Expected Annual Damages from Storms

E_c is a comparison between the change in EAD within a community under FWOA and under FWA (22).

$$E_c = 1 - \frac{EAD_{FWA50,c} - EAD_0}{EAD_{FWOA50,c} - EAD_0} \quad (18)$$

Where:

c	=	community within a region
EAD_0	=	expected annual damages under initial conditions at year 0
EAD_{FWOA50}	=	expected annual damages under future without action at year 50
EAD_{FWA50}	=	expected annual damages under future with action at year 50

To remain consistent with the planning level analysis of EAD conducted with CLARA, relatively minor differences between FWOA and FWA EAD at year 50 were not included in this analysis. To remain consistent with model uncertainties and confidences developed by the CLARA analysis, any differences less than $1,000,000 indicated an indistinguishable difference between FWOA and FWA year 50 EAD.

4.3.3 Metric Value

The metric value is calculated as the geometric mean of *Fisheries*$_C$ and E_C for each community. However, if either or both of the individual components, *Fisheries*$_c$ and E_c, are negative the entire metric will be set to negative. A negative metric value will represent either a decrease in expected annual damage, a decrease in fisheries habitat within the resource region, or both. A positive metric will be realized only if the regional fisheries habitat improves and flood damages are

If E_c was determined to be insignicant (based on the description above), the metric value, SF_c, was set equal to *Fisheries*$_c$.

4.4 Output

The SF_C values are averaged for all communities within each ecoregion, and a single value for each ecoregion is used in the Planning Tool to compare alternatives. Individual community level values for each metric component for both FWOA and FWA can also be provided to enable a greater understanding of where the changes are occurring and how the changes are distributed among traditional fishing communities.

4.5 Example Results

As this metric is based on outputs from both the landscape/ecosystem and the risk models, results are available only for alternatives that were run through both sets of models. Table 6 shows results for alternative G301[3] and the draft master plan by ecoregion. Negative values indicate that one of the components of the metric is negative. This could be due to a reduction in habitat or an increase in flood damages. This occurs in Upper Pontchartrain (UPO) in all the variants shown in Table 6, but the pattern is complex among alternatives and scenarios. In the East/West Chenier Ridges (EWCR) and Calcasieu/Sabine (CAS) ecoregions, the pattern is clearer with more negative results for the draft plan compared to G301 for both scenarios but less negative values for the high scenario compared to the medium. This could reflect less of a difference in habitat between alternatives under the high scenario, when the Chenier Plain is dramatically impacted by sea level rise and salinity incursion, or the efficacy of restoration in marginally reducing surge in an area with no structural protection projects. Positive results in the Lower Terrebonne (LTB) ecoregion occur for both alternatives presented with higher values for the medium scenario for the draft plan, perhaps due to an adjustment in the timing of restoration project implementation producing greater protection or habitat benefits at year 50.

[3]G301 is the Modified Maximize Risk Reduction and Land alternative; see Appendix D for the full list and description of alternatives

Table 6: Results for alternative G301 and the draft master plan for both high and medium scenarios by ecoregion for the Support for Traditional Fishing Communities Metric.

	G301		Draft Plan	
Ecoregion	**High**	**Medium**	**High**	**Medium**
AVT – Lower Atchafalaya/Vermillion/Western Terrebonne	0.04	-0.27	0.18	-0.16
LTB – Lower Terrebonne	0.21	0.11	0.21	0.14
UBA – Upper Barataria	0.18	0.20	0.16	0.13
BFD – Bird's Foot Delta	0.00	0.00	0.00	0.00
UPO – Upper Pontchartrain	-0.09	-0.18	-0.07	-0.14
LPO – Lower Pontchartrain	0.00	0.00	0.00	0.00
MEL – Mermentau Lakes	0.00	0.00	0.00	0.00
LBA – Lower Barataria	0.36	0.01	0.12	0.03
BRT – Breton	-0.15	-0.24	-0.10	-0.09
CAS – Calcasieu/Sabine	-0.03	-0.05	-0.06	-0.07
EWCR – East/West Chenier Ridges	-0.01	-0.05	-0.02	-0.06

5.0 Support for Oil and Gas Activities and Communities

5.1 Overview

The metric is designed to reflect Master Plan Objective #5: "Promote a viable working coast to support regionally and nationally important business and industry." This metric considers 1) damages to commercial, residential, and infrastructure assets within an oil and gas community and 2) land area within a region. High values are achieved when high levels of protection are accompanied by lower rates of land loss.

5.2 Inputs

The calculation first required defining communities and regions and combining model output from both the ICM and CLARA modeling domains. Communities selected through discussion with focus groups and delineated using the procedure outlined in section 1.2 were selected due to their identified association with the oil and gas industry. Regions are areas that include oil and gas communities in close proximity to one another and are associated with similar oil and gas facilities (Table 7). Region boundaries were established in the 2012 Coastal Master Plan (Figure

3), and correspond to subsets of the ecoregions used in the 2017 Coastal Master Plan. The Pontchartrain/Barataria oil and gas region is comprised of the UPO, LPO, BRT, BFD, UBA and LBA ecoregions; the Atchafalaya-Terrebonne oil and gas region is comprised of the LTB and AVT ecoregions, and the Chenier Plain oil and gas region is comprised of the MEL, CAS and EWCR regions. Communities that overlap multiple regions were assigned to the region in which the majority of the community boundary overlapped. Communities that were outside region boundaries were assigned to the nearest region. Within each community, EAD (in dollars) to commercial, residential, and infrastructure assets are summed at initial conditions (year 0), FWOA year 50, and FWA year 50. More specifically, the 50th percentile of EAD for the 1% exceedance probability is used in the EAD calculation. Within each region, land area is summed at initial conditions (year 0), FWOA year 50, and FWA year 50.

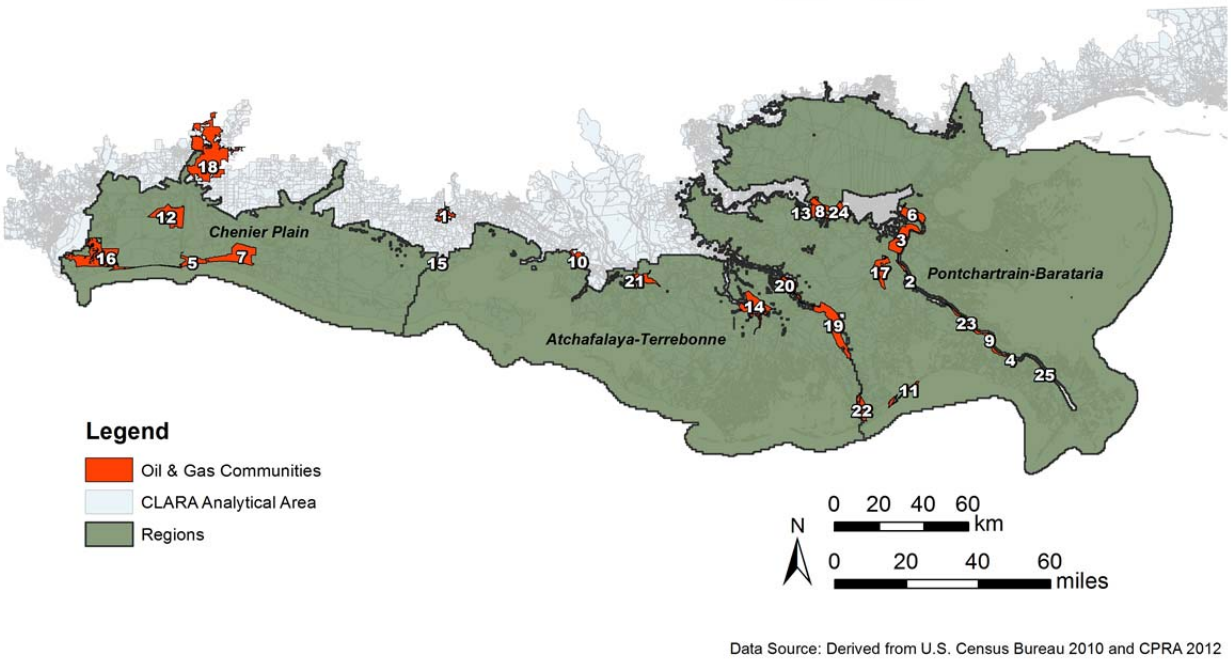


Figure 3: Oil and gas communities and regions. Communities are labeled as numbers which correspond to those listed in Table 7.

Table 7: Communities associated with oil and gas activities and their affiliated region.

