Appendices to

Economic Evaluation of

Coastal Land Loss in Louisiana

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Appendix A: Detailed Data and Methods for Non-Residential, Residential, and Network Stocks and Flows

Non-Residential Stocks and Flows

Possible Data Sources

Two sources of data stand out as accurate counts of businesses and employment in Louisiana, but are aggregated at too large an area for this analysis: the U.S. Census Bureau's County Business Patterns (CBP) and Louisiana Workforce Commission's Quarterly Census of Employment and Wages (QCEW). Both data sources are used as a benchmark to evaluate other sources of data available, but have some limitations.

County Business Patterns is an annual series that provides economic data on number of establishments, firm size and employment, and first quarter payroll by industry, aggregated at the county and zip code level. Administrative records from the Internal Revenue service are the most common source of data, with some updates on geographic location and industry classification from Census Bureau conducted surveys. Establishments for a multi-unit company are identified through the Economic Census and the annual Company Organization Survey. Excluded from the CBP are self-employed individuals, employees of private households, railroad employees, agricultural production employees, and most government employees. There may also be a certain amount of under coverage, particularly for small employers (less than 10 employees). Data is from May 2012.

Data from QCEW comes from state administrative data on unemployment insurance, and includes the number of businesses, employees, and quarterly wages in Louisiana. Estimates are available statewide or aggregated into 8 regional labor markets. Like CBP, QCEW also excludes the self-employed. Data is from 2013.

In addition to CBP and QXEW, we also considered the Census OnTheMap tool with the LEHD Origin-Destination Employment Statistics (LODES) datasets. We also considered two commercial datasets on businesses in Louisiana, Info-USA and Dun & Bradstreet. Data are from 2011.

Info-USA, produced by Infogroup, a company that produced contact information and data for marketing analytics, was accessed through ESRI's Business Analytics software, which processed and geocoded the Infogroup data. This dataset includes all business types, including some self-employed, though likely does not capture the entire self-employed workforce. Data available include company name, address, coordinates (latitude and longitude), North American Industry Classification System (NAICS) code, number of employees, estimated sales volume, and square footage.

We received a representative sample of geocoded Dun & Bradstreet (D&B), a similar data collection group through HSIP-Gold, the Homeland Security Infrastructure Program geospatial database. This sample included the complete listing of several industries, but did not cover all sectors of the economy. The sample allowed us to run some tests on the data to evaluate quality. A follow-up with D&B did give us a count of total Louisiana establishments in their database. D&B includes the same set of variables as Info-USA. Data comes from 2012.

Finally, OnTheMap LODES data totals jobs and characteristics by workplace Census Block. This is an annual dataset based on state administrative databases of the unemployment insurance, like QCEW. It does not include an estimate of number of establishments, but there is data on the number of jobs broken down into several sets of ranges of worker's demographics, wages, industry, and firm size. Like QCEW, it excludes information on the self-employed.

Tests of Data Quality

The first test of data quality was to compare total counts for establishments and employees. We were most concerned about D&B and Info-USA, as they are both commercial datasets created for many purposes, but also have the finest geography detail. Table A.1 shows a comparison of these five data sources side by side.

Of the point-level data, D&B has a significantly higher number of total establishments than any other data source. A close examination of D&B microdata turned up many duplicates and closed businesses. Info-USA is much more in line with the other sources, potentially due to the geocoding process ESRI went through for their Business Analytics software.

Table A.1

Comparison of Selected Louisiana Business Data Sources

Name	Source	Georgraphy Detail	Excludes	Establishments (thousands)	Employees (millions)	
County Business Patterns	U.S. Census Bureau	County, Zip codes	Self-employed, government	104	1.64	*Benchmarks*
QCEW	LWC	County	Self-employed	126	1.89	
Dun & Bradstreet	Commercial dataset	Point		276		
Info-USA	Commercial dataset	Point		172	2.03	
OnTheMap	U.S. Census Bureau/state administrative data	Census block	Self-employed		1.72	

Source: CBP, QCEW, Dun & Brastreet, Info-USA, OnTheMap

We also ran a sample of the D&B and Info-USA through Google Places API. Google Places API searches company name and address to find the Google Places id and coordinates, and helped validate that these businesses do exist. Google Places is not treated as a 100 percent accurate list of every company in existence, but a useful secondary validation tool of micro-level data. While there was a relatively small rate of invalid matches between Info-USA and Google Places (11 percent), we saw a much larger error rate with D&B (28 percent). Furthermore, we found numerous duplicates (15 percent surplus) where D&B collected information with slight variations on name or address (e.g. "Dewey's" and "Dewey's Lounge" had two entries but the same address), and a huge number of incorrectly matched places where Google matched the name of the company with a similar one in another state like Illinois. This served as further validation that the processed Info-USA data was preferred over D&B.

Finally, we compared Info-USA with CBP by firm size, since both provide a matching set of employee size classifications. These numbers can be seen in Table A.2 below, where "Comparison" is a ratio of Info-USA: CBP and shows how much larger the Info-USA count is as a fraction of the other dataset. Info-USA appears to be very accurate in large size firms (F-I). Size A shows there are nearly twice as many establishments registered in Info-USA, which may capture a large portion of the self-employed. Other discrepancies could be explained by government and agricultural employees, as CBP excludes these from their data collection.

These tests support the use of the Info-USA dataset as a reasonably accurate and comprehensive source, superior to the alternative D&B for our purposes. The point data from Info-USA will be used to find the proportion of business activity affected by coastal erosion and supplemented by data from the Census.

Table A.2

Info-USA Compared to CBP by Firm Size

Size Code	Employees	Info-USA	CBP	Comparison
A	1-4	98,710	51,860	1.90
B	5-9	34,448	21,913	1.57
C	10-19	19,408	14,375	1.35
D	20-49	12,472	10,067	1.24
E	50-99	4,503	3,444	1.31
F	100-249	1,776	1,760	1.01
G	250-499	404	404	1.00
H	500-999	162	153	1.06
I	1000+	94	84	1.12
Total	Any	170,000	104,000	1.40

Source: CPB, Info-USA

HAZUS-MH

The Federal Emergency Management Agency (FEMA) has developed a nationally applicable standardized methodology for estimating potential losses from disasters, specifically focusing on earthquakes, floods, and hurricanes. The primary purpose of HAZUS – MH is for government planners, GIS specialists, and emergency managers to prepare for disasters in advance as well as determine losses after an event and implement mitigation strategies. There is a component of HAZUS-MH that will assess economic losses, but it has a few drawbacks for use in this project.

Most obviously, it is not designed for land loss scenarios, but for use in events like a hurricane in current conditions. A lot of data and methodology can overlap, but HAZUS-MH cannot be directly used to calculate losses in a future without action. Second, the data focuses on the number of buildings and structures rather than economic activity like sales and employment provided in other datasets. The base data for non-residential buildings was developed by dividing the square footage by occupancy by Census Block (from the first quarter of 2002 Dunn & Bradstreet) by nationally estimated “typical floor areas” for each occupancy type (personal email with Mourad Bouhafs, HAZUS-MH Project Manager) , so many assumptions go into estimating the number of units. Table A.3 shows the occupancy types and the average square feet per unit for each, from hzAnalParms.mdb in the HAZUS-MH metadata. This process uses a lot of different assumptions to estimate the number of units and is based on an outdated and non-preferred dataset.

Residential buildings are calculated directly from the 2000 Census but are converted from number of housing units to number of buildings using an algorithm for housing patterns (for instance, two units in a duplex become one structure).

A third shortcoming in the HAZUS-MH default database is that the underlying data comes from 2002 Dun & Bradstreet. As we have explored above, we believe Dun & Bradstreet contains many duplicates and outdated information. Additionally, the Louisiana landscape has changed significantly since 2002, particularly in the years following Hurricane Katrina (2005). Data on businesses from before Hurricane Katrina is not representative of the current landscape, especially in the areas hardest hit: the coastal region. Similarly, the 2000 Census population and residential housing data does not accurately reflect post-2005 Louisiana.

Finally, the use of square feet and conversion factors is not as useful as the employment and sales data in InfoUSA for an analysis of business activity. Much of the HAZUS-MH methodology is used in this report to calculate damages to non-residential structures, but we prefer the geocoded InfoUSA database over the HAZUS-MH building stock database to calculate the number of businesses affected and employment and sales at those businesses.

Table A.3

Occupancy Categories with Typical Square Footage per Unit

Occupancy	Occupancy Description	Typical Square Footage
AGR1	Agricultural	30,000
COM1	Retail	110,000
COM10	Parking	145,000
COM2	Wholesale	30,000
COM3	Personal services	10,000
COM4	Professional	80,000
COM5	Banking	4,100
COM6	Hospital	55,000
COM7	Medical office	7,000
COM8	Entertainment	5,000
COM9	Theaters	12,000
EDU1	Schools	130,000
EDU2	Colleges	50,000
GOV1	General services	11,000
GOV2	Emergency center	11,000
IND1	Heavy	30,000
IND2	Light	30,000
IND3	Food/drugs	45,000
IND4	Metal	45,000
IND5	High tech	45,000
IND6	Construction	30,000
REL1	Religious	17,000
RES1	Single-family	1,600
RES2	Manufactured	1,063
RES3A	Duplex	3,000
RES3B	3-4	3,000
RES3C	5-9	8,000
RES3D	10-19	12,000
RES3E	20-49	40,000
RES3F	50+	60,000
RES4	Temp lodging	135,000
RES5	Institutional	25,000
RES6	Nursing home	25,000

Source: CPB, Info-USA

Detailed Business Interruption and Business Survival Methodologies

Equations A.1 and A.2 describe the lost sales and lost wages for each establishment.

Equation A.1. $$SLOSS = (1 - RF) * \left(\frac{Time\ A}{12}\right) * (AS) * (F)$$

Equation A.2. $$WLOSS = (1 - RF) * \left(\frac{Time\ A}{12}\right) * (emp) * (AW) * (F)$$

SLOSS = lost sales at establishment
WLOSS = lost wages at establishment
RF = recapture factor for industry, either 0 or Hazus default
Time A = loss of function time at establishment in months
emp = number of employees at establishment
AS = average sales for the establishment
AW = average salary or annual wages for parish
F = 0 if no damage; 1 if damaged

The equations for lost rental income for owners of buildings are as follows:

Equation A.3. $$TLC = FA * \left[(1 - \%OO) * DC * F + \%OO * \left(DC + RENT * \frac{Time\ B}{12}\right) * F\right]$$

Equation A.4. $$RIL = FA * (1 - \%OO) * RENT * \frac{Time\ B}{12} * F$$

TLC = temporary location costs
RIL = rental income losses
FA = adjusted floor area for establishment
%OO = Hazus default % of owner-occupied businesses by industry
RENT = rental cost ($\$/ft^2$/month) for industry
DC = disruption costs for occupancy ($\$/ft^2$)
Time B = repair time – loss of function time for establishment
F = 0 if no damage; 1 if damaged

Agricultural Crop Data

Data and Methodology

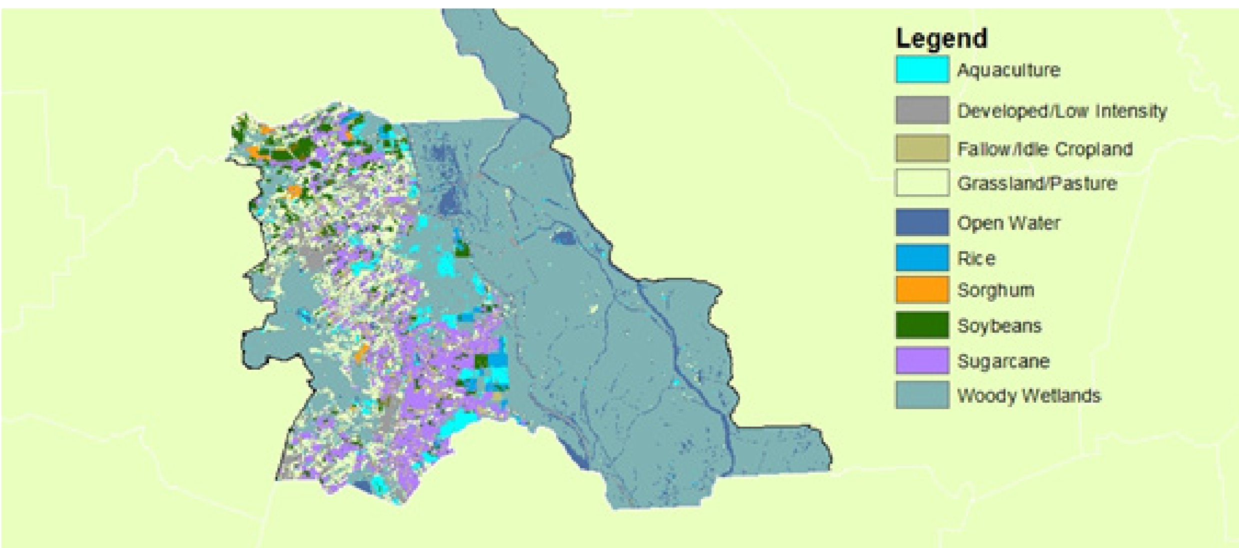
A review of the data in InfoUSA showed that agricultural crops were not well represented using the InfoUSA database. The two main sources of data used for estimating the economic value of the agricultural sector are the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) and the Louisiana State University Agricultural Center (AgCenter). NASS has a Louisiana field office that gathers and summarizes official statistical data for the state and is the premiere source of data for agriculture. LSU AgCenter closely aligns with NASS data, but in many cases is more detailed and looks at a much wider variety of crops, and includes clearer data on natural resources, animal industries, and fishing.

Total gross farm-gate value for the agricultural industry in Louisiana in 2014 was $7.1 billion (LSU Ag Center Summary). Plant enterprises accounted for $4.2 billion of the total. Along with the production in agricultural sectors, value-added activities, like the cleaning, processing, and packaging of agricultural goods, helped to generate $12.7 billion to the state of Louisiana in 2014 (LSU Ag Center Summary). In contrast to these findings, InfoUSA only includes $2.1 billion in annual sales for all agriculture.

Central to the methodology developed in this report is NASS's "CropScape" map, a geo-referenced, crop-specific GIS layer which shows the location where different crops are grown and allows states to estimate acres in production for major agricultural crops. It was created using moderate resolution imagery and extensive agricultural ground truth. It is about 85 – 95 percent accurate for major crops (NASS CropScape 2013).

Figure A.1 is the CropScape for St. Martin Parish. Each pixel on the map represents a 30mx30m square and has a value corresponding to the groundcover of the area. Summing up all the purple pixels, for instance, indicates that in St. Martin Parish 2013, there were an estimated 33,782 acres in production for sugarcane.

Figure A.1. St. Martin CropScape

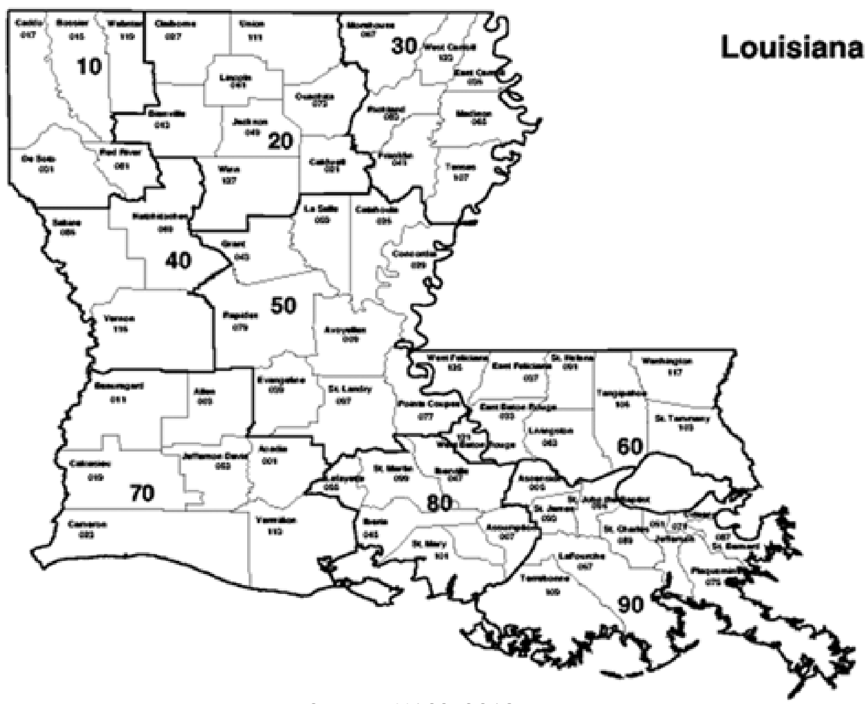


Source: NASS Crop Scape, 2013.

To more accurately reflect agricultural production in coastal Louisiana, data from the NASS CropScape was used to supplement the main infrastructure and economic activity at risk values in Chapter 3. NASS CropScape includes data for plant enterprises (crops) and land-based aquaculture, such as crawfish farms. Not included are timber and forestry and animal enterprises (except land-based aquaculture).