Map Label	Community	Region
1	Abbeville	Atchafalaya-Terrebonne
2	Alliance	Pontchartrain-Barataria
3	Belle Chasse	Pontchartrain-Barataria

Map Label	Community	Region
4	Buras	Pontchartrain-Barataria
5	Cameron	Pontchartrain-Barataria
6	Chalmette/Arabi/Meraux	Pontchartrain-Barataria
7	Creole	Chenier Plain
8	Destrehan/New Sarpy/Norco	Pontchartrain-Barataria
9	Empire	Pontchartrain-Barataria
10	Franklin	Atchafalaya-Terrebonne
11	Grand Isle	Pontchartrain-Barataria
12	Hackberry	Chenier Plain
13	Hahnville	Pontchartrain-Barataria
14	Houma	Atchafalaya-Terrebonne
15	Intracoastal City	Atchafalaya-Terrebonne
16	Johnson’s Bayou	Chenier Plain
17	Lafitte/Jean Lafitte/Barataria/Crown Point	Pontchartrain-Barataria
18	Lake Charles/Prien	Chenier Plain
19	Larose/Cut Off/Galliano/Golden Meadow	Atchafalaya-Terrebonne
20	Mathews/Lockport/Lockport Heights	Atchafalaya-Terrebonne
21	Morgan City/Berwick/Siracusaville	Atchafalaya-Terrebonne

Map Label	**Community**	**Region**
22	Port Fourchon	Pontchartrain-Barataria
23	Port Sulphur	Pontchartrain-Barataria
24	St. Rose	Pontchartrain-Barataria
25	Venice	Pontchartrain-Barataria

5.3 Equations

The metric consist of two suitability index values that represent the EAD from storms and the persistence of land to support the oil and gas industry. The metric is calculated under FWOA and FWA at the alternative level.

5.3.1 Landscape Support for Oil and Gas

Step 1

SI_R is a measure of the area of land within a region over the 50-year planning period (19). Calculations are based on 500 m x 500 m grid cells and reflect change in land area. Highest values are attained by retaining the current configuration of land-water (based on the grid cells) assuming that oil and gas facilities have been constructed taking the current landscape into account and, to some extent, are reliant on open water access and sheltering provided by coastal wetlands and barrier islands. Any change in land area (either positive or negative) results in a proportional decrease in the index value. The value is scaled from 0 to 1, with 1 signifying no land change, and 0 signifying 100% land loss or land gain.

FWOA

$$If\ Land_{g,0} \geq Land_{g,FWOA50}, then$$
$$SI_{R,FWOA} = 1 - \frac{Land_{g,0} - Land_{g,FWOA50}}{Land_{g,0}}$$
$$Else\ If\ Land_{g,0} < Land_{g,FWOA50}, then$$
$$SI_{g,FWOA} = \frac{Land_{g,0} - Land_{g,FWOA50}}{Land_{g,0}} + 1$$
$$SI_{R,FWOA} = \sum_{g} SI_{1,g,FWOA}$$

FWA (19)

$$If\ Land_{g,0} \geq Land_{g,FWA50}, then$$
$$SI_{g,FWA} = 1 - \frac{Land_{g,0} - Land_{g,FWA50}}{Land_{g,0}}$$
$$Else\ If\ Land_{g,0} < Land_{g,FWA50}, then$$
$$SI_{g,FWA} = \frac{Land_{g,0} - Land_{g,FWA50}}{Land_{g,0}} + 1$$
$$SI_{R,FWA} = \sum_{g} SI_{1,g,FWA}$$

Where:

R	=	member of a region
g	=	grid cell located within region, R
$Land_{g,0}$	=	land area in grid cell, g, under initial condition
$Land_{g,FWOA50}$	=	land area in grid cell, g, under future without action at year 50
$Land_{g,FWA50}$	=	land area in grid cell, g, under future with action at year 50

Step 2

$Land_{C}$, is a comparison between land change within a community's resource region, *R*, over FWOA and the change within the region over FWA. For each region, *R*, the index value representing change in land area under FWOA, $SI_{R,FWOA}$, is combined with the change in land area under FWA, $SI_{R,FWA}$, such that it ranges from 0 to 1, with smaller values signifying a FWA with greater land change (either loss or gain) than FWOA (20).

$$\boldsymbol{Land_c = 1 - \frac{SI_{R,FWOA}}{SI_{R,FWA}}} \quad (20)$$

Where:

c	=	community
R	=	oil and gas region for community

5.3.2 Expected Annual Damages from Storms

E_c is a comparison between the change in EAD within a community under FWOA and under FWA (21).

$$\boldsymbol{E_c = 1 - \frac{EAD_{FWA50,c} - EAD_0}{EAD_{FWOA50,c} - EAD_0}} \quad (21)$$

Where:

c	=	community within a region
EAD_0	=	expected annual damages under initial conditions at year 0
EAD_{FWOA50}	=	expected annual damages under future without action at year 50
EAD_{FWA50}	=	expected annual damages under future with action at year 50

To remain consistent with the planning level analysis of EAD conducted with CLARA, relatively minor differences between FWOA and FWA EAD at year 50 were not included in this analysis. To remain consistent with model uncertainties and confidences developed by the CLARA analysis, any differences less than $1,000,000 indicated an indistinguishable difference between FWOA and FWA year 50 EAD.

5.3.3 Metric Value

The final value for Support for Oil and Gas Activities and Communities, SOG, is calculated as the geometric mean of $Land_C$ and E_c (22). This is calculated for each community. If either or both of the individual components, $Land_c$ and E_c, are negative the entire metric will be set to negative. A negative metric value will represent either an increase in expected annual damage, a decrease in land area within the oil and gas resource region, or both. A positive metric will be realized only if the land area with the resource region increases from FWOA and flood damages are reduced under FWA.

$$SOG_c = \sqrt[2]{Land_c * E_c} \quad (22)$$

If E_c was determined to be insignicant (based on the description above), the metric value, SOG_c, was set equal to $Land_c$.

5.4 Output

The metric values are averaged across each ecoregion and single value is used for each ecoregion in the Planning Tool to compare alternatives. FWOA and FWA values can also be reported for each region to understand the interactive effects of land change and community flood risk across the coast. Individual community level values for each metric component for both FWOA and FWA can also be provided to enable a greater understanding of where the changes are occurring and how the changes are distributed among oil and gas communities.

5.5 Example Results

Table 8 shows example results for G301 and the draft master plan for both high and medium scenarios. Values are mostly positive, demonstrating that compared to FWOA there is both more land being sustained and less risk to oil and gas communities with each of the alternatives. One exception is the Bird's Foot Delta (BFD) ecoregion where no change reflects the lack of restoration efforts in that region and the lack of oil and gas communities. The lack of communities in the Lower Pontchartrain (LPO) ecoregion also makes the metric zero across scenarios and alternatives. In some ecoregions, the pattern is complex. For example, in the Upper Pontchartrain (UPO) ecoregion, the draft plan has higher values for the medium scenario compared to G301, but lower values for the high scenario. This likely reflects the different projects included in G301 versus the draft plan and the complex way in which land loss and land sustaining and building projects influence the land loss patterns. The Union Diversion, for example, is included in the draft plan but not in G301, and it has a much greater effect in UPO under the high scenario when there is substantial land loss under FWOA.

Table 8: Results for alternative G301 and the draft master plan for both high and medium scenarios by ecoregion for the Support for Oil and Gas Communities Metric.

	G301		**Draft Plan**	
Ecoregion	High	Medium	High	Medium
AVT	**0.27**	**0.26**	**0.28**	**0.27**
LTB	**0.26**	**0.25**	**0.27**	**0.26**
UBA	**0.38**	**0.27**	**0.39**	**0.26**
BFD	**0.00**	**0.00**	**0.00**	**0.00**
UPO	**0.25**	**0.07**	**0.27**	**0.07**
LPO	**0.00**	**0.00**	**0.00**	**0.00**

	G301		**Draft Plan**	
Ecoregion	High	Medium	High	Medium
MEL	**0.08**	**0.07**	**0.09**	**0.07**
LBA	**0.08**	**0.09**	**0.09**	**0.09**
BRT	**-0.19**	**-0.29**	**-0.35**	**-0.12**
CAS	**0.08**	**0.09**	**0.12**	**0.12**
EWCR	**0.06**	**0.07**	**0.12**	**0.08**

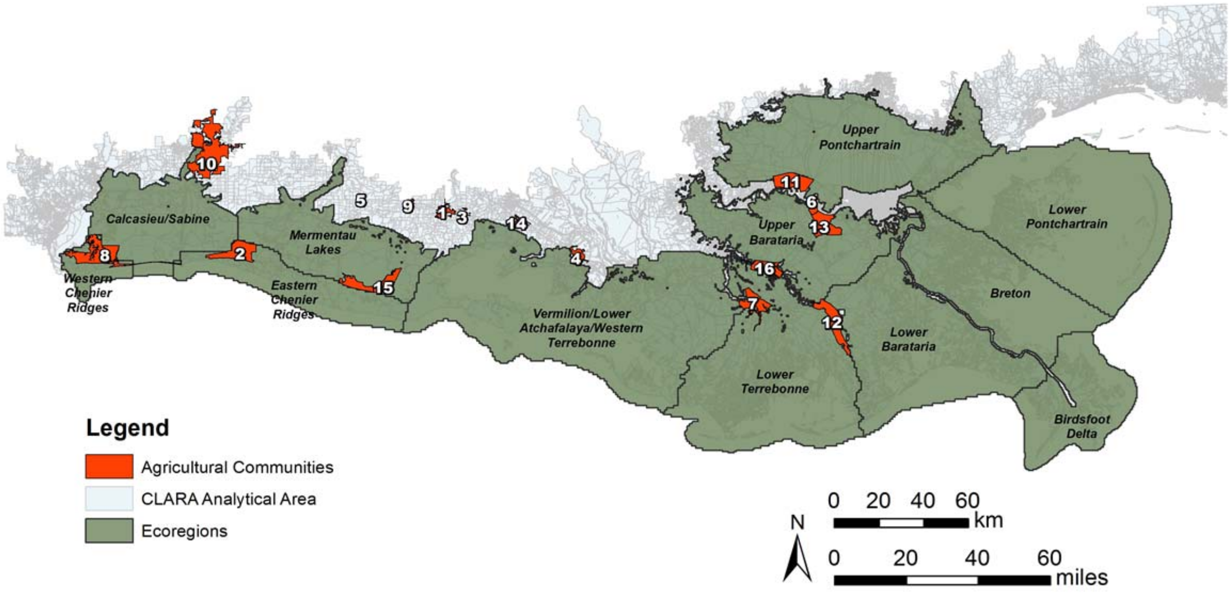
6.0 Support for Agricultural Communities