Where available (as in the case of soybeans, rice, and corn), data on crop yield per acre and commodity prices were collected from NASS by agricultural district (see Figure A.2). Data on other crops were collected at the state level from the LSU AgCenter. Crawfish production data was used to approximate aquaculture, because it makes up over 60 percent of gross revenue from land-based aquaculture (primarily this excludes revenue from oysters).

Figure A.2. Louisiana Agricultural Districts



Source: NASS, 2013

The direct land loss effect on agriculture is difficult to capture because agricultural fields can be lost either by directly subsiding under sea level, or by frequent flooding and salinity resulting in unproductive land. Therefore, there is a "buffer" of fallow fields almost everywhere along the coast. We could not calculate this buffer, so we could not calculate the direct land loss effect, though it is likely there would be at least some effect on agricultural production. As such, we estimate only the value of flooded crops from the three case study storms.

To replace plant enterprises in the InfoUSA data, we drop any establishments with NAICS 111, Crop Production, and add the gross farm value flooded calculated from NASS CropScape to the totals for economic activity. Agricultural losses and damages are calculated in terms of gross farm value flooded as follows:

*Gross farm value flooded = acres flooded * yeild per acre * commodity price*

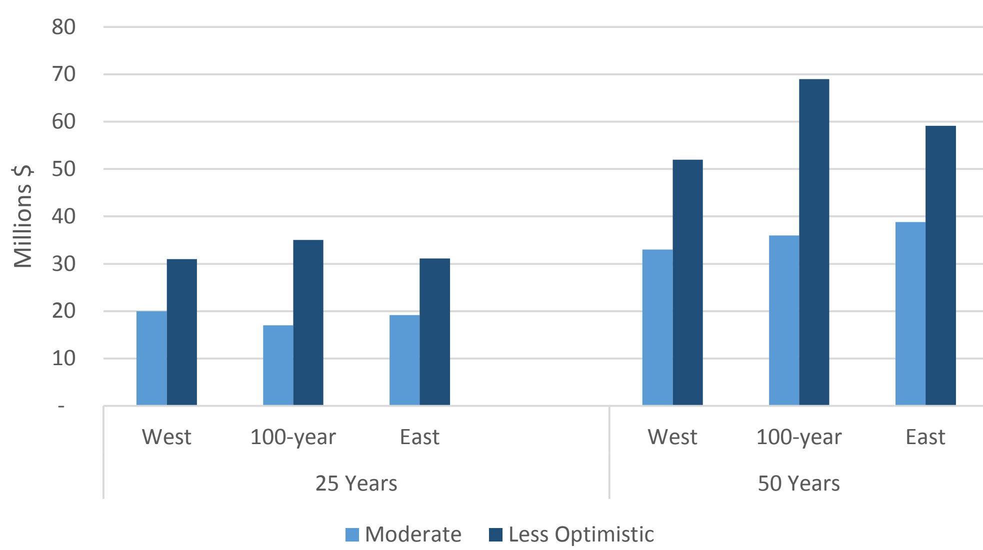
Any structures listed in InfoUSA for NAICS 111 remain for calculations of damaged infrastructure. Affected agricultural workers and salaries are assumed proportional to the percentage of total gross farm value flooded. Data on number of agricultural workers and salaries come from 2012 Louisiana Workforce Commission estimates.

Results

The estimated total damage from flooding in a future without action ranges from $31 million in the eastern storm track at 25 years to $221 million in the western storm track, compared to approximately $159 million in crop damage (this excludes timber and livestock losses) from Hurricane Katrina and $201 in crop damage from Hurricane Rita (Disaster Recovery LSU AgCenter 2005). In Figure A.3, crop damage from flooded acreage in the future condition minus current conditions ranges from approximately $17 million in the 100-year storm, 25 year moderate scenario to $69 million in the 100 year, 50 year less optimistic scenario. These estimates are included in the total economic activity at risk reported in Chapter 3. Incremental workers affected were no more than 150 in any scenario, and lost wages run from $0.8 to $3.0 million. Note that for the eastern-track storm under the less optimistic scenario, the 50-year estimate of incremental damage is not markedly greater than in other scenarios, as levee failures in New Orleans do not tend to affect agricultural production.

Damages to crops in a storm can come from flooding or from wind damage, but in this model we can only estimate crop flooding. This is likely an overestimate of flood damage and underestimate of wind damage to crops, but roughly similar to damage from storms observed in the past.

Figure A.3. Flooded Crop Gross Farm Value From Increased Storm Damage



Source: Authors' calculations. Note: All results presented in 2012 dollars.

Residential Stocks

To the authors' knowledge, there is no publicly-available geospatially-referenced housing stock database suitable for estimating the effects of direct land loss on residential structures. As such, we use information from the 2010 American Community Survey (ACS) on housing stocks coupled with the nighttime population data of the 2012 LANDScan dataset to estimate the value of housing stocks by each 100x100m cell in the LANDScan data and aggregate these estimates to the census block level for use with the CLARA flood-level estimates.

The 2010 ACS data related to housing was extracted from the U.S. Census website. This includes information on structure type, vacancy rates, household size, median values for owner-occupied structures, and median rental values by census tract. We used the count of structures by type and average household size information to estimate the implied owner-occupied and rental populations, which provides a basis for disaggregation to the LANDScan cells, which report estimated population by cell. Total value of the residential housing stock was computed through the product of median value and structure counts and adjusting for vacancy rates for owner-occupied housing. For rental properties, the average value structure is assumed to be the net present value of rents over an infinite time horizon, using a discount rate/rate of return that resulted in the average values per person of owner-occupied and rental properties to be equivalent statewide. This rate was estimated at 7.13 percent, which appears to be a reasonable estimate for the market-clearing rate of return on rental properties. The total value of rental structures was also adjusted by the tract-specific vacancy rate reported for rental housing. Adjustments were made for those tracts in which not all information was available (e.g., in the two cases in which all structures were vacant). Population counts by structure type were calculated as well.

Per-capita total structure values were then constructed for each tract, and used in conjunction with the LANDScan population counts to estimate the total value of housing stock in each cell, which was assigned a unique census tract and census block identification using GIS techniques. In the event that such an ID was unavailable, tract- or county- level averages were used.

To test the veracity of the estimates, we used the 2010 Bureau of Economic Analysis national-level value of residential fixed assets figure, and estimates of both U.S. and Louisiana populations to estimate Louisiana's share of the national value of residential fixed assets. This calculation resulted in an estimate of $238 billion, while our methods using ACS and LANDScan data produced an estimate of $245 billion for the state.

Estimates of the at-risk residential infrastructure directly attributable to land loss was calculated by first estimating the share of each LANDScan parcel assumed to be lost, and then applying this proportion to the assumed value of residential capital stocks in that cell. This procedure implicitly assumes that the value of housing stocks are uniformly distributed across the LANDScan cell.

Estimates of the value of residential structures used in conjunction with residential depth-damage curves in CLARA were aggregated to the census block level using the per-capita estimated values and LANDScan population cells, again using tract- or county- specific data when needed.

Network Stocks and Flows

Railroad Data and Methodology

Data from the National Transportation Atlas Database (NTAD) 2014 was used to identify rail lines in coastal Louisiana. The NTAD, published by U.S. Department of Transportation's Bureau of Transportation Statistics, is a set of nationwide datasets of transportation facilities, networks and other associated infrastructure. Specifically, the NTAD's "rail_lines" dataset was used in conjunction with four land loss scenario maps provided by the Louisiana Coastal Protection and Restoration Authority (CPRA).

To identify railroads impacted by future land loss, the NTAD "rail_line" geographic dataset and CPRA land loss maps were overlaid in ESRI's ArcMap program to find the intersection of the "rail_line" dataset with each of the four land loss scenario maps. The length in miles was then calculated for each of the segments of intersected rail line. Finally, the attributes table of each intersect layer was exported for further analysis.

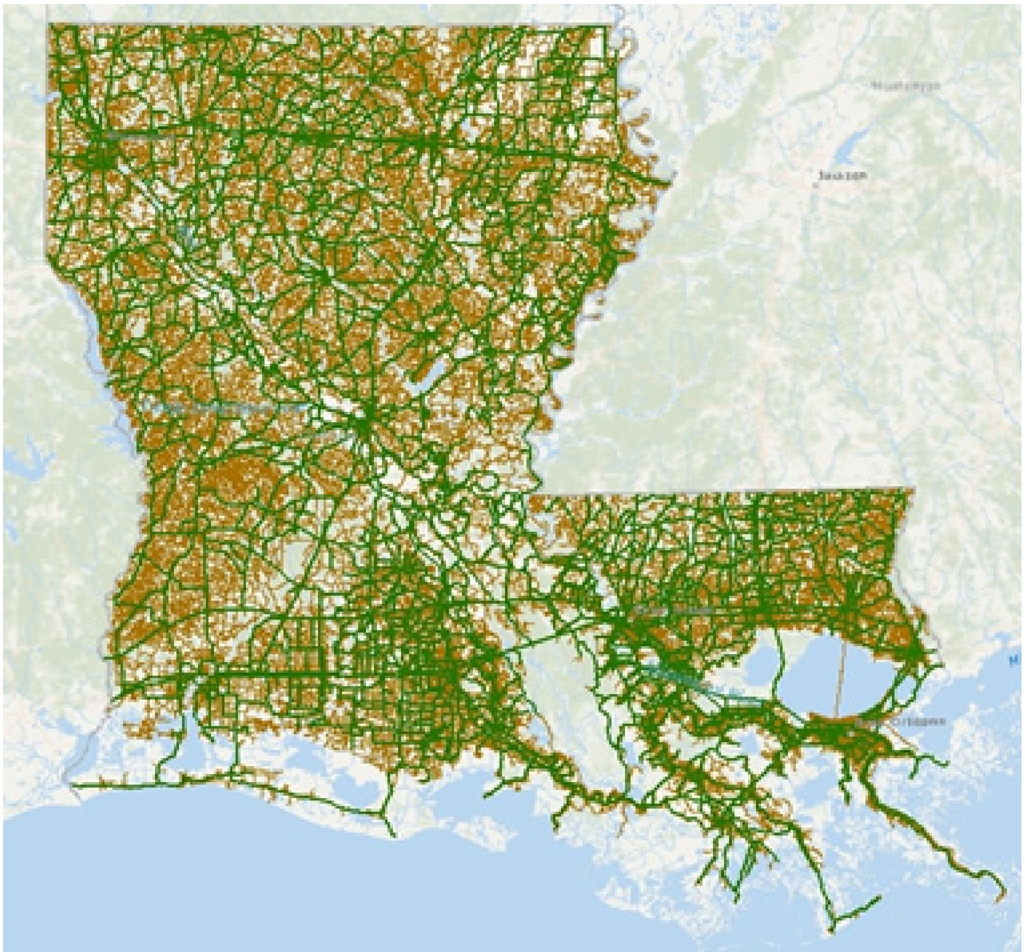
Using Stata, the exported attributes table of the intersected segments of rail line were filtered to remove segments of rail lines that are considered abandoned according to the NTAD "rail_line" dataset. Additionally, the miles of track impacted by land loss were calculated by multiplying the length of the impacted rail line segments by the number of tracks along that segment of rail line. The miles of impacted track were then totaled for each of the four scenarios. Replacement costs are taken from HAZUS-MH.

Road Data and Methodology

Road locations came from two separate geodatabases: state-maintained roads from the Louisiana Department of Transportation & Development (LADOTD) and local/all roads from the U.S. Census Bureau. The LADOTD data include information about the number of lanes and surface types for all state-maintained roads, like interstates, U.S. highways, and state highways. The U.S. Census Bureau's TIGER/Line data offers less detailed information about all roads, but includes local and private roads. Figure A.4 shows a map of both data sources.

Table A.4 shows the distribution of pavement type for state roads in the LADOTD database. In addition to the geodatabase from LADOTD, we received a database containing pavement types for different road segments and average replacement costs from 2012 for these pavement types. We used this information to estimate the cost of land loss to current road infrastructure. Control segments were classified by pavement type as gravel, asphalt, composite, jointed concrete, continually reinforced concrete, brick, or bridge. Estimates for gravel road replacement costs were supplemented by a 2013 paper by the Indiana Local Technical Assistance Program at Purdue University.

Figure A.4. Roads Included in the LADOTD Database (Green) and Census TIGER/Line (Tan)



Source: LADOTD, U.S. Census Bureau TIGER/Line 2013.

Table A.4

State Road Pavement Type Distribution

Pavement type	Percentage
Asphalt	72.6
Composite	18.6
Jointed Concrete	6.0
Bridge	1.2
Gravel	0.4
Continually Reinforced Concrete	0.2
Brick	<0.1

Source: LADOTD, 2012.

For roads where we did not know the pavement type, we modeled pavement type based on functional class and road type. For local and parish roads (those not in the LADOTD database), we assume a distribution of pavement type in Table A.5.

Table A.5

Assumed Distribution of Local Roads

Pavement Type	Percentage
Asphalt	72.6
Composite	18.6
Concrete	3.5
Gravel	5.3

Source: LADOTD, 2012.

To determine the losses to roads, we calculated replacement costs for the intersection of road and the land loss maps based on our model of pavement types. Using this general methodology, we can calculate total mileage affected and its replacement cost.

There are a few roads in particular that need more detailed analysis, particularly Louisiana Highway 1 Golden Meadow to Leeville, and I-10 New Orleans East to Lake Pontchartrain. These roads are heavily trafficked and very vulnerable to land loss due to their vulnerable location.

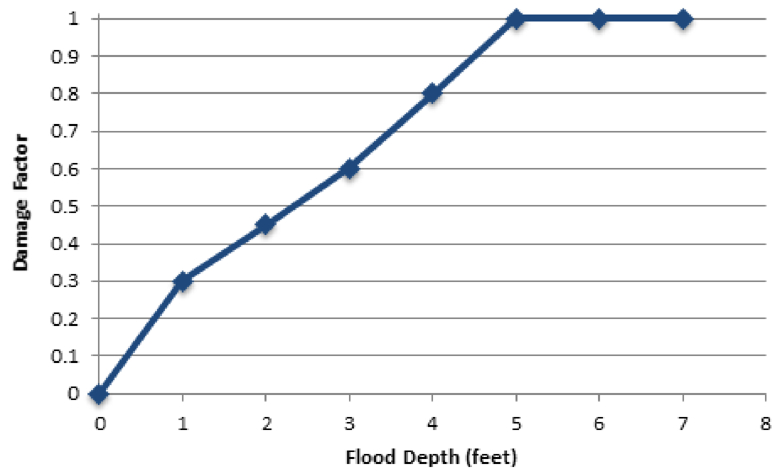
Rail and Road Depth-Damage Curves

While the CLARA modeling system does include depth-damage curves for roads and railway infrastructure, the research team was skeptical of the high values of damage at relatively low flood levels due to the default depth-damage curves included in the CLARA/HAZUS MH modeling system. As such, we identified three additional sources of depth-damage curves from European sources that could be used to determine the expected cost of storm damage. These include the following: HIS-SSM (Standard Method), Damage Scanner, and Rhine Atlas Damage Model (RAM).

HIS-SSM

The HIS-SSM model (Hoogwater Informatie Systeem – Schade en Slachtoffer Methode), also known as the Standaardmethode (Standard Method) was developed by Kok et. al in 2000, with subsequent revisions in 2002 and 2004 (Kok et al. 2005). The road and rail curve developed for the HIS-SSM model can be found in Figure A.5:

Figure A.5. HIS-SSM Model (Standard Method) Depth-Damage Curve



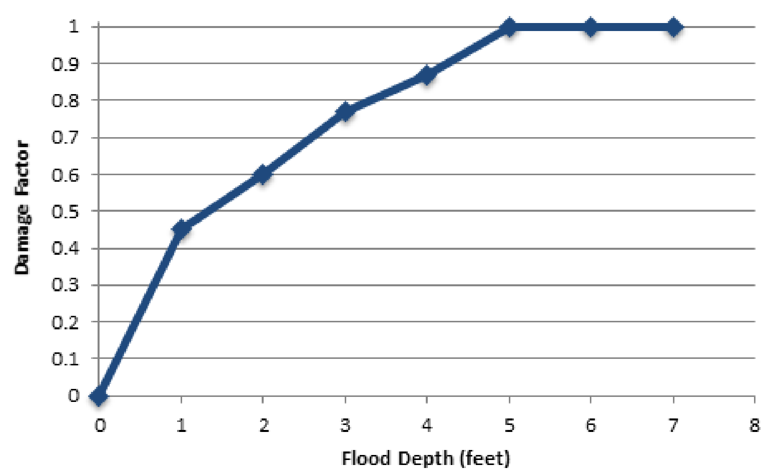
Source: Kok et al. 2005, recreated by authors.

Using this model, all roads and railways are considered 100 percent destroyed with 5m of flood waters.