6.1 Overview

The metric is designed to reflect Master Plan Objective #5: "Promote a viable working coast to support regionally and nationally important business and industry." This metric considers 1) damages to commercial, residential, and infrastructure assets within agricultural communities and 2) potential for continued agricultural practice. High values are achieved when high levels of protection are accompanied by reduced flooding/appropriate salinities in current agricultural areas.

6.2 Inputs

Calculation of this metric requires defining agricultural communities and combining model output from both the ICM and CLARA modeling domains. Community boundaries are identified using the approach described in Section 1.2 above and assigned to an ecoregion (Figure 4 and Table 9). Communities that overlap multiple ecoregions are assigned to the ecoregion in which the majority of the community boundary overlapped. Communities that are outside ecoregion boundaries are assigned to the nearest ecoregion. Within each identified agricultural community, EAD (in dollars) to commercial, residential, and infrastructure assets are calculated at initial conditions (year 0), FWOA year 50, and FWA year 50. More specifically, the 50th percentile of EAD for the 1% exceedance probability is used in the EAD calculation. Current agricultural practice was obtained from the 2014 U.S. Department of Agriculture (USDA) cropland data layer. These data are in 30 m raster format and are derived from satellite imagery. USDA did test the accuracy of these data. However, USDA uses the USGS National Land Cover Database Land Use Cover (LULC) dataset to identify the non-agricultural land, including pasture, and did not verify the accuracy of these data. Dominant agricultural practice (e.g., soybeans, rice, sugarcane, and pasture) was assigned to the 500 m x 500 m grid associated with the hydrodynamic modeling domain within the ICM. Maximum 2-week averaged salinity from the ICM at 500 m grid resolution, the extent of which matches the hydrodynamic compartment boundaries extent, is also required for the calculation of the metric.



Data Source: Derived from U.S. Census Bureau 2010 and CPRA 2012

Figure 4: Agricultural communities and ecoregions. Communities are labeled as numbers which correspond to those listed in Table **9**9.

Table 9: Communities associated with agricultural activities and their affiliated ecoregion.

Map Label	**Community**	**Ecoregion**
1	Abbeville	Lower Atchafalaya/Vermilion/ Western Terrebonne
2	Creole	Eastern Chenier Ridges
3	Erath	Lower Atchafalaya/Vermilion/ Western Terrebonne
4	Franklin	Lower Atchafalaya/Vermilion/ Western Terrebonne
5	Gueydan	Mermentau Lakes
6	Hahnville	Upper Barataria
7	Houma	Lower Terrebonne
8	Johnson's Bayou	Calcasieu/Sabine
9	Kaplan	Mermentau Lakes
10	Lake Charles/Prien	Calcasieu/Sabine
11	Laplace/Reserve	Upper Pontchartrain

Map Label	Community	Ecoregion
12	Larose/Cut Off/Galliano/Golden Meadow	Lower Terrebonne
13	Luling/Boutte	Upper Barataria
14	Lydia	Lower Atchafalaya/Vermilion/ Western Terrebonne
15	Pecan Island	Mermentau Lakes
16	Raceland	Lower Terrebonne

6.3 Equations

The metric consists of two suitability index values that represent the EAD from storms and the effect of salinity on agricultural suitability. The metric is calculated under FWOA and FWA at the alternative level.

6.3.1 Expected Annual Damages from Storms

E_c is a comparison between the change in EAD within a community under FWOA and under FWA (23).

$$\boldsymbol{E_c = 1 - \frac{EAD_{FWA50,c} - EAD_0}{EAD_{FWOA50,c} - EAD_0}} \qquad (23)$$

Where:

c	=	community within a region
EAD_0	=	expected annual damages under initial conditions at year 0
EAD_{FWOA50}	=	expected annual damages under future without action at year 50
EAD_{FWA50}	=	expected annual damages under future with action at year 50

To remain consistent with the planning level analysis of EAD conducted with CLARA, relatively minor differences between FWOA and FWA EAD at year 50 were not included in this analysis. To remain consistent with model uncertainties and confidences developed by the CLARA analysis, any differences less than $1,000,000 indicated an indistinguishable difference between FWOA and FWA year 50 EAD.

6.3.2 Effect of Salinity

Step 1

Saline water can negatively impact crops depending on the physiological condition of the plant, soil properties, growth stage, and rooting habits. Salinity thresholds were established based on Louisiana State University Agricultural Center studies of crop productivity and the Food and Agricultural Organization of the United Nations review on crop tolerances. Based on the agricultural practice in each 500 m grid cell, the salinity thresholds shown in Table 10 are used to calculate the salinity index, SI_2, scaled 0 to 1 for the metric (24).

Table 10: Salinity thresholds for crops.

	Salinity Thresholds (ppt)		**Salinity Tolerance**
	Max	Min	
Rice	3	0.5	Sensitive
Sugarcane	3	1	Moderately Sensitive
Soybeans	3	1.5	Moderately Tolerant
Pasture[4]	6	1.5	Tolerant

Cells which are not dominated by one of these agricultural types at the initial conditions are not assigned a value. Agriculture within a cell does not change over time.

FWOA

$$If\ Sal_{g,FWOA} < Min_{Sal}, Then\ SI_{2,g,FWOA} = 1$$
$$If\ Sal_{g,FWOA} > Max_{Sal}, Then\ SI_{2,g,FWOA} = 0$$
$$Else\ SI_{2,g,FWOA} = 1 - \frac{Sal_{g,FWOA} - Min_{Sal}}{Max_{Sal} - Min_{Sal}}$$

FWA (24)

$$If\ Sal_{g,FWA} < Min_{Sal}, Then\ SI_{2,g,FWA} = 1$$
$$If\ Sal_{g,FWA} > Max_{Sal}, Then\ SI_{2,g,FWA} = 0$$
$$Else\ SI_{2,g,FWA} = 1 - \frac{Sal_{g,FWA} - Min_{Sal}}{Max_{Sal} - Min_{Sal}}$$

Where:

g	=	grid cell defined by agricultural type
$Sal_{g,FWOA50}$	=	maximum two-week averaged salinity under future without action at year 50
$Sal_{g,FWA50}$	=	maximum two-week averaged salinity under future with action at year 50
Min_{sal}	=	minimum salinity threshold for crop
Max_{sal}	=	maximum salinity threshold for crop

Step 2

The salinity index values for both FWOA and FWA are then averaged to the ecoregion scale, E, and combined such that it ranges from -1 to 1 (25).

[4] Based on Bermuda grass tolerances.

$$Ag_c = 1 - \frac{\frac{\sum_g SI_{2,g,FWOA}}{n}}{\frac{\sum_g SI_{2,g,FWA}}{n}} \quad (25)$$

Where:

n	=	count of all grid cells, g, within ecoregion dominated by one of the agricultural types

6.3.3 Metric Value

The metric value is calculated as the geometric mean of Ag_C and E_C for a community (26). However, if either or both of the individual components, Ag_c and E_c, are negative the entire metric will be set to negative. A negative metric value will represent either an increase in expected annual damage, a decrease in agricultural suitability, or both. A positive metric will be realized only if the agricultural suitability is improved and flood damages are reduced under FWA.

$$SAG_c = \sqrt[2]{Ag_c * E_C} \quad (26)$$

If E_c was determined to be insignicant (based on the description above), the metric value, SAG_c, was set equal to Ag_c.

6.4 Output

The metric values are averaged across each ecoregion and single value is used for each ecoregion in the Planning Tool to compare alternatives. FWOA and FWA values can also be reported for each ecoregion to understand the interactive effects of salinity change and community flood risk across the coast and how these changes are distributed among agricultural communities.