Damage Scanner

The Damage Scanner model is considered a simplified version of the HIS-SSM model, and the model requires less detailed inputs, which is both a strength and weakness of the model (Admiraal 2011, Kellerman et al 2015). Damage Scanner was developed to help the Netherlands predict climate change impacts, but only considers inundation depth (Admiraal 2011). The Damage Scanner curve was developed using expert judgment rather than empirical data (Kellerman et al 2015). Figure A.6 shows this depth-damage curve.

Figure A.6. Damage Scanner Depth-Damage Curve



Source: Kellermann et al. 2015, recreated by authors.

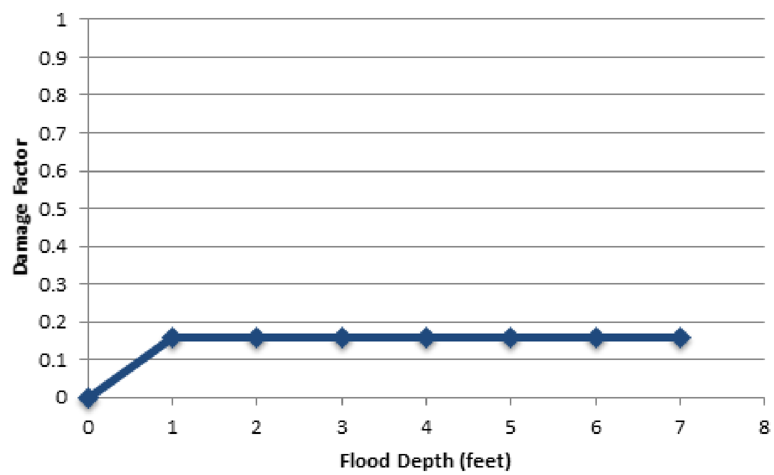
In this model, again, roads and railroads are considered 100 percent damaged with 5m of flood depth. However, this model has more damage at the lower flood depths relative to the HIS-SSM model.

Rhine Atlas Damage Model

An additional depth damage curve is named the Rhine Atlas Damage Model (RAM). RAM was developed based on empirical flood damage data from the HOWAS database (Kellermann et al 2015). In the curve below, the term "traffic" refers to the infrastructure sector (Kellermann et al 2015).

The RAM depth-damage curve is illustrated in Figure A.7.

Figure A.7. Rhine Atlas Damage Model (RAM) Depth-Damage Curve



Source: Kellermann et al. 2015, recreated by authors.

Assessment of Models

For rail, a 2015 study compared data from the 2006 flood of the Austrian Northern Railway to the Damage Scanner and the Rhine Atlas curves. The results of this study showed that Damage Scanner more accurately reflected the damage incurred to railways (Kellermann et al., 2015).

Road damage behaves differently from rail damage, and an expert from the Louisiana Transportation Research center informed us that the Rhine Atlas curve is most consistent with flood damage to roads.

Depth-Damage Curves Used in the Analysis

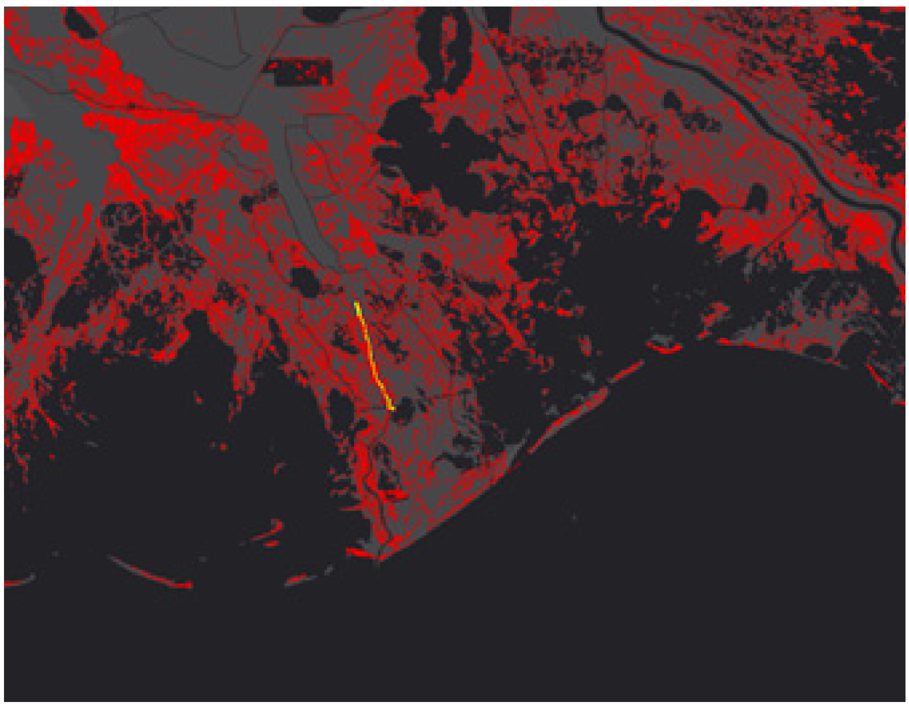
To assess the damage to rail, we used the Damage Scanner curve. To assess the damage to roads and highways, we used the Rhine Atlas curve.

Strategic Roads at Risk from Direct Land Loss

Estimates of the value of roads and highways at risk from direct land loss are presented in Table 3.3 in the main report. However, there are two specific highways that are at risk of damage due to land loss that could create substantial disruptions and increase economic costs beyond those quantified in the main report: Highway 1 between Golden Meadow and Leeville to Port Fourchon, and I-10 near New Orleans before the Twin Spans over Lake Pontchartrain. Both are both heavily used highways in Louisiana and will likely need some improvement before 50 years pass.

Figure A.8 shows the location of Highway 1 between Golden Meadow and Leeville relative to the 50 year, less optimistic scenario. Parts of original Highway 1 have been replaced by an elevated toll road, though this segment is still at grade. The LA 1 Coalition hopes to upgrade this section to an elevated road, but as of yet there are no dedicated plans or funding to do so (LA 1 Coalition).

Figure A.8. Hwy 1 to Port Fourchon, Less Optimistic Scenario, 50 Year

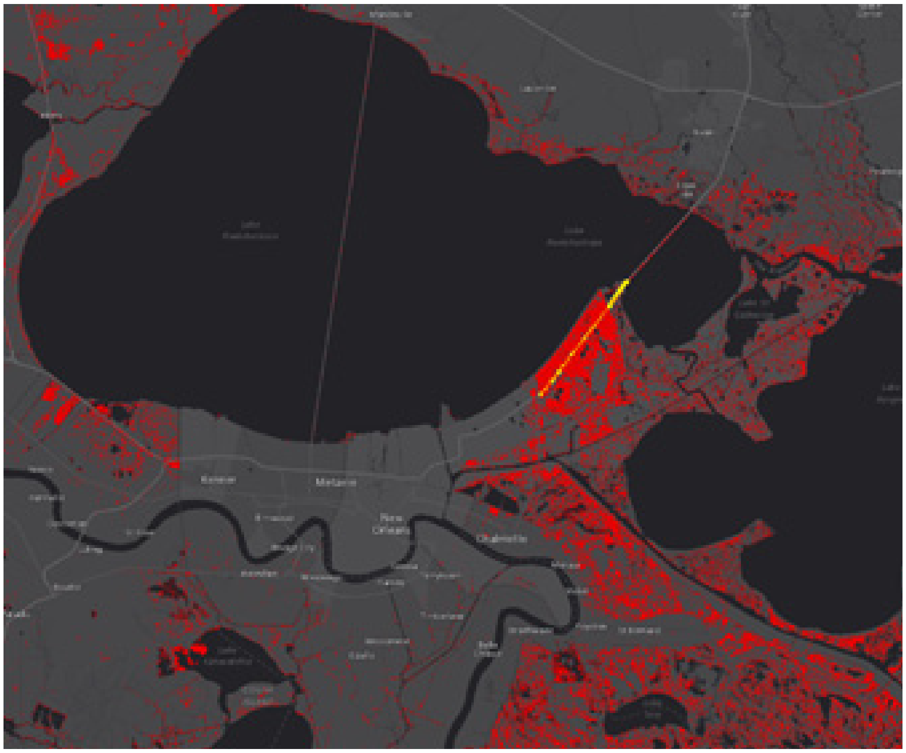


Source: CPRA, LADOTD.

Highway 1 from Golden Meadow to Leeville is located in Lafourche Parish, surrounded by marsh and wetlands, and not protected within a levee system. This highway is expected to see significant damage over the next 50 years, possibly being completely washed out over this time horizon. It is a heavily traveled road, the only land route to Port Fourchon, the southernmost sea port for servicing offshore oil platforms and drilling rigs and the Louisiana Offshore Oil Port (LOOP) pipeline, and to Grand Isle, a barrier island town and popular destination. Average daily traffic on Highway 1 between Golden Meadow and Leeville was 12,854 vehicles in 2012.

Figure A.9 shows the location of Interstate 10 between New Orleans and Lake Pontchartrain relative to the less optimistic, 50-year land loss scenario.

Figure A.9. I-10 Between New Orleans and Lake Pontchartrain, Less Optimistic Scenario, 50 Year



Source: CPRA, LADOTD.

This stretch of I-10 between Lake Pontchartrain and New Orleans is located within Orleans Parish and the city of New Orleans, but does not have any habitation or businesses along it. It is located in the Bayou Sauvage National Wildlife Refuge, an area of low-lying wetlands inside the protective levee system. Though it is within the levee system, this area is sinking. Thus the road segment is expected to experience heavy losses over the next 50 years and will be put at risk of complete disconnection at some points. Average daily traffic on this stretch of I-10 was 662,239 in 2012. In addition to being the southernmost transcontinental highway and an important road for commerce and through-traffic, it also supports daily commuter traffic into New Orleans jobs from the north shore of Lake Pontchartrain, especially Slidell. The Census OnTheMap tool shows that in 2011, nearly 25,000 workers drive into New Orleans from the northeast and another 10,500 drive from New Orleans to these communities, most of whom take I-10 to and from work every day.

Pipelines

Data and Methodology

Pipeline geodatabase and replacement costs come from the LSU Center for Energy Studies. Although length of pipelines exposed to open water and length of pipelines can be calculated, we cannot calculate the amount of damage that will occur, or the replacement cost of these pipes.

Dismukes, et al. (undated) argue that coastal erosion can have two types of impacts on energy infrastructure. First, coastal erosion and land loss can contribute to the damage suffered from “catastrophic” storm events. This damage is included in the Chapter 3. Second, coastal erosion results in increased costs for operation and maintenance and/or infrastructure hardening due to the changing environment. However, the authors did not speculate as to the magnitude of the increased costs.

Pipelines and Direct Land Loss

Pipes that were originally engineered to be buried can be exposed due to water and wave action and subsidence of wetlands. We discussed possible outcomes of newly exposed pipelines and whether the increased vulnerability could be quantified with David Dismukes, Executive Director of the LSU Center for Energy Studies. Dismukes said that there is no current literature to quantify exactly how pipelines would be affected, but that it could be expected that these pipelines would require more maintenance and be more prone to damage (i.e., maintenance and operations costs may increase). Once exposed, these pipelines become more vulnerable to ruptures. Without protective marshes to moderate wave strength and without the stabilizing effect of surrounding dirt, they can be impacted by the elements, causing cracks and breaks in pipes. Many of the older pipes are particularly vulnerable to cracking.

Waves are not the only risk faced by exposed pipelines: propellers from fishing and recreational vessels or anchors dragging across the sea floor can crack natural gas or crude oil pipes. For example, a boating incident in 2002 ruptured a recently exposed pipeline and discharged nearly 100,000 gallons of oil into the Gulf before divers could repair the pipe (Dell'Amore 2010).

In Table 3.5, we calculate the total mileage of pipelines at risk from the four land loss scenarios. Pipeline network geodata and replacement costs were compiled by the LSU Center for Energy Studies. It is not expected that exposed pipelines will all need to be replaced; these are just an indication of increased vulnerability. In the event that pipelines do need to be replaced, the Center for Energy Studies has compiled pipeline construction costs in the United States from 2005 to 2014. Replacement costs for smaller diameter pipes (<20in) average about $2.5 million/mile; for larger diameter pipes (>20in), about $3.3 million/mile.

Pipelines and Storm Damage

Like exposed pipelines, pipelines experiencing flooding are more vulnerable to cracks and ruptures. Exactly to what degree they are affected cannot be determined, but the length of flooded pipelines is detailed in Table 3.5 in the main report.

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Appendix B: Detail on Specific Industries and Public Structures at Risk

The structures and activities in this appendix are included in the results from Chapter 3, but additional detail is presented here.

Military

Coastal Louisiana has seven major military locations that may be directly at risk of land loss and will likely be impacted by increased flood damage in the future. Table B.1 lists the facility, owner, and building area, in addition to the number of military personnel if available.

Table B.1

Military Post Locations in Coastal Louisiana

Name	Base Owner	Parish	Building Area (millions of square feet)	Number of Military Personnel
Naval Air Station Joint Reserve Base New Orleans	Navy	Plaquemines	197	5,400
Coast Guard Station Venice	Coast Guard	Plaquemines	0.1	38
Louisiana National Guard Gillis Long Center	National Guard	Iberville	20	Unknown
Camp Villere	National Guard	St. Tammany	92	Unknown
Coast Guard Station New Orleans	Coast Guard	St. Bernard	0.8	330
Jackson Barracks Air National Guard	National Guard	St. Bernard	7.7	Unknown
Coast Guard Station Grand Isle	Coast Guard	Jefferson	1.9	46

Source: TIGER/Line Shapefile, Military Installation National Shapefile, United States Census Bureau.

We were unable to locate depth-damage curves for military facilities, and thus incremental storm damage estimates were not estimated. However, Table B.2 reports costs for military construction as in the UFC 3-701-01: DoD Facilities Pricing Guide:

Table B.2

Military Construction Facility Unit Costs

Facility Type	Unit Cost ($ per sq foot)
COMMUNICATIONS BUILDINGS	$250-320
AIRCRAFT OPERATIONS BUILDINGS	$270 facility, $36,000 tower
AIRFIELD FIRE & RESCUE STATION	$270
HEADQUARTERS/OPERATIONS BUILDINGS	$200-230
ACADEMIC INSTRUCTION BUILDINGS	$200-280
ARMED FORCES RESERVE CENTER	$190
MAINTENANCE HANGARS	$220-230
MAINTENANCE SHOPS	$140-250
WAREHOUSE/ STORAGE FACILITIES	$120-260
MEDICAL (MED) FACILITIES	$230-430
ADMINISTRATIVE FACILITIES	$230-290
UNACCOMPANIED PERSONNEL HOUSING	$170-190
OFFICERS QUARTERS	$220
DINING FACILITY	$280-350
FAMILY HOUSING	$92-120
FAMILY SUPPORT FACILITIES	$220-260
COMMUNITY SUPPORT FACILITIES	$210-270
DEPENDENT SCHOOLS	$220
TRANSIENT LODGING FACILITY	$220
PARKING GARAGE / BUILDING (450 SF/vehicle includes turning space and ramps)	$43
INDOOR FIRING RANGE	$290
KENNEL- MILITARY WORKING DOG	$260

Source: UFC 3-701-01, Change 6, May 2014: DoD Facilities Pricing Guide.
Note: All monetary values presented in 2012 dollars.

It seems likely from Table B.2 that costs per square foot are likely between $200-300 on average. Using the square footage estimates in Table B.1, there are a total of just under 300 million square feet of military structures in coastal Louisiana at risk from land loss, valued at between $60 to 90 billion. Because they do not appear in the InfoUSA database, these buildings are not included in the baseline non-residential stock of structures.

Schools

Land loss and storm damage infrastructure costs to schools are included in the result totals in Chapter 3. This appendix uses another data source with additional information about enrollment to characterize schools that receive flooding from the three storm case studies.

Data

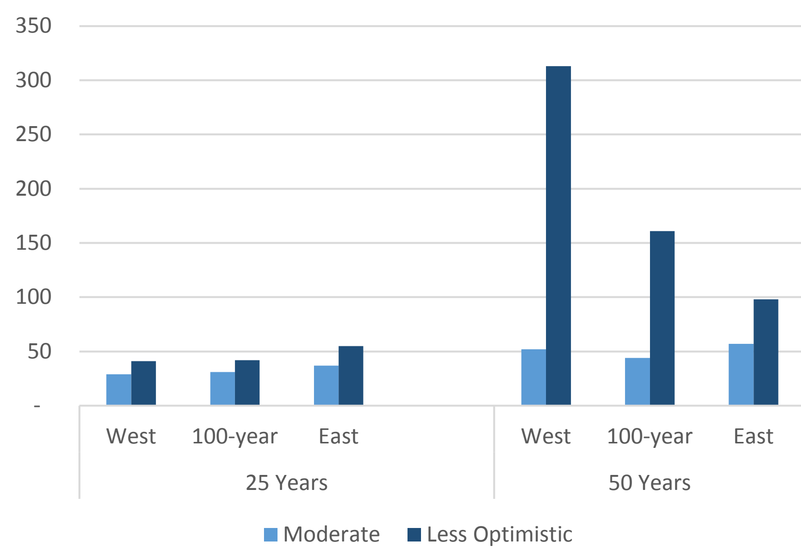
Data on locations of schools were accessed through HSIP-Gold 2013. There are two kinds of location data. For private and public schools K – 12, we have point files from the Oak Ridge National Laboratory (ORNL), a multi-program science and energy laboratory with the U.S. Department of Energy. For colleges and universities, we have polygon boundary files from NAVTEQ, outlining the entire campus of a school. The ORNL point files for public and private schools contain attributes on start and end grades, enrollment, and full time equivalent positions, last updated in 2009 or 2010.