6.5 Example Results

As shown in Figure 4, several ecoregions do not include agricultural communities. In addition, to achieve a high score for this metric requires that an alternative must attain high levels of protection accompanied by reduced flooding/appropriate salinities in current agricultural areas. In general, values for the metric are higher for the draft master plan than for alternative G301, except UBA where values remain unchanged for the medium scenario and have a slight decrease for the high scenario. This is the result of a slightly larger decrease from Year 50 FWOA EAD under alternative G301 than under the draft plan for the two agricultural communities of Hahnville and Lulling/Boutte. This difference in EAD reduction at year 50 is likely due to the inclusion of the Lafitte Ring Levee in alternative G301 as well as an earlier implementation of the Greater New Orleans High Level system in alternative G301. Table 11 shows negative values for the AVT ecoregion for the medium scenario under both alternatives shown. There are several agricultural communities in this region (Table 4), and these values may reflect a slight increase in risk in these communities under the medium scenario when induced flooding from structural protection projects affects some communities.

Table 11: Results for alternative G301 and the draft master plan for both high and medium scenarios by ecoregion for the Support for Agricultural Communities Metric.

	G301		Draft Plan	
Ecoregion	**High**	**Medium**	**High**	**Medium**
AVT	0.00	-0.24	0.00	-0.13
LTB	0.51	0.82	0.54	0.84
UBA	0.96	1.0	0.95	1.0
BFD	0.00	0.00	0.00	0.00
UPO	0.00	0.00	0.00	0.00
LPO	0.00	0.00	0.00	0.00
MEL	0.00	0.05	0.00	0.22
LBA	0.00	0.00	0.00	0.00
BRT	0.00	0.00	0.00	0.00
CAS	0.00	0.00	0.00	0.00
EWCR	0.00	0.00	0.00	0.00

7.0 Use of Natural Processes

7.1 Overview

The purpose of this metric is to reflect Master Plan Objective #2: "Promote a sustainable coastal ecosystem by harnessing the processes of the natural system." The approach evaluates three characteristics based on project types:

- Degree to which a project type establishes natural process connections within the coast;
- Use of sediment from outside the coastal system; and
- Degree to which a project impedes existing natural process connections (i.e., plugs or structures in natural waterways or wetlands).

The scoring is calculated based on project types and accounts for 1) the effect of levees or gated structures on natural waterways that are closed periodically, 2) the effect of replicating natural patterns of estuarine exchange, 3) the magnitude of sediment input as a result of restoration using an external source, and 4) the magnitude of sediment input as a result of a river diversion. These are assessed based on modifications to the ICM compartments to track relative changes in hydrology and sediment introduction among projects.

7.2 Inputs

Calculation of the metric requires several ICM outputs and project attributes depending on the project type. Links in the ICM control hydrologic exchanges among the compartments (see Attachment C3-22 for more information on the ICM). For hydrologic restoration and ridge restoration projects, these links are adjusted from their FWOA values at the year the project is initiated during the 50-year simulation. The cross sectional area of these links is calculated at year 0 (initial condition) and at project initiation. For marsh creation and barrier shoreline projects that rely on external borrow sources, the magnitude of sediment used for projects is calculated at project initiation. This is determined by project attributes and the nature of the landscape (e.g., water depth) at the time of project initiation. Structural protection projects are valued based on the project's anticipated change in current estuarine hydrologic exchange as indicated by gates and structures across natural waterways. For river diversions, the magnitude of sediment loading at the end of the 50 year simulation is calculated. As in the 2012 Coastal Master Plan, projects that do not include characteristics that influence any of these mechanisms (e.g., marsh creation projects with estuary borrow sources, nonstructural projects, etc.) will receive a value of "0", indicating that their effect on this metric is neutral.

7.3 Equations

7.3.1 Effect on Hydrology from Structural Protection Projects

Following the approach used in 2012, structural protection projects are assigned a value, *SP*, based on their impact to waterways or sheetflow or whether they limit exchange (Table 12). The relative size of the impact to natural processes is scaled from 0 to -1. Levees that permanently block waterways or sheetflow are valued based on the scale of the project effect. If most of the levee is constructed on existing hydrologic barriers, then the project is evaluated for the number and size of gates. Gates that close periodically are valued based on the number and size of gates that would be close periodically. A project is considered to have no effect on natural processes if it is constructed on uplands or ridges with no impact to natural points of exchange with coastal region. This also includes projects with levees and/or gates constructed on an existing footprint. A value of -1 is assigned where a project permanently blocks key natural process exchange points.

Table 12: Structural protection projects values, *SP*, to reflect their effect on hydrology.

Project	SP Value
Abbeville and Vicinity	-0.2
Amelia Levee Improvements (3E)	-0.2
Bayou Chene Floodgate	-0.2
Donaldsonville to the Gulf	-0.6
Fort Jackson to Venice	0
Franklin and Vicinity	0
Greater New Orleans High Level	0
Greater New Orleans LaPlace Extension	-0.8
Iberia/St Mary Upland	-0.2
Lafitte Ring Levee	-0.2
Lake Pontchartrain Barrier (Low)	-0.6
Larose to Golden Meadow-basic	0
Larose to Golden Meadow-enhanced	0
Morgan City Back Levee	-0.2
Morganza to the Gulf	-1
Oakville to LaReusite	0
Slidell Ring Levee	0
St. Jude to City Price	0

7.3.2 Effect on Hydrology from Hydrologic Restoration and Ridge Restoration Projects

The change in hydrologic exchange associated with hydrologic restoration and ridge restoration projects' link modifications are used to reflect the effect of a project on hydrology. For each project, the magnitude of change in cross sectional flow area in links is calculated from the link cross sectional area at project initiation, A_i, and the cross sectional area of the link at year 0, A_0. The magnitude of change for a given project is scaled from 0 to 1, relative to the maximum cross sectional adjustment across all projects, $Max_{|A0-AI|}$ (27).

$$\boldsymbol{H} = \frac{|\boldsymbol{A_i} - \boldsymbol{A_0}|}{\boldsymbol{Max}_{|\boldsymbol{A_i}-\boldsymbol{A_0}|}} \tag{27}$$

Where:

A_i	=	cross sectional area of adjusted links at project initiation
A_0	=	cross sectional area in adjusted links at year 0
$Max_{\|Ai-A0\|}$	=	maximum of cross sectional area changes across all projects

7.3.3 Magnitude of Sediment Input from Marsh Creation and Barrier Shoreline Projects

For each marsh creation and barrier shoreline project that uses an external borrow source, the magnitude of sediment used for the project is calculated. The magnitude of the input is then scaled relative to the maximum introduction of sediment for any marsh creation and barrier shoreline project using an external source. Following the approach used in 2012, the largest introduction is valued at 0.4 and the smallest is 0.1(28).

$$\boldsymbol{M} = \frac{\boldsymbol{0.3} * (\boldsymbol{S} - \boldsymbol{Min_S})}{(\boldsymbol{Max_S}) - (\boldsymbol{Min_S})} + \boldsymbol{0.1} \tag{28}$$

Where:

S	=	magnitude of sediment input
Min_S	=	minimum introduction of sediment
Max_S	=	maximum introduction of sediment

7.3.4 Magnitude of Sediment Load from Diversion Projects

For each diversion project, the cumulative sediment load is calculated over the entire simulation period. The magnitude of the load is then scaled relative to the maximum load of sediment of any of the diversion projects. Consistent with the approach to scoring diversions used in the 2012 Coastal Master Plan, the largest sediment load is valued at 1 and the smallest is 0.4 (29).

$$D = \frac{\mathbf{0.6} * (\boldsymbol{S} - \boldsymbol{Min_S})}{(\boldsymbol{Max_S}) - (\boldsymbol{Min_S})} + \mathbf{0.4} \tag{29}$$

Where:

S = cumulative sediment load over simulation period for a diversion project

Min_S = minimum total sediment load over simulation period of all diversion projects

Max_S = maximum total sediment load over simulation period of all diversion projects

7.3.5 Metric Value

7.3.5.1 Project Effects

The following equations are used to calculate a total value for each project's effect on the coast wide scale, depending in the project type (30).

$$Nat_S = SP \tag{30}$$

$$Nat_H = H$$

$$Nat_M = M$$

$$Nat_D = D$$

Where:

Nav_S = structural protection projects

Nav_H = hydrologic restoration and ridge restoration projects

Nav_M = marsh creation and barrier shoreline projects

Nav_D = Mississippi River diversion projects

7.3.5.2 Alternatives

To assess the sustainability of alternatives, individual projects are calculated in the same manner as for project effects and the arithmetic mean of all projects within the alternative is used to generate the metric value (31). Variables should only be included in the equation below if the alternative includes a project that may result in a meaningful effect on the variable. Otherwise, the variable should be removed and the denominator adjusted to reflect the number of variables in the numerator. Thus, the equation shown below is an example which would be adjusted based on the alternatives considered.

$$\boldsymbol{Nat_{ALT}} = \frac{\sum \boldsymbol{S} + \sum \boldsymbol{H} + \sum \boldsymbol{M} + \sum \boldsymbol{D}}{\boldsymbol{n}} \tag{31}$$

Where:

Nat_{ALT} = all projects implemented in an alternative

n = number of projects implemented in an alternative

7.4 Output

A single value for each project can be used in the Planning Tool for alternative formulation (i.e., only include projects which have a natural process value of greater than a certain value). Values for each project illustrate the general effects of the project on natural processes. The ICM results provide further detail on the landscape and ecosystem outcomes of the natural process influences of the project.

7.5 Example Results

Table 13: Average values by project type for the Use of Natural Processes Metric.Table 13 includes average values for each master plan project type for the Use of Natural Processes metric. This metric is based on the characteristics of the projects rather than the nature of the landscape following project implementation, thus there is no difference among environmental scenarios. The most negative score for any project type is hurricane protection projects, which in some cases block natural process flows with gates. The highest average score is for sediment diversions which are focused on mimicking natural process exchanges between the rivers and the estuary.

Table 13: Average values by project type for the Use of Natural Processes Metric.

Project Type	All environmental scenarios
BH	0.283
BS	0
DI	0.438
HP	-0.247
HR	0.159
MC	0.149
OR	0
RC	0.106
SP	0

Inspection of project level metric values (Attachment C4-11.1) indicates that Mid-Barataria Diversion (002.DI.03a), which has a capacity of 7079 cms, has the highest value (most positive) for the Use of Natural Processes metric under the high environmental scenario and Morganza to the Gulf (03a.HP.02b), which includes a number of gates across natural channels, has the lowest value.

For comparison, the value for Use of Natural Processes for the Draft Plan is 0.19 for the medium Scenario and 0.2 for the high scenario.

8.0 Flood Protection of Historic Properties

8.1 Overview

This metric is designed to reflect Master Plan Objective #4: "Sustain, to the extent practicable, the unique cultural heritage of coastal Louisiana, by protecting historic properties and traditional living cultures and their ties and relationships to the natural environment." It considers the potential benefit that flood risk reduction projects would provide by improving protection for archaeological sites and historic properties, historic sites, and historic districts across coastal Louisiana.

8.2 Inputs

This criterion uses data collected by the Louisiana State Historic Preservation Office (SHPO) regarding locations and properties of historical significance. Datasets are clipped to the CLARA study region, and relevant locations and properties are associated with the nearest CLARA grid point for flood depth comparisons.

The new inventory adapted from the state dataset for the 2017 Coastal Master Plan includes 3,489 relevant archaeological sites identified by SHPO for this analysis. It also includes data from the National Register of Historic Places describing 366 National Register Listings (historic buildings) in the study area. Finally, a separate survey of buildings in Orleans Parish assembled for the Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program was incorporated. This survey includes all buildings mapped within National Register Historic Districts in Orleans Parish, and includes 41,076 total structures. All buildings identified by the Orleans Parish survey within the Historic District are assumed to be historic buildings for the purposes of this analysis.

This metric utilizes flood depth at the median 50-year (2%) annual exceedance probability interval for each of the archaeological sites and historic buildings included. Flood depths for each asset are calculated at the CLARA grid point nearest to the asset.

8.3 Equations

To estimate this metric, the algorithm sums the total number of archaeological sites and historic buildings that are inundated by at least 30 cm (1 ft) of flood depth at the 50-year flood event in each risk region and estimates a proportion flooded for each risk region (32).

(32)

FWOA

$$HF_{r,FWOA} = \frac{\sum_g HIS_{r,g,FWOA,F=1} - \sum_g HIS_{r,g,FWOA,F=0}}{\sum_g HIS_{r,g,FWOA}}$$

FWA

$$HF_{r,FWA} = \frac{\sum_g HIS_{r,g,FWA,F=1} - \sum_g HIS_{r,g,FWA,F=0}}{\sum_g HIS_{r,g,FWA}}$$

Where:

HF_r	=	proportion of historical properties plus archaeological sites flooded to at least 30 cm of flood depth in risk region, r
$HIS_{r,g}$	=	number of historical properties plus archaeological sites in CLARA grid point g
F	=	binary indicator indicating flood depths of at least 30 cm ($F = 1$ indicates $\geq$ 30 cm flood depth)

The change in proportion from FWOA to FWA is used to represent the net benefit in each region.

8.4 Output

An archaeological site or historic building is considered to be protected by a project or alternative if it would have flooded to a depth of greater than 30 cm under FWOA conditions but does not flood to a depth of greater than 30 cm when the project or alternative is implemented. Outputs are the sum and proportion of total archaeological sites and historic buildings flooded by risk region, with the benefit represented by the reduction in this proportion.

8.5 Example Results

Table 14 shows example results for two structural protection projects, including the risk regions where the benefits are located, and for the draft plan. This shows that Morganza to the Gulf (03a.HP.02b) provides protection for 65% of national register listed historic properties in the four risk regions listed for the high scenario (Table 14 A). The percentage is approximately the same for the medium scenario, but only 11 listings are flooded in FWOA and the effects are limited to the Terrebonne and Lafourche risk regions shown in Table 14 B. Under the high scenario, FWOA flooding, and the protective effect of the project, is greater. For historic districts, one district is flooded under the high scenario, but there is no flooding under the medium scenario. For archaeological sites for the high scenario, 16% are protected. The number of archaeological sites flooded in the medium scenario increases under FWOA and the Morganza project only protects 8% of the sites with many of those still flooded being in the TER.01R risk region.

In contrast, the West Shore Lake Pontchartrain (001.HP.05) project affects a smaller number of both national listed sites and archaeological sites under the high scenario, but the proportion protected is higher (Table 14 A). For the medium scenario, the effect on national listed sites is the same, and 64% of the exposed archaeological sites are protected. There is no effect on historic districts in either scenario.

Overall, the draft master plan provides protecion for 39% of national listed sites, 6.2% of archaeological sites and 50% of the historic districts under the high scenario (Table 14 A). This decreases to 33% of historic sites for the medium scenario, but the number of listed sites flooded under FWOA is reduced to 49. The proportion of archaeological sites protected by the draft plan for the medium scenrio is also 6.2%. Under the medium scenio one histroic distric is subject to induced flooding.

Table 14: Proportional change in flooding for national register listings, archaeological sites and historic districts for the high scenario (A) and the medium scenario (B) for two example structural protection projects and the draft master plan.

A

Historic Properties **High Scenario** **Year 50**	**National Register Listings** **number subject to flooding**			**Archaeological Sites** **number subject to flooding**			**Historic Districts** **number subject to flooding**		
	FWOA	**FWA**	**Percent Benefited**	**FWOA**	**FWA**	**Percent Benefited**	**FWOA**	**FWA**	**Percent Benefited**
Morganza to the Gulf (03a.HP.02b)	20	7	65%	379	317	16%	1	0	100%
Affected Risk Regions	LAF.03R TER.02R STM.05R STM.01R			LAF.03R ASU.01R TER.02R			TER.02R		
West Shore Lake Pontchartrain (001.HP.05)	1	0	100%	37	27	27%	0	0	N/A
Affected Risk Regions	SJB.01R			ASC.02R SJB.02R SJB.01R					
Draft Master Plan	64	39	39%	2073	1944	6.2%	2	1	50%

B

Historic Properties **High Scenario** **Year 50**	**National Register Listings** **# subject to flooding**			**Archaeological Sites** **# subject to flooding**			**Historic Districts** **# subject to flooding**		
	FWOA	**FWA**	**Percent Benefited**	**FWOA**	**FWA**	**Percent Benefited**	**FWOA**	**FWA**	**Percent Benefited**
Morganza to the Gulf (03a.HP.02b)	11	4	64%	547	503	8%	0	0	N/A
Affected Risk Regions	TER.02R			TER.02R					
	LAF.03R			LAF.03R					
				ASU.01R					
				SMT.01R					
				TER.01R					
West Shore Lake Pontchartrain (001.HP.05)	1	0	100%	14	5	64%	0	0	N/A
Affected Risk Regions	SJB.01R			SJB.02R					
				SJB.01R					
Draft Master Plan	49	33	33%	1958	1836	6.2%	0	1	Increased flooding

9.0 Flood Protection of Strategic Assets

9.1 Overview

This metric is designed to reflect Master Plan Objective #1: "Reduce economic losses from storm surge based flooding to residential, public, industrial, and commercial infrastructure" and Master Plan Objective #5: "Promote a viable working coast to support regionally and nationally important business and industry." Strategic assets include transportation assets (ports and airports), oil and gas storage and processing facilities, power plants and power substations, military bases, and key manufacturing facilities. This metric is intended to augment the economic damage analysis by summarizing the proportion of these strategic assets protected by a project or alternative in each risk region. A simplified approach that classifies facilities as either flooded or not flooded is applied, because, with few exceptions, asset values and relationships between flood depth and damage (depth-damage curves) are not available to support damage estimation for these asset types. Critical facilities may also have site-specific hardening measures that reduce their vulnerability to given flood levels.

9.2 Inputs

This metric utilizes flood depth at the median 50-year annual exceedance probability interval for each of the 833 strategic assets. Flood depths for each asset are calculated at the CLARA grid point nearest to the asset.