Schools are assigned to Census blocks and considered "flooded" if the mean flood depth in the census block is greater than 0.

Results

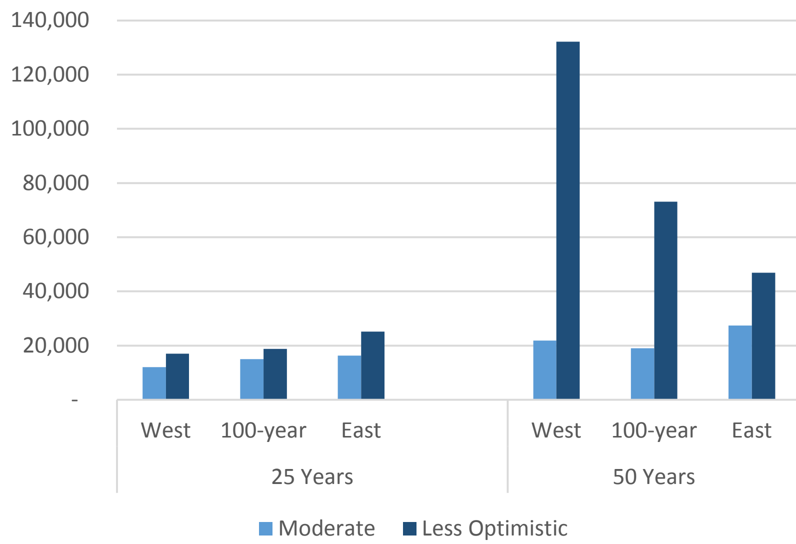
The increased number of K-12 schools flooded in the three storm scenarios and 2010 enrollment at those schools is shown in Figures B.1 and B.2.

Figure B.1. Number of K-12 Schools Facing Increased Storm Damage



Source: Authors' calculations.

Figure B.2. Student Enrollment in K-12 Schools Facing Increased Storm Damage



Source: Authors' calculations.

The figures show that depending on the land loss scenario, between 30 and 55 K-12 schools will be put at risk from increased storm damage within 25 years, with that range increasing to 44 to over 300 schools in 50 years. This could mean more than 130,000 K-12 students affected. The relatively large increases in the 100-year and eastern storm track cases are again due to predicted failure of storm protection systems in New Orleans. Fewer than five colleges and universities are at risk of land loss, so student enrollment is not presented.

Hospitals

Land loss and storm damage infrastructure costs to hospitals are included in results totals in Chapter 3. This appendix uses another data source with additional information about hospital admissions and other data to characterize hospitals that receive flooding from the three hypothetical storms. Hospitals at risk to direct land loss are too few to present in this section.

Data

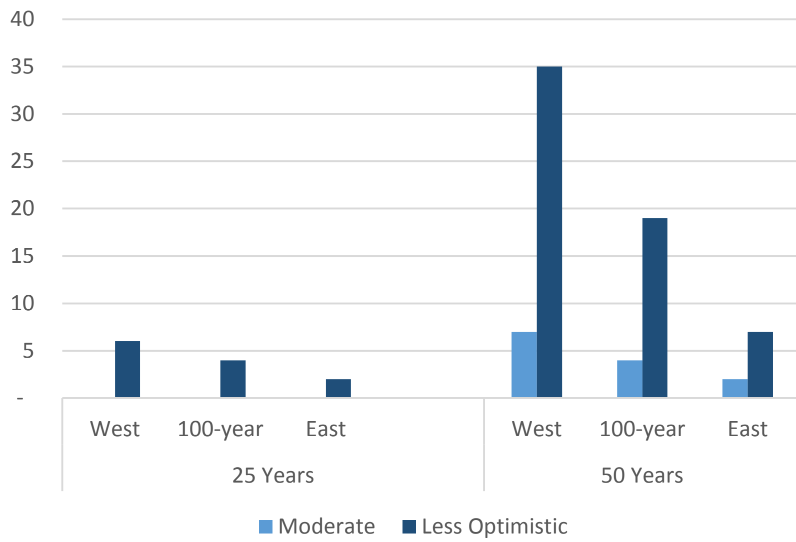
LSU Atlas contains a shapefile from 2007 for hospitals produced by Louisiana Department of Health and Hospitals (DHH), which accredits hospitals in the state and has the most complete and accurate list. We compared this shapefile to an updated 2015 list of hospitals on DHH's website to update the information. Additional information about many of these hospitals was found using the American Hospital Association Healthcare DataViewer. Each search for a specific hospital in the database returned the primary service provided, total beds, urban-rural classification, admissions, outpatient visits, births, and personnel.

Hospitals are assigned to Census blocks and considered "flooded" if the mean flood depth in the census block is greater than 0.

Results

The increased number of hospitals flooded in the three storm scenarios is shown in Figure B.3.

Figure B.3. Flooded Hospitals From Increased Storm Damage



Source: Authors' calculations.

The figure shows that while no additional hospitals are at risk of flooding under the moderate land loss scenario in 25 years, an additional 2-6 hospitals are at risk under the less optimistic scenario. This range expands to 2 to 25 additional hospitals in 50 years, with the largest increases coming when New Orleans is predicted to flood.

Because data on admissions and outpatient visits could not be found for every hospital, we do not present a table tabulating these. However, most hospitals lacking information in the American Hospital Association Database are smaller hospitals that would not add significantly to the number of beds and admissions statistics. In the eastern track storm 50 year less optimistic scenario, hospitals flooded saw more than 135,000 patients in general admissions annually and received more than 2 million outpatient visits. This does not mean that more than 2 million people will be affected, since many hospitals will receive only minimal damage from flooding and reopen again quickly.

Wastewater Treatment Plants

Data

Wastewater treatment plants are crucial for human and environmental health. The list of wastewater treatment plants was found in the HSIP database.

Results

One location (in Cameron Parish) was at risk for damage from land loss and storm damage. Despite the relative low risk to wastewater treatment plants in the state, care should still be taken designing and siting wastewater treatment plants, because functioning wastewater treatment plants are critical for human health and pollution reduction.

Tourism

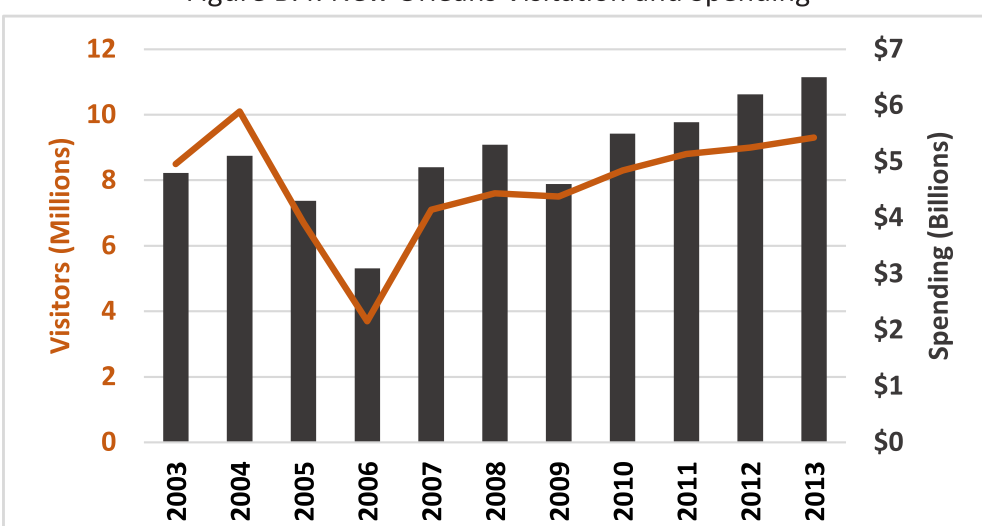
While damages and disruptions to businesses supported by tourism are included in the results in Chapter 3, we review Louisiana tourism in this section to highlight a prominent connection that many from outside of Louisiana have to coastal Louisiana. The city of New Orleans drives most tourist activity in the state. This is seen by the fact that total tourist spending in the state was $10.8 billion in 2013 and $6.5 billion of that was spent by visitors to New Orleans. For comparison, total recreation-related expenditures across the state, including by Louisiana residents, totaled $2.7 billion.

Most of the tourist activity in New Orleans is not intrinsically linked to coastal marshes or other threatened areas, although approximately 5 percent of visitors report outdoor recreation as their primary purpose. Visitor surveys show that the most common reasons reported for visiting New Orleans are visiting friends or relatives, general business, entertainment, sightseeing, and conferences or conventions. Louisiana's four largest festivals (Mardi Gras, New Orleans Jazz & Heritage Festival, French Quarter Festival, and Essence Music Festival) are all in New Orleans. Some of New Orleans' other draws include casinos, cruises, and museums.

Although most of this tourist activity occurs in the city of New Orleans and not in the wetlands and other areas of heavy land loss, the threat of future severe storms may still affect tourism. Figure B.4 reports estimated tourism and associated spending in the City of New Orleans from 2003 through 2013. Note that from 2004-06, annual visitors declined by more than half, presumably due to Hurricanes Katrina and Rita, and that the number of visitors in 2013 had still not reached the level seen in 2004, before the storm.

Future severe storms may have similar detrimental effects on the tourism industry in Louisiana, though Katrina, due to its magnitude and the failing of the levees, affected tourists for a much longer period of time than most other storms.

Figure B.4. New Orleans Visitation and Spending



Source: CRT. Note: All monetary values presented in 2012 dollars.

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Appendix C: Oil and Gas Industry Detail

Louisiana is an important source of oil and natural gas production and processing for the United States. In addition to the production within Louisiana borders and Louisiana waters, much of the oil and gas extracted from the Gulf of Mexico travels through Louisiana. We anticipate that coastal land loss will create some changes to the oil and gas industry. We include oil and gas-related industries in the results from Chapter 3, but in this appendix, we provide more detail and additional information about strategic oil and gas infrastructure in Louisiana, which may become increasingly vulnerable due to land loss.

Brief History of Oil and Natural Gas Production in Louisiana

The first oil well to produce commercial quantities of oil in Louisiana was drilled in 1901 near Jennings, Louisiana. Thousands of wells for both oil and natural gas have been drilled since then, as well as a multitude of other infrastructure. The first natural gas pipeline was laid in 1908. The first refinery (now the Exxon refinery in Baton Rouge) went on stream and the first long-distance oil pipeline began construction in 1909. By 1910, the first over-water drilling in America occurred in Caddo Lake near Shreveport (History of the Industry 2010).

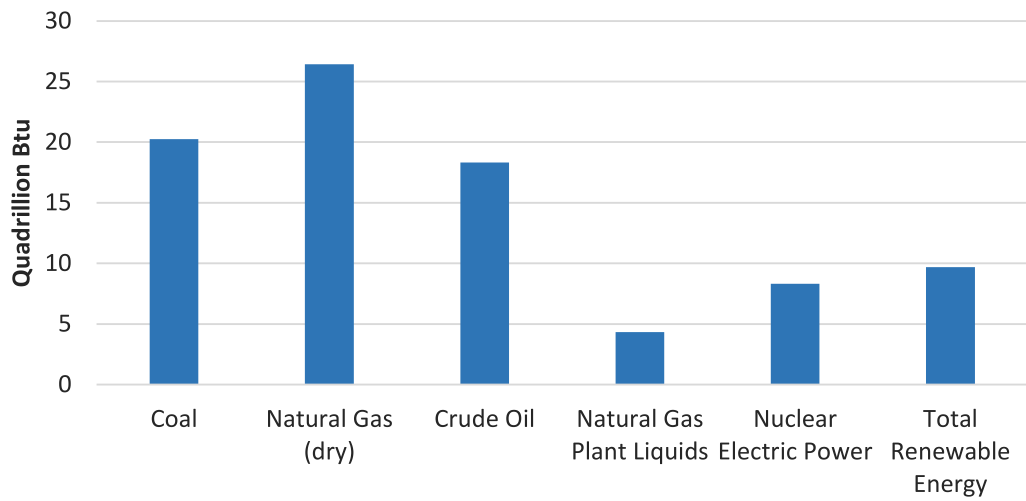
The oil and gas and refining industries have continued to grow in leaps and bounds since these first steps, moving further offshore and dredging open saltwater canals through the marsh to lay pipelines. This infrastructure is a vital part of oil and gas in Louisiana, with approximately 125,000 miles of pipelines onshore and in Louisiana waters (Pipelines 2010). In 2014, Louisiana pipelines were estimated to have a fair market value of over $3.7 billion by the Louisiana Tax Commission (Louisiana Tax Commission 2014). When many of these pipelines were laid, the coast was seen as much more stable than it is perceived today. In addition, Louisiana is home to two major oil and gas distribution centers, the Louisiana Offshore Oil Port (LOOP), and Henry Hub. These are discussed in further detail under the Supplemental Oil and Gas Infrastructure At Risk later in this section.

Louisiana is now the second largest producer of crude oil and natural gas in the nation, and second in petroleum refining capacity after Texas. The energy sector accounted for $73.8 billion in sales in Louisiana firms, generated over $20.5 billion in household earnings for Louisianans, or 11.6 percent of total earnings in Louisiana, and supported 287,008 jobs in 2011 (Loren Scott 2014). These industries contributed $4.2 billion to state and local treasuries directly through state taxes and fees and indirectly through taxes derived from household earnings (Loren Scott 2014).

Louisiana's Contribution to U.S. Energy Supply

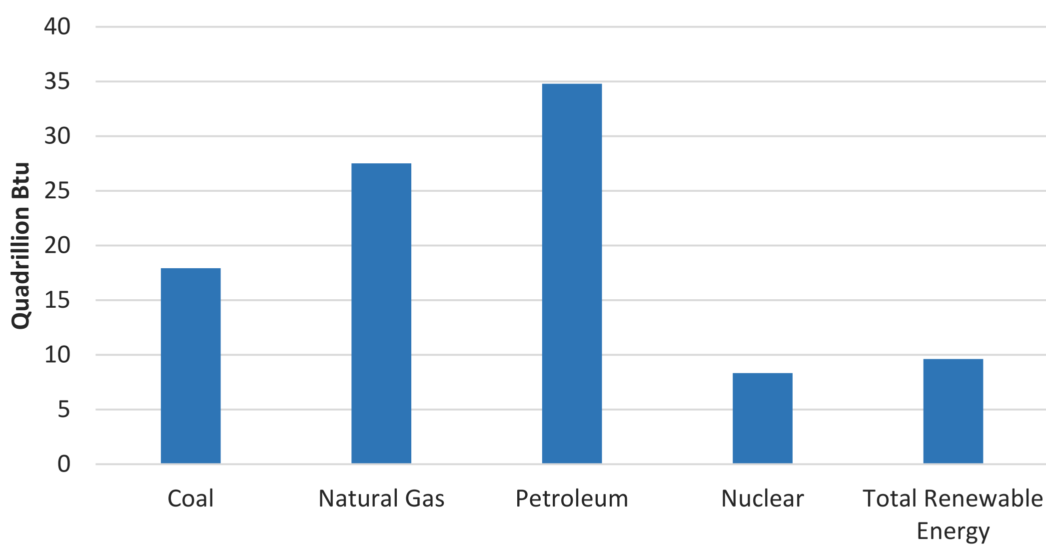
Most energy produced and consumed in the United States comes from fossil fuels, especially coal, natural gas, and oil/petroleum. Figures C.1 and C.2 show U.S. energy production and consumption by source in 2014. Natural gas and petroleum are the largest sources of energy consumption in the United States and are produced domestically in large quantities as well. Much of this production occurs in Louisiana or in the Gulf of Mexico. Louisiana serves as a base for much of the support, supplies and employees for the offshore region, as well as for the pipelines that deliver oil and gas to the rest of the nation.

Figure C.1. US Energy Production by Source, 2014



Source: EIA, 2014.

Figure C.2. US Energy Consumption by Source, 2014



Source: EIA, 2014.

Table C.1 details the sources of crude oil in the United States by production and imports. Louisiana and the Gulf of Mexico together contribute 18 percent of domestic production in the United States in 2014. About 45 percent of total crude oil imports comes through the Gulf Coast, much of this through Louisiana.

Table C.1

Crude Oil Production and Imports in Louisiana and the Gulf

Source Of Crude Oil	Thousands of Barrels	Percent of Total
TOTAL US PRODUCTION	3,176,621	
Louisiana	68,356	2%
Federal Offshore Gulf of Mexico	509,976	16%
TOTAL US IMPORTS	2,680,626	
Imports through the Gulf Coast	1,195,569	45%

Source: EIA, 2014.

Louisiana and the offshore region are also very important to domestic natural gas production. As of 2012, Louisiana had 19,792 producing gas wells, representing about 4.1 percent of all the gas wells in the United States. Table C.2 reports total natural gas production and Louisiana's share of that total.[1]

Table C.2

Natural Gas Production in Louisiana and the Gulf

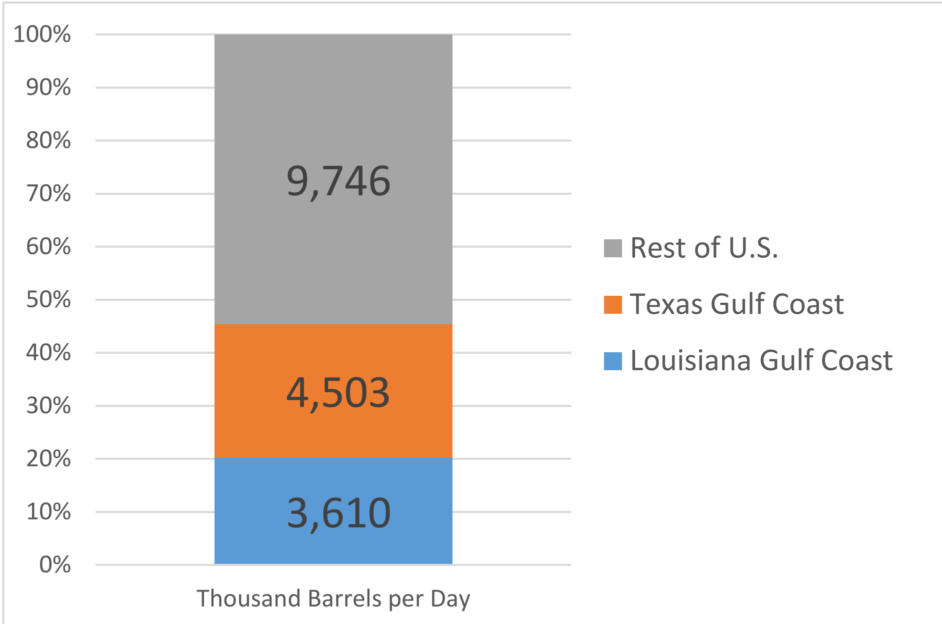
Source Of Natural Gas	Millions of Cubic Feet	Percent of Total
TOTAL US WITHDRAWLS AND PRODUCTION	32	
Louisiana	2.0	6%
Federal Offshore Gulf of Mexico	1.2	4%

Source: EIA, 2014.

Finally, Louisiana's refineries and natural gas processing centers are a vital part of its economy. Louisiana refineries comprise a significant portion of the U.S. refining capacity. Overall, the Louisiana Gulf Coast refineries (this does not include a small number of refineries in northern Louisiana) had a net input of 1.17 billion barrels of crude oil in 2014, up from around 741 million barrels in 1981 (EIA Refinery Utilization and Capacity). This results in the production of 972 million barrels of finished petroleum products (EIA Product Supplied) Louisiana Gulf Coast refineries have an operable capacity of 3.6 million barrels per calendar day and ran at a utilization rate of 92 percent in 2014 (EIA Refinery Utilization and Capacity). Together with the Texas Gulf Coast, this comprises nearly half the refining capacity in the United States. Figure C.3 documents Louisiana's share of total U.S. refining capacity.

[1] Total figures for the United States include natural gas withdrawals, which is the removal of natural gas from storage facilities.

Figure C.3. Operating Capcity of Refineries on the Gulf Coast and the Rest of the United States



Source: EIA, 2014.

Natural gas processing in Louisiana totaled 923,772 million cubic feet in 2013, approximately 4.5 percent of total processing in the United States. Just a few years ago in 2011, Louisiana natural gas processing totaled 12.4 percent of the entire U.S. processing, but the domestic market has changed (EIA Natural Gas Plant Processing).

Supplemental Oil and Gas Infrastructure at Risk

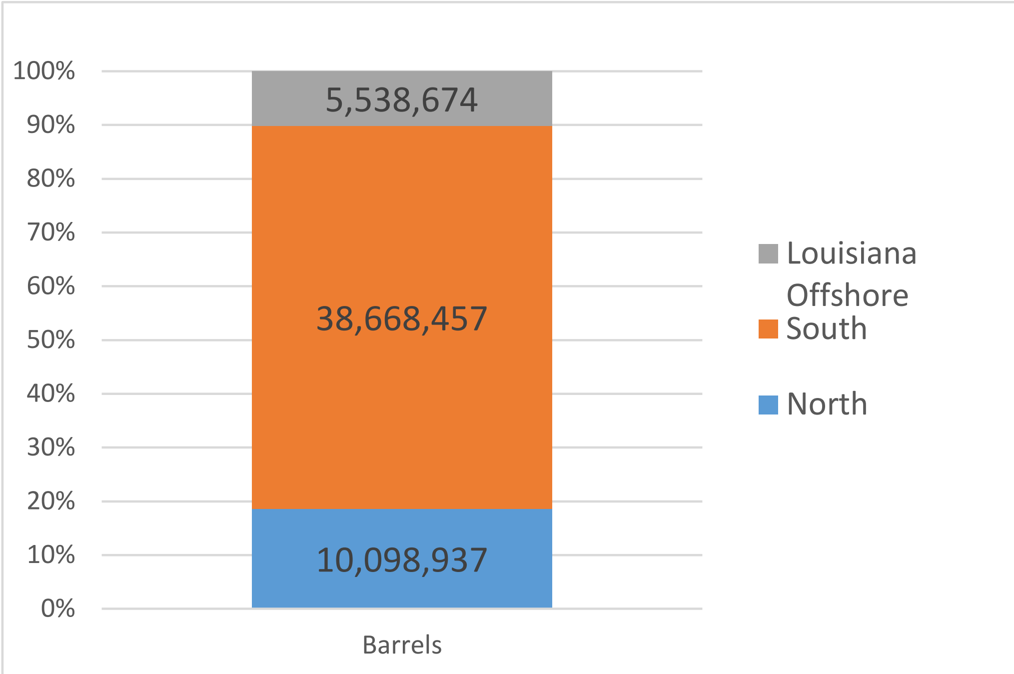
Oil and gas infrastructure such as terminals, platform fabrication, and supply bases are included in the calculations on general economic infrastructure and activity in Chapter 3, but this section will highlight and provide more detail for certain critical oil and gas infrastructure put at greater risk due to coastal land loss.

Oil and Gas Wells

Louisiana has thousands of oil and gas wells drilled over the last century. Most are plugged and abandoned, but many are still producing today. Geodata on oil and gas wells comes from Louisiana Department of Natural Resource's Strategic Online Natural Resource Information System. The data include all inland wells and wells just offshore in Louisiana state waters. There are over 235,000 wells listed, most of them plugged and abandoned or otherwise shut down; only about 19 percent are still active.

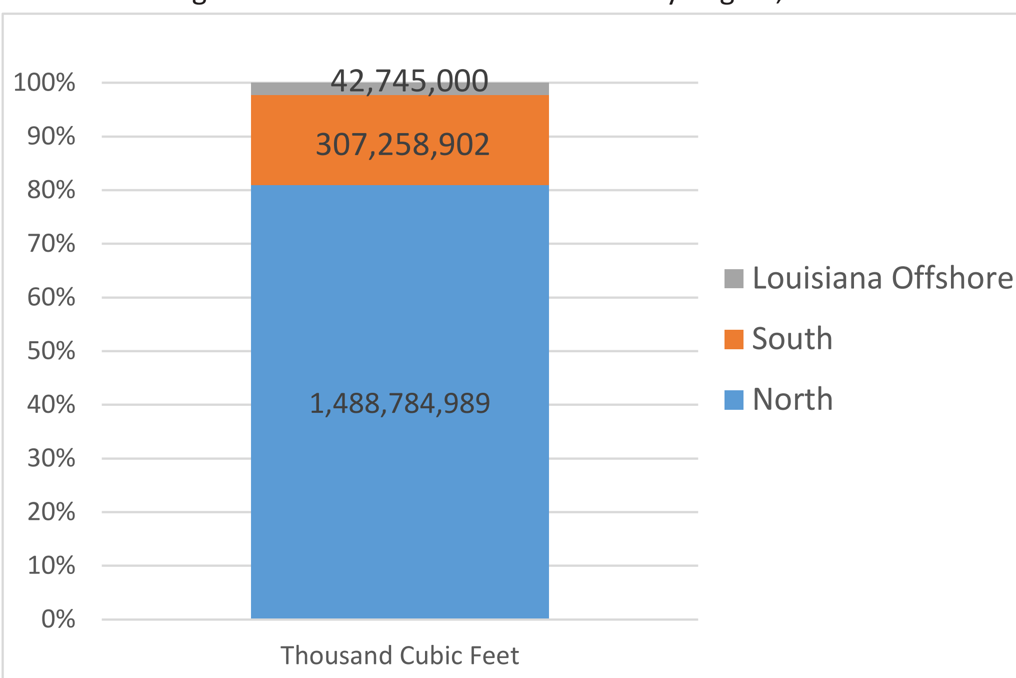
Figures C.4 and C.5 show Louisiana oil and gas production by region (north, south, and offshore). These figures show Louisiana oil production is concentrated in the south, where land loss occurs, while gas production is concentrated in northern Louisiana.

Figure C.4. Louisiana Oil Production by Region, 2014



Source: Louisiana Department of Natural Resources, 2015.

Figure C.5. Louisiana Gas Production by Region, 2014



Source: Louisiana Department of Natural Resources, 2015.

Land loss around oil and gas wells can lead to a significant loss of production. For the most part, inland facilities are not designed to accept the wind and wave forces experienced in open water. Many of these inland facilities are older and would incur high enough expenses to adapt to a more open environment where waves would occur, that many wells would shut-in production (Waldemar S. Nelson 2003).

While the extent of the damage is unclear, we follow the procedures used for infrastructure stocks and identify the total number of active wells that are located in areas projected to be affected by land loss. Table C.3 shows that between 13-14 percent of all wells are located in land loss areas, but regardless of scenario, only about 6 percent of these are currently active. As such, approximately 2000 active wells are at direct risk from land loss.

Table C.3

Number of Wells in Land Loss Area

	Total Wells in State	Total Wells in Land Loss Area	Active Wells in Land Loss Area	Percent Land Loss Wells Active
Moderate, 25 Years	240,000	31,000	1,900	6.3
Moderate, 50 Years	240,000	31,000	2,000	6.3
Less Optimistic, 25 Years	240,000	32,000	2,000	6.2
Less Optimistic, 50 Years	240,000	33,000	2,000	6.2

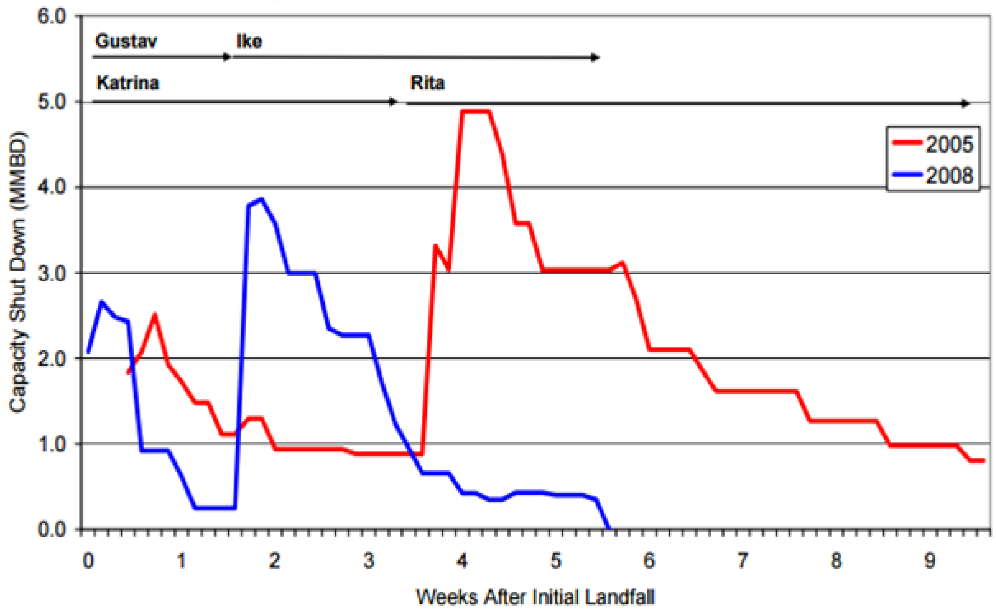
Source: Louisiana Department of Natural Resources, 2014.

Refineries

No refineries are directly located in land loss areas in any of the scenarios under consideration, but a portion of these facilities are at risk to increased storm damage. Many refineries along the coast may be damaged by severe wind and possible flooding, and also are likely to lose power during a storm. Many have berms to protect from storm surge and generators that can produce power for partial operations until full power is restored. Surrounding communities may be affected, causing workforce disruptions. Many refineries shut down in preparation for a storm and take several days to several weeks to restart again for these reasons. In the past, most refineries have only completely shut down for a few days during and after a major storm. They tend to operate at reduced runs on backup power for a few more days to a few weeks before resuming normal operations (U.S. Department of Energy 2009).

Figure C.6 illustrates how refineries quickly resume full capacity after a storm, based on hurricane data in 2005 and 2008. In 2005, the refinery shutdowns from Hurricane Rita were much larger than during Hurricane Katrina because Hurricane Rita hit the western part of Louisiana and eastern Texas, where there is more total refining capacity than in eastern Louisiana and Mississippi, the foci of Hurricane Katrina.

Figure C.6. Duration of Refinery Shut Downs During 2005 and 2008 Hurricanes



Source: U.S. Department of Energy, 2009.

Given the fluctuation in prices of natural resources during the mid-2010s we do not estimate the value of disruption in capacity represented in Figure C.6. However, this information, combined with capacity information in Figure C.3 and assumptions about daily operations (as a percent of capacity), average prices of crude oil, and percent of capacity affected by a given storm could, in theory, be used to estimate the interruption in refinery flows.

Natural Gas Processing

There are four natural gas processing plants with total capacity 2,340 million cubic feet per day on land at risk of being lost in the moderate 25 year scenario, and one additional plant with approximately 800 million cubic feet per day in the less optimistic 50 year scenario. These plants have invested in their protective infrastructure, however, so it is not certain exactly how much risk these plants have. Like refineries, many natural gas processing facilities have protection against storm surge and have backup generators in place. But there will still be some increase in damage if land loss allows storm surge higher than protective structures to occur.

Other Important Oil and Gas Infrastructure Locations

Louisiana Offshore Oil Platform (LOOP)

The Louisiana Offshore Oil Platform (LOOP) is the only port in the nation capable of offloading deep draft tankers known as Ultra Large Crude Carriers and Very Large Crude Carriers. It plays a key role in receiving waterborne crude oil imports as well as domestic crude oil produced in the Gulf of Mexico. It has a throughput of 1.7 million BPD crude oil. LOOP has a marine terminal offshore and onshore facilities at the Fourchon Booster Station in Port Fourchon and Clovelly Dome Storage terminal near Galliano, 25 miles inland.

Pipelines connect LOOP to refineries in Louisiana and along the Gulf Coast as well as to Capline, a pipeline which transports crude oil to refineries in the Midwest (LOOP, LLC). Although land loss will not affect the marine terminal, onshore facilities may be affected. There is a significant amount of land loss directly around these onshore facilities and they are both in areas at risk to flooding during a hurricane, though the Clovelly facility is within a levee system. Additionally, The Fourchon Booster Station can only be reached by land across Louisiana Highway 1. As explored in the roads section of Appendix A, the non-elevated portion of Highway 1 (Golden Meadow to Leeville) is at risk to land loss, which creates a real threat to current support a for oil and gas operations in the Gulf of Mexico.

Even if the highway is not washed out, it may see greater rates of inundation from storms and seasonal weather and be impassible for periods of time. This prevents employees from reaching the Booster Station. Another significant factor is the supply of electricity. In recent years, LOOP was shut down due to Hurricanes Rita and Katrina in 2005 and Gustav in 2008 for periods of 2 to 5 days. LOOP continued to operate at reduced rates for one to two weeks after the shut downs due to loss of power (U.S. Department of Energy 2009). Generators can assist with some flow, but without power restored, LOOP cannot operate at full capacity.

Port Fourchon

Port Fourchon is a service port in southern Lafourche parish, which supports the vast majority of offshore oil and gas exploration and production operations in the Gulf of Mexico. The port can be accessed by land only over Highway 1. This land route is threatened by land loss, as discussed in Appendix A, and without a bridge, may be washed out in the next 25 to 50 years. Port Fourchon is the land base for LOOP and is connected to 50 percent of U.S. refining capacity. It services over 90 percent of the Gulf of Mexico's deepwater oil production, and serves as a base of operation for over 250 companies (Port Facts).