A new inventory of strategic assets was developed for the 2017 Coastal Master Plan, including asset classes not previously considered. Newly-available datasets from the Homeland Security Infrastructure Program (HSIP) Gold database (HSIP, 2014) were utilized to incorporate electric power plants, power substations, oil refineries, petroleum pumping stations, ports, and water and wastewater facilities into the inventory of assets. The strategic assets inventory was augmented by an inventory strategic assets identified by the State of Louisiana in late 2014. Strategic assets identified by state agencies include the following categories: airports, gas processing, government/military, liquid natural gas (LNG), manufacturing/chemical, ports, power plants, oil refineries, the Louisiana Offshore Oil Port (LOOP), and the strategic petroleum reserve. The HSIP Gold dataset was merged with the Louisiana strategic assets list and duplicates were identified and removed, creating a single set to support this metric. For selected categories, however, only assets from the state's list were retained. In particular, there are a large number of manufacturing/chemical facilities in the HSIP Gold dataset that appeared largely duplicative with CLARA's existing commercial and industrial assets data; so for this category only, the Louisiana-provided inventory was included. A summary of strategic assets considered is shown in Table 14.

Table 14: Count of strategic assets in study area.

Strategic Asset Class[5]	Count
Airport/Heliport	191
Electric Power Plant	90
Electric Substation	295
Gas Processing	82
Government/Military	5
Liquid Natural Gas	3
Louisiana Offshore Oil Port (LOOP)	2
Manufacturing/Chemical	54
Nuclear Power Plant	1
Petroleum Pump Station	40
Port	11
Refinery	21
Strategic Petroleum Reserve	1
Wastewater	32
Water Supply	5
Total	833

9.3 Equations

To estimate this metric, the algorithm sums the total number strategic assets that are inundated by at least 30 cm of flood depth of the 50-year flood event in each risk region. Individual hardening measures are not taken into account in these calculations for individual strategic assets due to lack of available data (33).

[5] Additional government, military, manufacturing, and chemical structures are included in the damage calculation as part of the "public" and "industrial" asset classes, respectively.

FWOA

$$SAF_{r,FWOA} = \frac{\sum_g SA_{r,g,FWOA,F=1} - \sum_g SA_{r,g,FWOA,F=0}}{\sum_g SA_{r,g,FWOA}}$$

FWA

$$SAF_{r,FWA} = \frac{\sum_g SA_{r,g,FWA,F=1} - \sum_g SA_{r,g,FWA,F=0}}{\sum_g SA_{r,g,FWA}} \qquad (33)$$

Where:

SAF_r	=	proportion of total strategic assets flooded to at least 30 cm of flood depth in risk region, *r*
$SA_{r,g}$	=	number of strategic assets in CLARA grid point *g*
F	=	binary indicator indicating flood depths of at least 30 cm (F = 1 indicates ≥ 30 cm flood depth)

The change in proportion from FWOA to FWA is used to represent the net benefit in each region.

9.4 Output

An asset is considered to be protected by a project or alternative if it would have flooded to a depth of greater than 30 cm under FWOA conditions but does not flood to a depth of greater than 30 cm when the project or alternative is implemented. Outputs include the sum and proportion of total strategic assets protected or unprotected by risk region. Results can also be provided by specific strategic asset class in the event that metrics are established for different sectors.

9.5 Example Results

To illustrate the effects of projects and alternatives on strategic assets, Table 15 shows results for two example projects and the draft plan for the high and mediujm scenarios for three individual classes of assets: airports, gas processing plants, and manufacturing/chemical plants, as well as the total assets protected. The projects shown are the same as those described for their effects in historic and archaeological sites above.

The results for any given project are dependent on the geographic distriubution of the assets. For example, there are no gas processing or manufacturing/chemical plants flooded within the area affected by the West Shore Lake Pontchartrain project under the high scenario.

Table 15: Proportional change in flooding for select classes of strategic assets and total assets for the high scenario (A) and the medium scenario (B) for two example structural protection projects and the draft plan.

A

High Scenario **Year 50**	**Airports** **# subject to flooding**			**Gas Processing** **# subject to flooding**			**Manufacturing/Chemical** **# subject to flooding**			**All Assets** **# subject to flooding**		
	FWOA	FWA	Percent Benefited	FWOA	FW A	Percent Benefited	FWOA	FWA	Percent Benefited	FWOA	FWA	Percent Benefited
Morganza to the Gulf (03a.HP.02b)	13	10	23%	12	10	17%	3	2	33%	33	26	21%
Affected Risk Regions	LAF.03R TER.02R			ASU.01R TER.02R			LAF.03R					
West Shore Lake Pontchartrain (001.HP.05)	1	0	100	0			0			7	0	100%
Affected Risk Regions	SJB.01R											
Draft Master Plan	111	84	24%	67	50	25%	18	10	44%	372	276	26%

B

High Scenario **Year 50**	**Airports** **# subject to flooding**			**Gas Processing** **# subject to flooding**			**Manufacturing/Chemical** **# subject to flooding**			**All Assets** **# subject to flooding**		
	FWOA	FWA	Percent Benefited	FWOA	FWA	Percent Benefited	FWOA	FWA	Percent Benefited	FWOA	FWA	Percent Benefited
Morganza to the Gulf (03a.HP.02b)	10	1	90%	9	8	11%	3	2	33%	27	12	55%
Affected Risk Regions	LAF.03R TER.02R			TER.02R			LAF.03R					
West Shore Lake Pontchartrain (001.HP.05)	1	0	100%	0	0	N/A	0	0	N/A	5	0	100%
Affected Risk Regions	SJB.01R											
Draft Master Plan	94	70	26%	64	47	26%	18	9	50%	312	226	28%

10.0 Social Vulnerability Index

10.1 Overview

Social impacts of hazard exposure often fall disproportionately on the most vulnerable populations, including low income, minority, children, the elderly, and the disabled. In broad terms, social vulnerability refers to the inherent characteristics of a person or group that influences their capacity to anticipate, cope with, resist, or recover from the impact of a hazard (Wisner et al., 2004). One method for identifying the locations of these populations is the Social Vulnerability Index (SVI) approach, a statistical modeling approach that utilizes indicator variables to quantify relative levels of social vulnerability across space (Cutter et al., 2003). The SVI approach enables relative vulnerability comparisons between communities and between geographical regions, which can aid in evaluating the susceptibility of communities to future hazardous threats. An enhanced understanding of the factors that determine vulnerability will also aid in identifying actions to reduce vulnerability (Adger et al., 2004).

This research utilized an SVI approach to examine the underlying socioeconomic, institutional, political, and cultural factors that determine how people within coastal Louisiana respond to a wide range of existing or hypothetical hazards events (Adger et al., 2004). Details on the SVI can be found in Attachment C4-11.2 - SVI. In brief, a SVI was developed and used to generate a value of relative vulnerability for populated census block groups across the coast. Principal Components Analysis (PCA) was used to statistically combine 37 highly correlated socioeconomic variables from the 2010 Census and 2009-2013 American Community Survey (ACS) into a number of uncorrelated variables, or principal components. Weighted values for each of the principal components were derived and summed to develop a composite social vulnerability value for all populated census block groups within the study area.

10.2 Inputs

Key variables used to derive the social vulnerability index were selected based on a review of existing literature, including the work of Cutter et al. (2003), the State of Texas (Peacock et al. 2011), and the U.S. Army Corps of Engineers (Dunning and Durden, 2011). Data used to represent the key socio-economic variables were extracted from the 2010 Census and 2009-2013 ACS at the census block group level.[6] All census block groups within the 2017 Coastal Master Plan modeling domain were utilized for this analysis.

10.3 Equations

All input variables were normalized as percentages, per capita values, or density functions and then standardized using z-score standardization. Calculating z-scores allows for comparison of dissimilar data sets on a common scale, generating variables with a mean of 0 and standard

[6] The American Community Survey is an ongoing survey conducted by the U.S. Census Bureau that regularly gathers data previously gathered in the decennial census. At small census geographies, such as the census block group, data gathered by the American Community Survey exhibit higher amounts of sampling error.

deviation of 1. After all the data were transformed into the units required for analysis of each category, PCA was run on the variables.

Using the results of the PCA, variables with the highest loadings (> 0.3) within a component were identified as the most important, and these variables were then used to assign a descriptive label to the component. These components are surrogate variables that serve to simplify a large number of correlated variables. A value of 0.3 or above indicates multicollinearity, meaning that the predictor variables are highly correlated with one another (Hair et al. 1998). Variables that failed to load significantly on any component were eliminated from the analysis and a new component solution was calculated. Groups of variables with the highest loadings were divided into components that account for as much of the variability in the data as possible. The first component accounts for the greatest amount of variation in the original variables. The second component is uncorrelated with the first and accounts for the maximum variation that is not accounted for in the first component. Each subsequent component, likewise, accounts for the maximum variation not accounted for in the previous components. The directionally-adjusted components in this study were assigned the percentage of their respective eigenvalues, or variance explained, as weights

$$W_i = \frac{l_i}{\sum l_i} \quad (34).$$

$$W_i = \frac{l_i}{\sum l_i} \quad (34)$$

Where W_i is the weight assigned to each component, and l_i is the eigenvalue, or variance explained, of each component.