A small amount of land loss in the Port Fourchon area is expected and accounted for the land loss and storm damage results; however, Port Fourchon has implemented several strategic land-building operations to expand capacity and protect the port from erosion. A larger consideration is the port's vulnerability to storm damage and the status of the all-important Highway 1 access, which warrant a more targeted analysis than could be completed within the context of this study.

Henry Hub

The Henry Hub, located outside of Erath, Louisiana, only a few miles from the Gulf of Mexico, is a distribution hub of 13 major natural gas pipeline systems. Because so much natural gas passes through Henry Hub, the price here is often used as a proxy for the average market price of natural gas in the United States. The Henry Hub area is not expected to see much land loss, though it is still vulnerable to flooding during hurricanes because of its close proximity to the coast.

Strategic Petroleum Reserve

The U.S. Strategic Petroleum Reserve's (SPR) two Louisiana facilities consist of 29 salt caverns capable of holding almost 300 million barrels of crude oil. These facilities are West Hackberry and Bayou Choctaw (Office of Fossil Energy, U.S. Department of Energy). There is some land loss expected near West Hackberry in Cameron Parish, but Bayou Choctaw is further north than any expected land loss. However, both may be affected by storms in the future. West Hackberry experienced flooding in both the 2005 and 2008 hurricane seasons, while Bayou Choctaw was temporarily shut down due to flooding after Hurricane Katrina (U.S. Department of Energy 2009). This made it more difficult to retrieve petroleum stores.

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Appendix D: Commodity Flow Detail

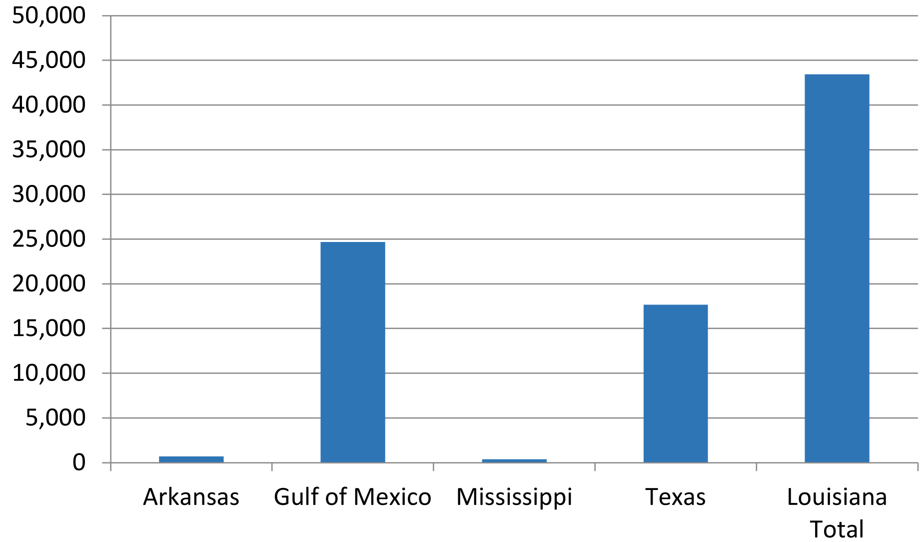
Disruption to commodity flows could occur due to disruptions in infrastructure directly attributable to land loss, or via disruptions due to storm damage. Without complex transportation system modeling and additional data, the extent of the disruption due to each is unknown, though the ultimate result of the disruption would likely be higher costs to shippers which would ultimately lead to higher prices for moved goods.

Instead, we report data on the commodity flows through Louisiana in more detail than in Chapter 4 of the main document. Data is segmented by transportation mode, and presented by commodity type where available. The data includes both flows that originate in Louisiana and for which Louisiana is the final destination, as well as "throughput" from outside of Louisiana to the rest of the world (where a Louisiana port is the final domestic destination) as well as vice-versa. Disruptions or changed costs for some or all of the commodities detailed here could generally be expected as a result of the effect of the land loss process on network infrastructure, though the precise magnitude of the disruptions is not estimated. Estimates in Chapter 3 and Chapter 4 provide the potential disruptions due directly to land loss by industry. However, these estimates do not include any potential effects from differences in transport costs on commodities passing through the state. This appendix documents these flows.

Commodity Flows by Pipeline

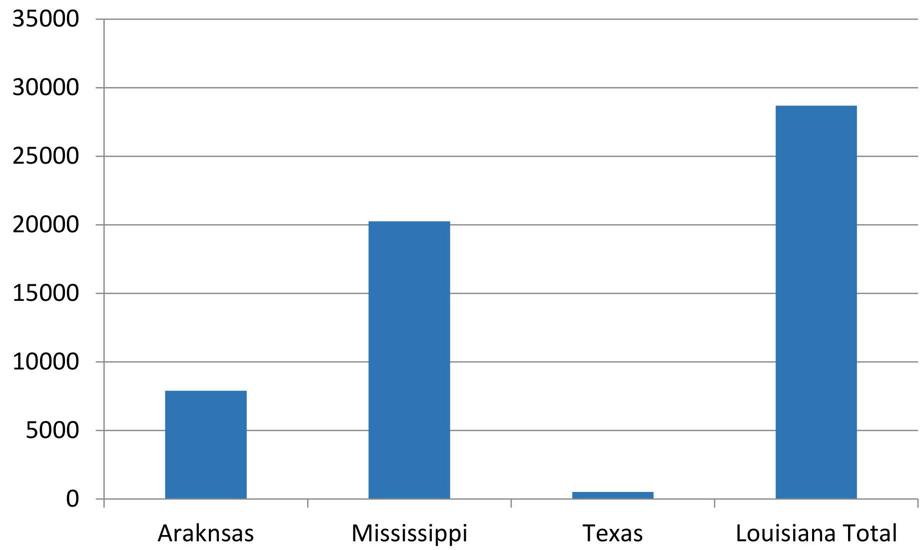
Pipelines provide vital transportation links for the oil and gas industry in Louisiana. These pipelines carry oil and gas from offshore, to refineries and production facilities onshore, and to refineries and facilities in other states. There are approximately 125,000 miles of pipelines in Louisiana, including onshore and in Louisiana waters (Pipelines 2010). In 2014, Louisiana pipelines were estimated to have a fair market value or use value of over $3.7 billion by the Louisiana Tax Commission (L.A. Tax Commission 2014). A comparison of pipeline inflow and outflow capacity by state is presented in Figures D.1 and Figure D.2.

Figure D.1. Pipeline Inflow Capacity 2013, in million cubic feet per day (MMcf/d)



Source: U.S. Energy Information Administration, U.S. state-to-state capacity.

Figure D.2. Pipeline Outflow Capacity 2013, in million cubic feet per day (MMcf/d)



Source: U.S. Energy Information Administration, U.S. state-to-state capacity.

Between 2003 and 2013, inflows into Louisiana increased by approximately 40 percent. During the same decade, outflows from Louisiana increased by approximately 20 percent.

Pipeline economic flow information on crude oil from Louisiana to other states is available from the Freight Analysis Framework (FAF) database. As seen in Table D.1, the value of total flows of crude oil from Louisiana to other states through pipelines totaled $30.9 billion in 2012, with volumes just under 70,000 thousand tons.

Table D.1

Pipeline Flows From Louisiana to Other States, 2012			
Origin	Destination	Total (thousand tons)	Total ($ millions)
Louisiana	Louisiana	55,000	$24,000
Louisiana	Illinois	4,200	$1,800
Louisiana	Tennessee	3,300	$1,400
Louisiana	Ohio	2,000	$850
Louisiana	Indiana	1,500	$680
Louisiana	Texas	1,300	$550
Louisiana	Arkansas	1,200	$490
Louisiana	Oklahoma	590	$260
Louisiana	Kansas	310	$140
Louisiana	Alabama	280	$120
Louisiana	Mississippi	230	$100
Louisiana	Michigan	210	$89
Louisiana	Minnesota	110	$51
Louisiana	New Mexico	9	$39
Louisiana	Wisconsin	36	$16
Louisiana	North Dakota	22	$10
Louisiana	West Virginia	14	$6
Louisiana	Pennsylvania	6	$3
	Totals	**70,000**	**$31,000**

Source: Freight Analysis Framework, 2014.
Note: All results presented in 2012 dollars.

With a commodity flow value of over $30 billion, it is apparent that the pipeline infrastructure that provides resources from Louisiana to the rest of the nation is a valuable asset.Coastal land loss may have a significant negative effect on the network of oil and gas pipelines running all across the state. Because so much oil and gas activity occurs offshore, a significant portion of pipelines in Louisiana are in the coastal areas most vulnerable to land loss.

Dismukes, et al. (undated) argues that coastal erosion can have two types of impacts on energy infrastructure. First, coastal erosion and land loss can contribute to the damage suffered from "catastrophic" storm events. This damage is included in Chapter 3. Second, coastal erosion results in increased costs for operation and maintenance and/or infrastructure hardening due to the changing environment. However, the authors did not speculate as to the magnitude of the increased costs given a lack of appropriate data.

Storms may also affect oil and gas production. Most oil and natural gas production was shut down during Hurricane Katrina in 2005, as was significant proportions of regional refining capacity, due to evacuations, loss of electricity, and other damage (Kumins and Bamberger, 2005). Capacity was further disrupted by Hurricane Rita. However, other than the direct and storm damage effects from flood damage discussed in Chapter 3, it is unclear how additional land loss would ultimately affect commodity flows.

Commodity Flows by Truck

Trucks transport the most valuable portion of imports and exports to and from Louisiana. Table D.2 reports commodities moved from all states to Louisiana by truck in 2012.

Table D.2

Truck Flows From All States to Louisiana

Commodity	Thousand Tons	Value ($ millions)
Equipment (transportation equipment, electronics, machinery, motorized vehicles, precision instruments)	5,000	$44,000
Misc (Alcoholic beverages, textiles/leather, pharmaceuticals, misc. products, unknown, mixed freight, plastics/rubber)	12,000	$34,000
Fuel (crude petroleum, fuel oils, gasoline, coal)	46,000	$24,000
Metal products (Base metals, metallic ores, articles-base metal)	9,100	$16,000
Chemicals (chemicals, fertilizers, chemical products)	18,000	$15,000
Agricultural products (grains, feed, other foodstuffs)	430,000	$14,000
Forest products (Wood products, paper articles, newsprint/paper, logs, furniture, printed products)	29,000	$8,000
Stone products (Nonmetallic minerals, nonmetallic mineral products, gravel, natural sands, building stone)	64,000	$3,700
Perishable agricultural products (meat/seafood)	2,200	$3,700
Waste/scrap	16,000	$1,100

Source: Freight Analysis Framework, 2014. Note: All results presented in 2012 dollars.

The largest truck imports (by weight) to Louisiana were stone products, followed by fuel resources. The most valuable truck import to Louisiana was equipment, followed by miscellaneous products.

Table D.3 reports commodities moved from Louisiana to all states by truck in 2002.

Table D.3

Truck Flows From Louisiana to All States		
Commodity	Thousand tons	Value ($ millions)
Equipment (transportation equipment, electronics, machinery, motorized vehicles, precision instruments)	3,200	$27,000
Misc (Alcoholic beverages, textiles/leather, pharmaceuticals, misc. products, unknown, mixed freight, plastics/rubber)	9,400	$24,000
Fuel (crude petroleum, fuel oils, gasoline, coal)	45,000	$24,000
Metal products (Base metals, metallic ores, articles-base metal)	13,000	$15,000
Chemicals (chemicals, fertilizers, chemical products)	25,000	$18,000
Agricultural products (grains, feed, other foodstuffs)	46,000	$13,000
Forest products (Wood products, paper articles, newsprint/paper, logs, furniture, printed products)	31,000	$9,000
Stone products (Nonmetallic minerals, nonmetallic mineral products, gravel, natural sands, building stone)	67,000	$3,900
Perishable agricultural products (meat/seafood)	1,300	$2,800
Waste/scrap	16,000	$1,300

Source: Freight Analysis Framework 2014. Note: All results presented in 2012 dollars.

The largest exports (by weight) by truck from Louisiana are stone products, with agricultural products running in second. The most valuable exports by truck are equipment, with fuel resources as the second most valuable exported commodity.

Commodity Flows by Waterway

Louisiana's location at the mouth of the Mississippi makes it a critical location for waterway shipping, both for the Midwest and across the Gulf of Mexico. What has been the status quo for waterway shipping is expected to change, however, as sea levels rise, land loss, changing drought cycles, and storm surge will all affect river and Gulf Intracoastal Waterway shipping. Given the complex dynamics involved, quantification of the exact changes is not possible. However, a qualitative characterization of possible changes is discussed below, followed by data on waterway commodity flows by commodity.

The key issue in waterway commodity flows is navigability of shipping channels (Barras, 2006; NRC, 2008; Titus, 2002). Land loss coupled with sea level rise may increase accessibility to areas further inland due to deeper channels, but this may be offset somewhat by changes in sedimentation patterns and lower bridge clearance levels (Barras, 2006; Titus, 2002).[2] In addition, some channels (such as the Gulf Intracoastal Waterway) may be partially or completely converted to open sea, which will negatively affect barge traffic, possibly putting pressure on additional transport modes in the region (Barras, 2006). Thus, in a future without action, shipping traffic patterns will almost certainly change, but the exact patterns (and how they

[2] Titus (2002) states that the depth effect is likely small compared with the draft of most vessels.

would differ absent the land loss process) are unknown (Titus, 2002).

Table D.4 reports waterway flows into Louisiana to other states by commodity (in both value and thousand tons) that might be affected by changes in shipping lanes.

Table D.4

Waterway Flows to Louisiana From All States, 2012

Commodity	Thousand Tons	Value ($ millions)
Agricultural products	130,000	$21,000
Chemicals	15,000	$6,400
Equipment	170	$550
Forest products	150	$32
Fuel	120,000	$44,000
Metal products	520	$330
Misc (Alcoholic beverages, textiles/leather, pharmaceuticals, plastics/ rubber)	33	$12
Perishable agricultural products	5	$4
Stone products	12,000	$410
Waste/scrap	1	$0

Source: Freight Analysis Framework, 2014. Note: All results presented in 2012 dollars.

The largest waterway imports to Louisiana by weight are agricultural products, followed closely by fuel imports. The most valuable import is fuel, followed by agricultural products.

Table D.5 displays flows domestically originating in Louisiana (including imports from other countries) and shipped to other states.

Table D.5

Waterway Flows From Louisiana to All states		
Commodity	Thousand Tons	Value ($ millions)
Agricultural products	26,000	$12,000
Chemicals	1,800	$1,900
Equipment	0	$0
Forest products	0	$0
Fuel	14	$20
Metal products	7,000	$240
Misc (Alcoholic beverages, textiles/leather, pharmaceuticals, plastics/rubber)	130,000	$54,000
Perishable agricultural products	0	$0
Stone products	220	$1,200
Waste/scrap	0	$0

Source: Freight Analysis Framework, 2014. Note: All results presented in 2012 dollars.

The largest commodity by weight and most valuable waterway export from Louisiana are miscellaneous products, followed distantly by agricultural goods.

Commodity Flows by Rail

Chapter 3 discusses the potential impact of direct land loss and storm damage to rail infrastructure, which would either disrupt rail traffic (including substitution to other modes of transport) or increase costs due to greater maintenance and repair requirements.

Tables D.6 and D.7 document commodity flows by rail imported to Louisiana from other states, and from Louisiana to all states.

Table D.6

Rail Flows from All States to Louisiana, 2012		
Commodity	Thousand Tons	Value ($ millions)
Agricultural products	16,000	$2,900
Chemicals	7,000	$4,600
Equipment	110	$1,000
Forest products	1,000	$470
Fuel	12,000	$2,200
Metal products	980	$690
Misc (Alcoholic beverages, textiles/leather, pharmaceuticals, plastics/rubber)	2,000	$1,900
Perishable agricultural products	0	$0
Stone products	4,000	$130
Waste/scrap	2,800	$390

Source: Freight Analysis Framework, 2014 Note: All results presented in 2012 dollars

The largest rail imports (by weight) to Louisiana were agricultural products, followed by fuel resources. The most valuable rail imports to Louisiana were chemical products, followed by agricultural products.

Table D.7

Rail Flows From Louisiana to All States		
Commodity	Thousand Tons	Value ($ millions)
Agricultural products	3,400	$810
Chemicals	24,000	$16,000
Equipment	160	$1,400
Forest products	5,600	$2,600
Fuel	8,500	$5,700
Metal products	3,700	$2,800
Misc (Alcoholic beverages, textiles/leather, pharmaceuticals, plastics/rubber)	4,900	$5,200
Perishable agricultural products	0	$1
Stone products	1,900	$110
Waste/scrap	35	$15

Source: Freight Analysis Framework, 2014. Note: All results presented in 2012 dollars.

The largest exports (by weight) by rail from Louisiana are chemical products, with fuel running a distant second. The most valuable exports by rail are also chemical products, with fuel resources as the second most valuable exported commodity.

Commodity Flows by Air

No public airports were identified that were at risk of direct land loss.
Table D.8 reports commodity flows by air to Louisiana in terms of value and volume for 2012.

Table D.8

Air Flows From All States to Louisiana, 2012

Commodity	Thousand Tons	Value ($ millions)
Agricultural products	2.0	$14
Chemicals	12.0	$140
Equipment	39.0	$6,100
Forest products	3.7	$27
Fuel	0.2	$1
Metal products	13.0	$170
Misc (Alcoholic beverages, textiles/leather, pharmaceuticals, plastics/rubber)	8.4	$360
Perishable agricultural products	0.1	$1
Stone products	2.5	$20
Waste/scrap	0.0	$0

Source: Freight Analysis Framework, 2014. Note: All results presented in 2012 dollars.

The largest imports to Louisiana by weight through air transport were equipment followed by metal products. The most valuable commodities imported by air from Louisiana were equipment followed by miscellaneous products.

Table D.9 reports commodity flows by air from Louisiana to all other states by value and volume for 2012. The largest by weight and most valuable exports from Louisiana by air are equipment and miscellaneous products.

Table D.9

Air Flows from Louisiana to all states, 2012		
Commodity	Thousand Tons	Value ($ millions)
Agricultural products	1.1	$9
Chemicals	0.5	$95
Equipment	24.0	$3,300
Forest products	6.7	$46
Fuel	0.1	$0
Metal products	1.9	$97
Misc (Alcoholic beverages, textiles/leather, pharmaceuticals, plastics/ rubber)	6.0	$1,100
Perishable agricultural products	0.0	$0
Stone products	0.3	$5
Waste/scrap	0.0	$0

Source: Freight Analysis Framework, 2014. Note: All results presented in 2012 dollars.

Agricultural Commodity Flows To Louisiana by State

Because of its location at the mouth of the Mississippi River, Louisiana serves as an important hub for agricultural products. Table D.10 reports the volumes and values of agricultural values shipped to Louisiana. As is shown below, most agricultural products are shipped by water to Louisiana.

The largest commodities shipped by volume into Louisiana are agricultural products. Most non-perishable bulk agricultural commodities are shipped by water, where the products are either consumed in state, or exported abroad.

Table D.10

Top Agricultural Commodity Flows by State, 2012, by Volume					
From	To	Commodity	Mode	Total (thousand tons)	Total Value ($ millions)
Illinois	Louisiana	Cereal grains	Water	29,000	$4,000
Missouri	Louisiana	Cereal grains	Water	17,000	$2,500
Minnesota	Louisiana	Cereal grains	Water	16,000	$2,100
Illinois	Louisiana	Other ag. prods.	Water	11,000	$2,000
Missouri	Louisiana	Other ag. prods	Water	5,800	$1,500
Illinois	Louisiana	Cereal grains	Rail	5,500	$600

Source: Freight Analysis Framework, 2014. Note: All results presented in 2012 dollars.

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Appendix E: Fishery Detail

Louisiana fisheries are an important source of protein for the nation. Seafood is also an important cultural resource, as Louisiana cuisine is unique in the world and is inextricably tied to the availability of Gulf seafood. As a renewable natural resource, fisheries can provide income and food indefinitely, as long as the resources are properly managed.

This appendix provides detailed landing information by fish species in Louisiana in 2012. Data comes from the National Oceanic and Atmospheric Administration. Table E.1 reports landings for the commercial fisheries of Louisiana, sorted by value.

Table E.1.

Fish Landed in Louisiana, 2012

Species Name	Pounds (thousands)	Dollars ($)	Price ($)/Pound
SHRIMP, WHITE	71,216,417	$112,452,810	$1.58
MENHADEN	666,054,968	$44,875,101	$0.07
OYSTER, EASTERN	10,812,680	$39,931,044	$3.69
CRAB, BLUE	40,800,426	$38,585,189	$0.95
SHRIMP, BROWN	29,228,657	$33,258,734	$1.14
CRAYFISHES OR CRAWFISHES	6,711,592	$8,162,649	$1.22
TUNA, YELLOWFIN	1,883,001	$6,949,900	$3.69
DRUM, BLACK	3,448,206	$2,727,250	$0.79
SNAPPER, RED	943,118	$2,358,176	$2.50
CATFISH, BLUE	3,546,744	$1,733,739	$0.49
SWORDFISH	768,056	$1,539,844	$2.00
MACKEREL, KING	969,017	$1,475,318	$1.52
MULLET, STRIPED (LIZA)	1,267,788	$859,197	$0.68
SNAPPER, VERMILION	271,758	$619,442	$2.28
BUFFALOFISHES	2,590,191	$574,437	$0.22
SHARKS	847,891	$545,222	$0.64
CATFISH, CHANNEL	963,291	$530,176	$0.55
SHRIMP, SEABOB	1,235,622	$495,285	$0.40
GARS	519,084	$439,633	$0.85

Table E.1.

Fish Landed in Louisiana, 2012 (continued)

Species Name	Pounds (thousands)	Dollars ($)	Price ($)/Pound
CRAB, BLUE, PEELER	152,048	$432,073	$2.84
TUNA, BLUEFIN	66,180	$358,933	$5.42
SHEEPSHEAD	709,946	$293,998	$0.41
SHAD, GIZZARD	1,487,303	$286,920	$0.19
GROUPER, YELLOWEDGE	74,305	$227,345	$3.06
FLOUNDER, SOUTHERN	87,986	$157,355	$1.79
POMPANO, FLORIDA	37,517	$132,080	$3.52
CARPS AND MINNOWS	38,972	$131,742	$3.38
HERRINGS	418,624	$131,258	$0.31
CATFISH, FLATHEAD	241,360	$126,134	$0.52
ESCOLAR	144,720	$122,845	$0.85
BOWFIN	137,759	$122,574	$0.89
SHRIMP, MARINE, OTHER	9,754	$115,902	$11.88
TILEFISH, GOLDEN	61,604	$111,017	$1.80
AMBERJACK, GREATER	79,633	$94,663	$1.19
GROUPER, WARSAW	38,051	$82,102	$2.16
DRUM, FRESHWATER	429,609	$69,038	$0.16
SCAMP	18,675	$63,082	$3.38
CARP, COMMON	555,345	$58,577	$0.11
WAHOO	53,725	$57,120	$1.06
CRAB, BLUE, SOFT	8,894	$46,752	$5.26
SNAPPER, GRAY	20,171	$44,281	$2.20
GROUPER, SNOWY	15,591	$42,431	$2.72
DOLPHINFISH	29,241	$39,407	$1.35
FINFISHES, UNC GENERAL	25,916	$38,608	$1.49
TUNA, BIGEYE	15,526	$36,418	$2.35
SHRIMP, PINK	23,032	$35,109	$1.50
JACK, BAR	31,726	$29,538	$0.93
BLACK DRIFTFISH	18,712	$26,692	$1.43
CARP, GRASS	114,740	$23,004	$0.20
COBIA	10,625	$22,534	$2.12
CROAKER, ATLANTIC	4,195	$21,129	$5.04
TUNA, ALBACORE	37,833	$18,343	$0.48
SNAPPER, BLACK	6,406	$16,476	$2.57
GAG	4,812	$15,694	$3.26
CRAB, FLORIDA STONE CLAWS	2,008	$8,692	$4.33
SHARK, SHORTFIN MAKO	10,793	$7,887	$0.73
MACKEREL, SPANISH	7,730	$7,852	$1.02
FROGS	3,077	$7,541	$2.45
RUNNER, BLUE	13,665	$6,846	$0.50
SNAPPER, LANE	2,482	$5,894	$2.37

Table E.1.

Fish Landed in Louisiana, 2012 (continued)

Species Name	Pounds (thousands)	Dollars ($)	Price ($)/Pound
PORGY, RED	5,746	$5,877	$1.02
TRIGGERFISH, GRAY	5,063	$5,683	$1.12
CATFISHES & BULLHEADS	13,985	$5,409	$0.39
TURTLE, SLIDERS	8,228	$4,317	$0.52
TRIPLETAIL	3,546	$4,157	$1.17
JACK, ALMACO	2,913	$3,169	$1.09
SQUIDS	12,769	$3,147	$0.25
SHRIMP, ROCK	1,226	$2,922	$2.38
TUNA, BLACKFIN	5,440	$2,001	$0.37
SPADEFISHES	4,262	$1,919	$0.45
TUNA, LITTLE TUNNY	4,578	$1,903	$0.42
TURTLES	367	$1,853	$5.05
TURTLE, SOFT-SHELL	587	$1,745	$2.97
TURTLE, SNAPPING	433	$1,718	$3.97
HAKE, ATLANTIC, RED/WHITE	1,760	$1,651	$0.94
BIGEYE	1,140	$1,532	$1.34
KING WHITING	1,662	$1,512	$0.91
AMBERJACK, LESSER	1,532	$1,478	$0.96
SHELLFISH	1,064	$1,463	$1.37
SEATROUT, SAND	1,423	$1,126	$0.79
GROUPER, RED	143	$330	$2.31
SEATROUT, SPOTTED	98	$275	$2.81
SPOT	353	$243	$0.69
TOTALS	**849,407,116**	**$301,844,462**	

Source: NOAA Annual Commercial Landing Statistics, 2012. Note: All monetary values presented in 2012 dollars.

Appendix E References

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Appendix F: Natural Amenity and Historical Site Detail

This Appendix details site-level changes in land composition for Wildlife Refuges, Wildlife Management Areas, and Parks and Historic sites in Coastal Louisiana. These percentage changes in land area are calculated using the methodology described in the Recreation and Tourism section of Chapter 4 to measure the losses relative to statewide totals. Table F.1 documents the proportion of predicted area of land loss in wildlife refuges by site.

Table F.1

Estimated Land Loss in Wildlife Refuges

Site	Moderate, 25 Years	Moderate, 50 Years	Less Optimistic, 25 Years	Less Optimistic, 50 years
Atchafalaya National Wildlife Refuge	0%	0%	0%	0%
Bayou Sauvage National Wildlife Refuge	37%	42%	48%	52%
Bayou Teche National Wildlife Refuge	1%	1%	1%	1%
Big Branch Marsh National Wildlife Refuge	18%	21%	20%	23%
Bogue Chitto National Wildlife Refuge	0%	0%	0%	0%
Breton National Wildlife Refuge	*	*	*	*
Cameron Prairie National Wildlife Refuge	2%	4%	22%	29%
Delta National Wildlife Refuge	18%	34%	35%	72%
Lacassine National Wildlife Refuge	3%	3%	12%	22%
Mandalay National Wildlife Refuge	9%	13%	14%	33%
Sabine National Wildlife Refuge	7%	10%	13%	35%
Shell Keys National Wildlife Refuge	0%	0%	0%	0%
Grand Cote National Wildlife Refuge	0%	0%	0%	0%
Handy Brake National Wildlife Refuge	0%	0%	0%	0%
Lacassine National Wildlife Refuge	3%	3%	12%	22%
Lake Ophelia National Wildlife Refuge	0%	0%	0%	0%
Mandalay National Wildlife Refuge	9%	13%	14%	33%
Red River National Wildlife Refuge	0%	0%	0%	0%
Sabine National Wildlife Refuge	7%	10%	13%	35%
Shell Keys National Wildlife Refuge	0%	0%	0%	0%
Tensas River National Wildlife Refuge	0%	0%	0%	0%
Upper Ouachita National Wildlife Refuge	0%	0%	0%	0%

*Land loss map indicated that virtually all land would be lost.

Source: Authors' calculations from land loss models, Wildlife Refuges 2001, and National Hydrography Dataset 2013.

Table F.2 documents the predicted area of land lost in wildlife management areas by site.

Table F.2

Estimated Land Loss in Wildlife Management Areas

Site	Moderate, 25 Years	Moderate, 50 Years	Less Optimistic, 25 Years	Less Optimistic, 50 years
Atchafalaya Delta WMA	3%	1%	4%	1%
Attakapas Island WMA	4%	3%	4%	4%
Biloxi WMA	9%	16%	11%	18%
Elm Hall WMA	1%	2%	2%	3%
Isles Dernieres Barrier Islands Refuge	67%	81%	68%	83%
Joyce WMA	3%	7%	6%	12%
Lake Boeuf WMA	0%	0%	0%	0%
Lake Ramsay Savannah WMA	0%	0%	0%	0%
Little River WMA	0%	0%	0%	0%
Loggy Bayou WMA	0%	0%	0%	0%
Manchac WMA	2%	3%	3%	4%
Marsh Island Wildlife Refuge	8%	9%	10%	23%
Maurepas Swamp WMA (Eastern Tract)	1%	3%	2%	4%
Maurepas Swamp WMA (Western Tract)	0%	1%	1%	1%
Ouachita WMA	0%	0%	0%	0%
Pass A Loutre WMA	19%	44%	42%	75%
Pearl River WMA	4%	5%	4%	5%
Peason Ridge WMA	0%	0%	0%	0%
Pointe Aux Chenes WMA	12%	19%	16%	33%
Pomme de Terre WMA	0%	0%	0%	0%
Red River WMA	0%	0%	0%	0%
Rockefeller Wildlife Refuge	14%	17%	29%	64%
Russell Sage WMA	0%	0%	0%	0%
Sabine Island WMA	1%	1%	1%	1%
Sabine WMA	0%	0%	0%	0%
Salvador WMA	5%	8%	6%	9%
Sandy Hollow WMA	0%	0%	0%	0%
Sherburne WMA/Atchafalaya NWR/Bayou des Ourses Area (USACOE)	0%	0%	0%	0%
Sicily Island Hills WMA	0%	0%	0%	0%
Soda Lake WMA	0%	0%	0%	0%
Spring Bayou WMA	0%	0%	0%	0%
St Tammany Wildlife Refuge	23%	28%	24%	30%
State Wildlife Refuge	2%	3%	3%	8%
Tangipahoa Parish School Board WMA	0%	0%	0%	0%
Thistlethwaite WMA	0%	0%	0%	0%
Three Rivers WMA	0%	0%	0%	0%
Timken WMA	4%	7%	5%	8%

Table F.2

Estimated Land Loss in Wildlife Management Areas (Continued)

Site	Moderate, 25 Years	Moderate, 50 Years	Less Opti-mistic, 25 Years	Less Opti-mistic, 50 years
Union WMA	0%	0%	0%	0%
Waddill Wildlife Refuge	0%	0%	0%	0%
Walnut Hill WMA	0%	0%	0%	0%
West Bay WMA	0%	0%	0%	0%
White Lake Wetlands Conservation Area	3%	4%	4%	8%
Wisner WMA	8%	14%	9%	15%

Source: Authors' calculations from land loss models, Wildlife Management Areas 2006, and National Hydrography Dataset 2013.

Table F.3 documents the predicted area of land lost in state parks and historic sites for each land loss scenario.

Table F.3

Estimated Land Loss in Parks and Historic Sites				
Site	Moderate, 25 Years	Moderate, 50 Years	Less Optimistic, 25 Years	Less Optimistic, 50 years
Barataria Preserve	2%	3%	2%	4%
Bayou Segnette State Park	1%	1%	1%	2%
Chalmette Battlefield	0%	1%	4%	10%
Cypermort Point State Park	4%	4%	5%	6%
Fairview Riverside State Park	3%	3%	3%	3%
Fontainebleau State Park	4%	6%	5%	7%
Fort Pike State Historic Site	6%	6%	11%	11%
French Quarter Visitor Center	0%	0%	0%	0%
Grand Isle State Park	38%	54%	41%	62%
Lake Fausse Pointe State Park	0%	0%	0%	0%
Longfellow-Evangeline State Historic Site	0%	0%	0%	0%
New Orleans Jazz National Historical Park	0%	0%	0%	0%
Palmetto Island State Park	0%	0%	0%	0%
Plaquemine Lock State Historic Site	0%	0%	0%	0%
Sam Houston Jones State Park	0%	0%	0%	0%
St. Bernard State Park	1%	1%	2%	3%
Tickfaw State Park	0%	0%	0%	0%
Wetlands Acadian Cultural Center	0%	0%	0%	0%

Source: Authors' calculations from land loss models, Louisiana CRT, and National Hydrography Dataset 2013.

Appendix F References

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Appendix G: Employment and Wage Tables from Economic Contribution Analysis

This appendix provides supplementary material for the economic contribution analysis described in Chapter 4. It includes employment and wage measures of economic contribution. Employment is equivalent to jobs unless otherwise stated in the tables.