Assigning weights to each component based on the variance explained is reasonable because a larger eigenvalue represents a larger share of the total variance and a more important component. Thus, the first component explains the most variance and each successive component contributes less to the variance explained. The final SVI value was then calculated

$$F_s = \sum(F_i * W_i) \quad (35).$$

$$F_s = \sum(F_i * W_i) \quad (35)$$

Where F_s is the census block group level SVI value, F_i is the component value for each component, and W_i is the weight assigned to each respective component.

To graphically represent the relative nature of the metric, the weighted social vulnerability values were normalized by z-scores and mapped by census block group to form a distribution with a mean of 0 and standard deviation of 1. Census block groups with SVI values greater than one standard deviation from the mean have previously been classified as vulnerable (Cutter et al., 2003). For this analysis, five categories of vulnerability were identified: low, medium low, medium, medium high, and high. Medium values are within one standard deviation of the mean, medium low values are between -1 and -1.96 standard deviations, medium high values are between 1 and 1.96 standard deviations, and high and low values are those greater than 1.96 or less than -1.96 standard deviations from the mean, respectively. A z-score of 1.96 indicates that the respective index value is significantly above or below the mean value (alpha = 0.05). Finally, the census block level values were aggregated and mean parish-level index values were calculated. Both the census block group and the parish index values allow for a ranking of vulnerability relative to the parish average.

The initial 37 variables were analyzed using PCA. One variable (the percent Native American population) did not load significantly on any of the components and was not included in the final PCA run. The final 36 variables representing social vulnerability were grouped into eight components based on the Kaiser-Guttman criterion. In total, most of the variance explained was captured by economic status (20.3%), rural population (14.4%), and age/dependent population (9.5%). The remainder of the variance explained by each component can be found in Table 16.

There are several variables that have split loadings, meaning that they load onto more than one factor. As each of these variables has loadings greater than 0.3, they can be interpreted as contributing to more than one factor. These split loadings (sometimes referred to as complex structures) are not uncommon in the PCA and are not a problem if the components are interpretable.

Table 16: Cardinality and component loading for each principal component.

Component	Directional Adjustment	Variance Explained	Component Interpretation	Dominant Variables	Component Loading
1	+	20.2%	Economic Status	Percent of population living in poverty	0.8
				Percent African American population	0.8
				Percent of households that have no vehicles	0.7
				Percent of female headed households	0.7
				Percent renter-occupied housing units	0.6
				Percent of labor force that is unemployed	0.6
				Percent of households receiving Supplemental Social Security income	0.6
				Percent of population 25 years or older with no high school diploma	0.6
				Percent single parent households	0.3
				Percent of population employed in service	0.4

Component	Directional Adjustment	Variance Explained	Component Interpretation	Dominant Variables	Component Loading
				industries	
				Percent of adult population that is disabled	0.4
				Percent vacant housing units	0.4
				Percent of households receiving public assistance	0.4
				Percent of population participating in civilian labor force	-0.5
				Per capita income in dollars	-0.7
				Percent households making more than $75,000	-0.8
2	+	14.4%	Rural Population	Percent mobile homes	0.6
				Percent rural population	0.6
				Percent of population employed in mining and petroleum extraction industries	0.4
				Median value of owner-occupied housing in dollars	-0.5
				Heath facilities within 20 mile radius	-0.7
				Housing density, number of households per square mile	-0.7
				Population density, number of persons per square mile	-0.7
3	ǁ	9.5%	Age, Dependent	Percent of population over 65 years of age	0.7

Component	Directional Adjustment	Variance Explained	Component Interpretation	Dominant Variables	Component Loading
			Population	Median age	0.7
				Percent of households receiving Social Security income	0.6
				Percent in poverty and over 65 years of age	0.4
				Average persons per household	-0.5
				Percent of population under 5 years of age	-0.5
4	+	6.8%	Non-English Speaking, Migrant	Percent of population over 5 years of age that speak little or no English	0.7
				Percent of population born outside of the United States	0.7
				Percent Hispanic Population	0.6
5	+	4.3%	Natural Resource Dependent Communities	Percent vacant housing units	0.3
				Percent of population employed in forestry, agriculture, and fisheries industries	0.3
				Percent of population employed in mining and petroleum extraction industries	0.3
				Percent renter-occupied housing units	0.3
				Percent mobile homes	0.3
				Percent of households receiving Social Security income	-0.3

Component	Directional Adjustment	Variance Explained	Component Interpretation	Dominant Variables	Component Loading
6	–	3.4%	Nursing Home Residents	Percent of population participating in civilian labor force	-0.3
				Percent of population in nursing homes	-0.5
7	–	3.1%	Disabled, Dependent Population	Percent of households receiving public assistance	-0.3
				Percent of adult population that is disabled	-0.4
				Percent of population in nursing homes	-0.6
8	+	2.9%	Asian, Natural Resource Employees	Percent Asian population	0.5
				Percent of population employed in forestry, agriculture, and fisheries industries	0.4

The results of the PCA assigned a component value for all eight principal components to each census block group in the study area. These values were adjusted for cardinality and weighted, as preciously described. The final additive model was used to derive the overall socio-economic vulnerability value for each census block group, F_S, using the component values and weights

10.4 Output and Example Application

The SVI values were mapped and areas ranging from high to low vulnerability were identified across the coast (Attachment C4-11.2 - SVI). By examining the spatial distribution of these social vulnerability components, at both the individual component and combined index levels, this research can enable a greater understanding of social vulnerability factors that can be used in the planning process to anticipate and plan for hazard events (e.g., extreme weather events), evaluate management measures, and evaluate project alternatives. Knowing the location of socially vulnerable communities will allow planners to more effectively target and support efforts to mitigate and prepare for disaster events. This SVI enables an assessment of the relative vulnerability of communities and can be used to further interpret the findings of other master plan metrics (e.g., support for traditional fishing communities). For example, the metric results have been summarized by community according to the level of vulnerability assigned to that community and then compared to how alternatives impact risk within communities. This example entails first deriving the SVI scores at the community level and then the comparison with the risk reduction.

10.4.1 Determining Community-Scale Social Vulnerability

The Social Vulnerability Index (SVI) derived for the 2017 Coastal Master Plan examined the presence and location of socially vulnerable groups in coastal Louisiana at the census block group level. As the majority of the variables used to construct the SVI were not available at the census block level, the census block group was selected as the optimum unit of analysis. However, the community boundaries developed for the 2017 Coastal Master Plan were constructed using contiguous census blocks with population density values ranging from 500 to 1,000 persons per square mile. To derive an aggregate social vulnerability score for each community, utilizing the SVI data developed at the census block group level, it is necessary to account for the spatial mismatch between the units of analysis within the two datasets (Figure 5).

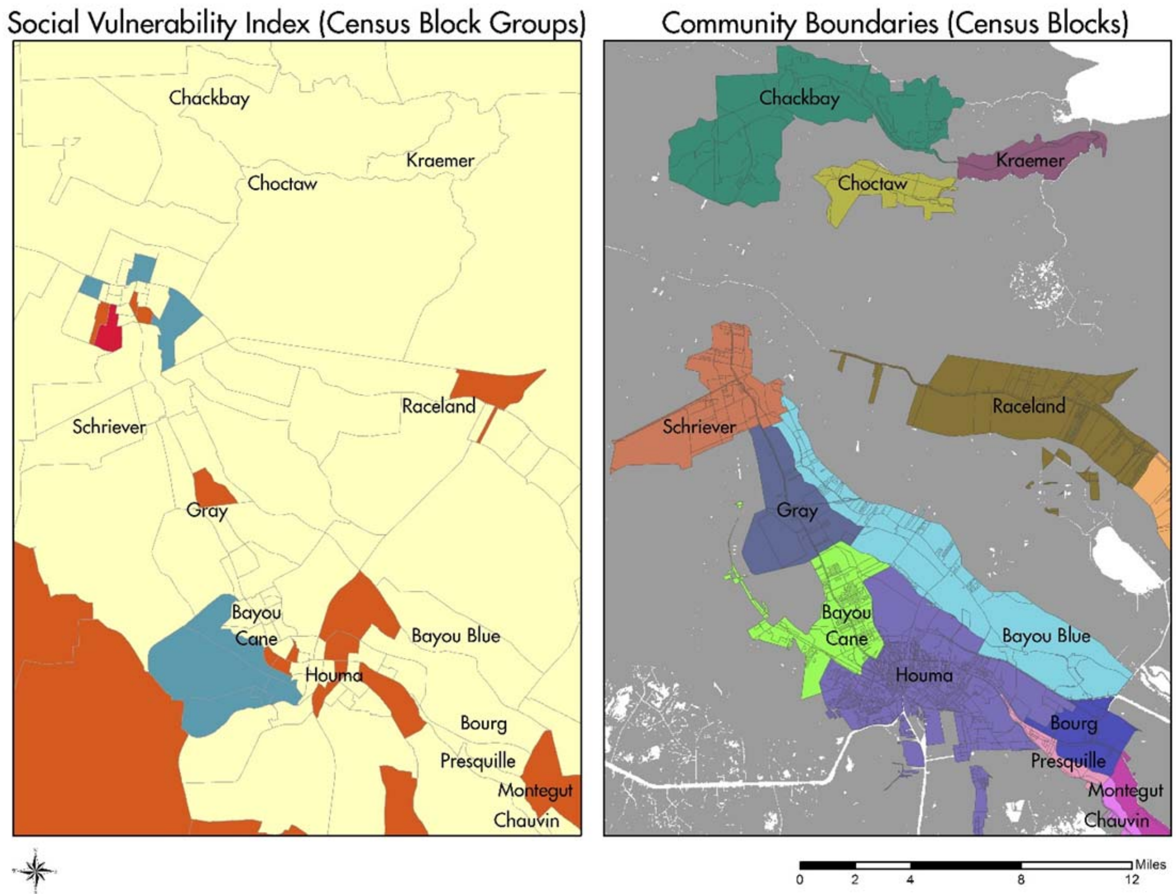


Figure 5: Illustration of the spatial mismatch between communities and census block groups.

To address this mismatch, it was necessary to estimate the social vulnerability for each census block and then aggregate these data to the community level. To accomplish this, each census block within the master plan communities was assigned the SVI value of the census block group that it was nested within. This assumes a spatial heterogeneity of values within the census block group.

Census blocks are extremely variable in total area and the area of populated land. To assure that the SVI values assigned to the community account for this variability, each census block assigned to a master plan community was also assigned a SVI value weighted by the total populated area within that block. The 2011 National Land Cover Database (NLCD) was used to identify populated area, defined in this analysis as agricultural land, low intensity developed, medium intensity developed, and high intensity developed land. Each pixel in the NLCD was classified on a binary scale as either populated or unpopulated. Because the SVI analysis includes variables related to urban and rural populations, agricultural land and developed land were assigned the same value and weighted equally.

The total populated area within each community was calculated and each constituent census block was assigned a proportion of that total area. This proportional value was multiplied by the SVI score to derive an area-weighted SVI score for each census block within a community. These scores were summed to determine the overall community-scale SVI score. The results were verified against the block group SVI scores to assure that the community results were consistent with the census block results (Figure 6).

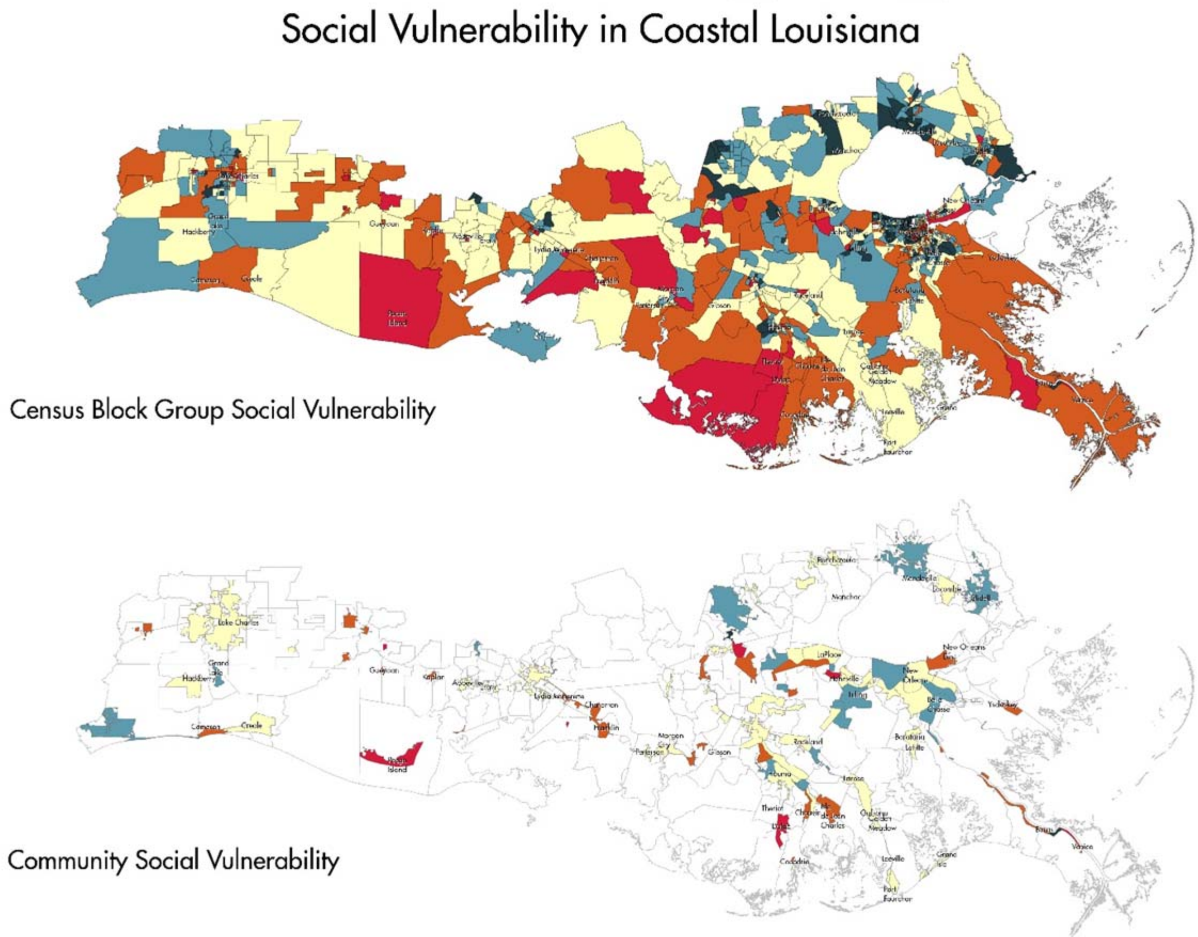


Figure 6: Comparison of social vulnerability for census block groups and at the community level.

10.4.2 Social Vulnerability and Changing Risk

For several of the indices described in this report, a component reflected the expected annual damages from storms (E_C). This risk reduction metric quantifies the impact of projects upon a community and indicates whether more or less risk reduction (compared to FWOA) under an alternative is realized. Nearly all of the more vulnerable communities (SVI>0) show a decrease in damages with the Draft Plan compared to FWOA for the medium scenario.

For the medium scenario, 73 of the 110 communities analyzed have a lower median EAD estimate at year 50 under a Draft Plan FWA than what would have occurred under a FWOA. Of these 73 communities showing a benefit, 17 have an estimated median EAD at year 50 lower than the median EAD under initial conditions. Of the 110 communities, 34 experience no significant difference in EAD (as defined previously) between FWA and FWOA.

For the medium scenario, only three communities have higher median EAD estimates at year 50 under a Draft Plan FWA than what would have occurred under a FWOA: Chalmette/Arabi/Meraux, Leeville, and Grand Isle. Grand Isle has a lower EAD at year 50 under both FWA and FWOA, than it would have had under initial conditions; however, the EAD is slightly higher under FWA than FWOA. This counterintuitive behavior of risk reduction under various landscapes reflects the complex interaction between land loss, protection structures, flooding patterns and changes in population and/or asset growth.

Under the high scenario, 73 communities are estimated to have a lower median EAD at year 50 under a Draft Plan FWA than what would have occurred under a FWOA. This is the same number of benefitted communities as seen under the medium scenario. However, the number of communities with no significant difference in year 50 EAD between FWA and FWOA is reduced to 28 communities under the high scenario; compared to the 34 communities with no significant differences under the medium scenario.

Under the high scenario, there are nine communities that have a higher EAD under a Draft Plan FWA than what would have occurred under a FWOA: Poydras/Violet/St. Bernard, Avondale/Waggaman, Port Fourchon, Leeville, Chalmette/Arabi/Meraux, Jefferson Parish (Westbank), New Orleans – Algiers, Cocodrie, and Grand Isle. Similar to the medium scenario results, two of these communities, Grand Isle and Cocodrie, have an estimated EAD at year 50 that is lower than initial conditions for both FWOA and FWA. However, the EAD from a Draft Plan FWA is higher than it would have been under a FWOA. The increase in communities with a higher median EAD under FWA than FWOA is likely due to increased flood depths from low probability events (500-year) under the various levee fragility scenarios included in the CLARA analysis (see Chapter 4 for discussion).

Of the three communities estimated to have a higher EAD at year 50 under a medium scenario Draft Plan FWA than a FWOA, all three have SVI values greater than one, indicating that they are more vulnerable than the coast wide average. Of the nine communities estimated to have a higher year 50 EAD under a high scenario Draft Plan FWA than under a FWOA, seven communities are considered more vulnerable than average and the remaining two are considered less vulnerable than average.

Nearly all of the communities in the more and most vulnerable categories show a reduction in damages, as discussed previously. Identifying these communities in advance allows localized exploration of flooding and community characteristics to determine, in a more detailed way than is possible for the master plan, how such effects can be alleviated prior to the year 50 conditions predicted by the models. Due to the complex interactions between EAD estimates, population and/or asset growth scenarios, and impacts of restoration and/or protection projects, methods for reducing EAD from the possible induced flooding/damages seen in FWA will be explored between the Draft and Final Master Plans.

11.0 References

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