Economic Contribution of Business Activity at Risk from Direct Land Loss

Top Industries at Risk in Moderate Scenario - 50 years

Table G.1

Top 10 Contributing Sectors by Lost Employment in Coastal Louisiana – Moderate 50 years

Sector	Direct	Indirect	Induced	Total
Food services and drinking places	500	200	500	1,200
Construction of new residential permanent site single- and multi-family structures	800	0	0	800
Insurance agencies, brokerages, and related activities	600	200	0	800
Wholesale trade businesses	400	200	100	700
Construction of other new nonresidential structures	600	0	0	600
Retail Stores- Food and beverage	300	0	100	400
Scenic and sightseeing transportation and support activities for transportation	500	50	10	560
Employment services	0	400	100	500
Real estate establishments	100	200	200	500
Retail Stores- Motor vehicle and parts	300	50	200	550
Private elementary and secondary schools	400	0	100	500
Total	**9,600**	**4,300**	**4,500**	**18,000**

Source: IMPLAN 2012 data output from MRIO model. Rounded to nearest hundred. Row sums do not equal total, as only top 10 industries displayed.

Table G.2

Top 10 Contributing Sectors by Lost Wages in Coastal Louisiana – Moderate 50 years				
Sector	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Construction of new residential permanent site single- and multi-family structures	$63	$0	$0	$63
Insurance agencies, brokerages, and related activities	$42	$10	$2	$53
Wholesale trade businesses	$29	$14	$9	$53
Scenic and sightseeing transportation and support activities for transportation	$36	$3	$1	$40
Construction of other new nonresidential structures	$35	$0	$0	$35
Extraction of oil and natural gas	$5	$25	$0	$31
Food services and drinking places	$13	$3	$9	$25
Petroleum refineries	$24	$2	$1	$27
Ship building and repair	$22	$0	$0	$22
Offices of physicians, dentists and other health practitioners	$1	$0	$19	$20
Total	**$557**	**$229**	**$173**	**$958**

Source: IMPLAN 2012 data output from MRIO model. Row sums do not equal total, as only top 10 industries displayed. Note: All results presented in 2012 dollars.

Table G.3

Top 10 Contributing Sectors by Lost Employment in Rest of Louisiana – Moderate 50 years			
Sector	Indirect	Induced	Total
Extraction of oil and natural gas	100	0	100
Maintenance and repair construction of nonresidential structures	70	0	70
Food services and drinking places	10	20	30
Architectural, engineering, and related services	20	0	20
Management of companies and enterprises	20	0	20
Wholesale trade businesses	10	0	10
Spectator sports companies	10	0	10
Securities, commodity contracts, investments, and related activities	10	0	10
Investigation and security services	10	0	10
Services to buildings and dwellings	10	0	10
Total	**360**	**160**	**520**

Source: IMPLAN 2012 data output from MRIO model. Rounded to nearest hundred. Row sums do not equal total, as only top 10 industries displayed.

Table G.4

Top 10 Contributing Sectors by Lost Wages in Rest of Louisiana – Moderate 50 years			
Sector	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Extraction of oil and natural gas	$6.9	$0.1	$7.0
Maintenance and repair construction of non-residential structures	$3.8	$0.3	$4.1
Architectural, engineering, and related services	$1.7	$0.1	$1.8
Management of companies and enterprises	$1.5	$0.2	$1.7
Wholesale trade businesses	$1.0	$0.4	$1.4
Offices of physicians, dentists, and other health practitioners	$0.0	$0.7	$0.7
Electric power generation, transmission, and distribution	$0.5	$0.2	$0.7
Cable and other subscription programming	$0.7	$0.0	$0.7
Private hospitals	$0.0	$0.6	$0.6
Food services and drinking places	$0.2	$0.4	$0.6
Total	**$26.0**	**$8.0**	**$34.0**

Source: IMPLAN 2012 data output from MRIO model. Row sums do not equal total, as only top 10 industries displayed. Note: All results presented in 2012 dollars.

Table G.5

Top 10 Contributing Sectors by Lost Employment in Rest of US – Moderate 50 years			
Sector	Indirect	Induced	Total
Extraction of oil and natural gas	1,800	0	1,800
Maintenance and repair construction of nonresidential structures	700	0	700
Food services and drinking places	100	500	600
Real estate establishments	100	300	400
Wholesale trade businesses	150	150	300
Securities, commodity contracts, investments, and related activities	200	100	300
Employment services	200	100	300
Management of companies and enterprises	200	100	300
Services to buildings and dwellings	200	100	300
Offices of physicians, dentists, and other health practitioners	0	200	200
Total	**6,800**	**5,600**	**12,400**

Source: IMPLAN 2012 data output from MRIO model. Rounded to nearest hundred. Row sums do not equal total, as only top 10 industries displayed. Note: All results presented in 2012 dollars.

Table G.6

Top 10 Contributing Sectors by Lost Wages in Rest of US – Moderate 50 years			
Sector	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Extraction of oil and natural gas	$150	$3	$150
Maintenance and repair construction of nonresidential structures	$30	$0	$30
Management of companies and enterprises	$30	$10	$40
Wholesale trade businesses	$15	$15	$30
Securities, commodity contracts, investments, and related activities	$15	$15	$30
Offices of physicians, dentists, and other health practitioners	$0	$20	$20
Private hospitals	$0	$10	$10
Management, scientific, and technical consulting services	$10	$0	$10
Food services and drinking places	$0	$10	$10
Monetary authorities and depository credit intermediation activities	$5	$5	$10
Total	**$500**	**$300**	**$800**

Source: IMPLAN 2012 data output from MRIO model. Row sums do not equal total, as only top 10 industries displayed. Note: All results presented in 2012 dollars.

Top Industries at Risk in Less Optimistic Scenario - 50 years

Table G.7

Top 10 Contributing Sectors by Lost Employment in Coastal Louisiana – Less Optimistic 50 years

Sector	Direct	Indirect	Induced	Total
Food services and drinking places	580	200	670	1,500
Construction of other new nonresidential structures	1,400	0	0	1,400
Construction of new residential permanent site single- and multi-family structures	900	0	0	900
Insurance agencies, brokerages, and related activities	640	170	30	840
Scenic and sightseeing transportation and support activities for transportation	700	60	10	770
Wholesale trade businesses	410	210	150	770
Retail Stores- Food and beverage	380	50	200	630
Employment services	20	500	110	630
Real estate establishments	100	220	300	620
Transit and ground passenger transportation	530	10	30	570
Total	**12,200**	**5,100**	**5,500**	**23,000**

Source: IMPLAN 2012 data output from MRIO model. Row sums do not equal total, as only top 10 industries displayed. Note: All results presented in 2012 dollars.

Table G.8

Top 10 Contributing Sectors by Lost Wages in Louisiana – Less Optimistic 50 years

Sector	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Construction of other new nonresidential structures	$80	$0	$0	$80
Construction of new residential permanent site single- and multi-family structures	$67	$0	$0	$67
Insurance agencies, brokerages, and related activities	$40	$10	$2	$53
Scenic and sightseeing transportation and support activities for transportation	$51	$2	$1	$53
Wholesale trade businesses	$33	$10	$10	$53
Food services and drinking places	$14	$4	$15	$34
Extraction of oil and natural gas	$6	$26	$0	$32
Petroleum Refineries	$25	$3	$0	$28
Employment and payroll only (state & local govt, non-education)	$26	$0	$0	$26
Retail Stores- Motor vehicle and parts	$17	$2	$6	$26
Total	**$700**	**$300**	**$200**	**$1,200**

Source: IMPLAN 2012 data output from MRIO model. Row sums do not equal total, as only top 10 industries displayed. Note: All results presented in 2012 dollars.

Table G.9

Top 10 Contributing Sectors by Lost Employment in Rest of Louisiana – Less Optimistic 50 years

Sector	Indirect	Induced	Total
Extraction of oil and natural gas	140	0	140
Maintenance and repair construction of nonresidential structures	70	5	75
Food services and drinking places	10	20	30
Architectural, engineering, and related services	20	0	20
Wholesale trade businesses	10	10	20
Management of companies and enterprises	20	0	20
Spectator sports companies	20	0	20
Securities, commodity contracts, investments, and related activities	10	10	10
Investigation and security services	10	0	10
Office administrative services	10	0	10
Total	550	250	800

Source: IMPLAN 2012 data output from MRIO model. Rounded to nearest hundred. Row sums do not equal total, as only top 10 industries displayed.

Table G.10

Top 10 Contributing Sectors by Lost Wages in Rest of Louisiana – Less Optimistic 50 years

Sector	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Extraction of oil and natural gas	$7	$0	$7
Maintenance and repair construction of nonresidential structures	$4	$0	$4
Architectural, engineering, and related services	$2	$0	$2
Management of companies and enterprises	$1	$0	$1
Wholesale trade businesses	$1	$0	$1
Offices of physicians, dentists, and other health practitioners	$0	$1	$1
Electric power generation, transmission, and distribution	$0	$0	$1
Food services and drinking places	$0	$0	$1
Private hospitals	$0	$1	$1
Cable and other subscription programming	$0	$0	$1
Total	$29	$10	$39

Source: IMPLAN 2012 data output from MRIO model. Row sums do not equal total, as only top 10 industries displayed. Note: All results presented in 2012 dollars.

Table G.11

Top 10 Contributing Sectors by Lost Employment in Rest of US – Less Optimistic 50 years

Sector	Indirect	Induced	Total
Extraction of oil and natural gas	1,900	50	1,900
Maintenance and repair construction of nonresidential structures	680	60	740
Food services and drinking places	100	550	650
Real estate establishments	170	290	460
Securities, commodity contracts, investments, and related activities	230	190	420
Wholesale trade businesses	200	200	400
Employment services	220	150	370
Management of companies and enterprises	250	70	320
Services to buildings and dwellings	200	120	320
Offices of physicians, dentists, and other health practitioners	0	240	240
Total	7,500	6,300	14,000

Source: IMPLAN 2012 data output from MRIO model. Rounded to nearest ten. Row sums do not equal total, as only top 10 industries displayed.

Table G.12

Top 10 Contributing Sectors by Lost Wages in Rest of US – Less Optimisitc 50 Years

Sector	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Extraction of oil and natural gas	$150	$4	$160
Maintenance and repair construction of nonresidential structures	$40	$0	$40
Management of companies and enterprises	$30	$10	$40
Wholesale trade businesses	$15	$15	$30
Securities, commodity contracts, investments, and related activities	$20	$10	$30
Offices of physicians, dentists, and other health practitioners	$0	$20	$20
Private hospitals	$0	$20	$20
Management, scientific, and technical consulting services	$10	$10	$20
Monetary authorities and depository credit intermediation activities	$10	$10	$20
Food services and drinking places	$0	$10	$10
Total	$540	$320	$860

Source: IMPLAN 2012 data output from MRIO model. Row sums do not equal total, as only top 10 industries displayed. Note: All results presented in 2012 dollars.

Table G.13

Coastal Louisiana Total Impact to Output, Employment, and Wages From Land Loss

Environmental Scenario	Time Horizon	Output ($ millions)	Employment	Wages ($ millions)
Moderate	25 years	$3,300	$16,500	$830
Moderate	50 years	$3,700	$18,400	$960
Less Optimistic	25 years	$3,500	$18,200	$920
Less Optimistic	50 years	$4,300	$22,800	$1,200

Source: Authors' calculations using 2012 IMPLAN data model inputs. Monetary results presented in 2012 dollars.

Table G.14

Rest of Louisiana Total Impact to Output, Employment, and Wages From Land Loss

Environmental Scenario	Time Horizon	Output ($ millions)	Employment	Wages ($ millions)
Moderate	25 years	$130	$620	$30
Moderate	50 years	$150	$700	$40
Less Optimistic	25 years	$130	$650	$30
Less Optimistic	50 years	$160	$800	$40

Source: Authors' calculations using 2012 IMPLAN data model inputs. Monetary results presented in 2012 dollars.

Table G.15

Rest of US Total Impact to Output, Employment, and Wages From Land Loss

Environmental Scenario	Time Horizon	Output ($ millions)	Employment	Wages ($ millions)
Moderate	25 years	$2,400	$11,000	$690
Moderate	50 years	$2,700	$12,400	$800
Less Optimistic	25 years	$2,500	$11,500	$710
Less Optimistic	50 years	$2,900	$13,800	$860

Source: Authors' calculations using 2012 IMPLAN data model inputs. Note: Monetary results presented in 2012 dollars.

Table G.16

Total Impact to Output, Employment, and Wages From Land Loss

Environmental Scenario	Time Horizon	Output ($ millions)	Employment	Wages ($ millions)
Moderate	25 years	$5,830	$28,120	$1,550
Moderate	50 years	$6,550	$31,500	$1,800
Less Optimistic	25 years	$6,130	$30,500	$1,600
Less Optimistic	50 years	$7,360	$37,400	$2,100

Source: Authors' calculations using 2012 IMPLAN data model inputs. Note: Monetary results presented in 2012 dollars.

Table G.17

Coastal Louisiana Loss of Employment From Increased Storm Damage (thousands)					
Storm	Environmental Scenario	Time Horizon	Direct Impact	Indirect/ Induced Impact	Total Impact
Eastern	Moderate	25 year	16	10	26
	Moderate	50 year	23	13	36
	Less Optimistic	25 year	21	12	33
	Less Optimistic	50 year	220	114	335
100 Year	Moderate	25 year	25	17	42
	Moderate	50 year	42	26	68
	Less Optimistic	25 year	38	24	62
	Less Optimistic	50 year	110	62	172
Western	Moderate	25 year	23	15	37
	Moderate	50 year	35	22	56
	Less Optimistic	25 year	35	22	57
	Less Optimistic	50 year	79	45	123

Source: Authors' calculations using 2012 IMPLAN data model inputs. Note: All monetary results presented in 2012 dollars.

Table G.18

Coastal Louisiana Loss of Wages From Increased Storm Damage

Storm	Environmental Scenario	Time Horizon	Direct Impact	Indirect/ Induced Impact	Total Impact
Eastern	Moderate	25 year	$0.8	$0.4	$1.2
	Moderate	50 year	$1.2	$0.6	$1.6
	Less Optimistic	25 year	$1.1	$0.5	$1.5
	Less Optimistic	50 year	$9.6	$4.8	$14.3
100 Year	Moderate	25 year	$1.3	$0.7	$2.0
	Moderate	50 year	$2.0	$1.0	$3.1
	Less Optimistic	25 year	$1.8	$1.0	$2.9
	Less Optimistic	50 year	$5.2	$2.6	$7.8
Western	Moderate	25 year	$1.2	$0.6	$1.9
	Moderate	50 year	$1.8	$0.9	$2.7
	Less Optimistic	25 year	$1.8	$0.9	$2.7
	Less Optimistic	50 year	$3.7	$1.9	$5.7

Source: Authors' calculations using 2012 IMPLAN data model inputs. Note: All monetary results presented in 2012 dollars.

Table G.19

Coastal Louisiana Loss of Output, Employment, and Wages From Increased Storm Damage					
Storm	Environmental Scenario	Time Horizon	Total Output Impact ($ billions)	Total Employment Impact (thousands)	Total Wages Impact ($ billion)
Eastern	Moderate	25 year	$3.1	26	$1.2
	Moderate	50 year	$4.2	36	$1.6
	Less Optimistic	25 year	$3.9	33	$1.5
	Less Optimistic	50 year	$36.0	335	$14.3
100 Year	Moderate	25 year	$5.1	42	$2.0
	Moderate	50 year	$8.1	68	$3.1
	Less Optimistic	25 year	$7.5	62	$2.9
	Less Optimistic	50 year	$20.0	172	$7.8
Western	Moderate	25 year	$4.8	37	$1.9
	Moderate	50 year	$7.1	56	$2.7
	Less Optimistic	25 year	$7.2	57	$2.7
	Less Optimistic	50 year	$14.0	123	$5.7

Source: Authors' calculations using 2012 IMPLAN data model inputs. Note: All monetary results presented in 2012 dollars.

Table G.20

Rest of Louisiana Loss of Output, Employment, and Wages From Increased Storm Damage					
Storm	Environmental Scenario	Time Horizon	Total Output Impact ($ billions)	Total Employ-ment Impact (thousands)	Total Wages Impact ($ billion)
Eastern	Moderate	25 year	$0.10	0.4	$0.02
	Moderate	50 year	$0.10	0.6	$0.03
	Less Optimistic	25 year	$0.10	0.5	$0.02
	Less Optimistic	50 year	$0.80	4.4	$0.16
100 Year	Moderate	25 year	$ 0.10	0.8	$0.03
	Moderate	50 year	$0.20	1.2	$0.05
	Less Optimistic	25 year	$0.20	1.1	$0.05
	Less Optimistic	50 year	$0.40	2.6	$0.15
Western	Moderate	25 year	$0.10	0.7	$0.04
	Moderate	50 year	$0.20	1.0	$0.05
	Less Optimistic	25 year	$0.20	1.0	$0.05
	Less Optimistic	50 year	$0.30	1.9	$0.05

Source: Authors' calculations using 2012 IMPLAN data model inputs. Note: All monetary results presented in 2012 dollars.

Table G.21

Rest of US Loss of Output, Employment, and Wages From Increased Storm Damage

Storm	Environmental Scenario	Time Horizon	Total Output Impact ($ billions)	Total Employment Impact (thousands)	Total Wages Impact ($ billion)
Eastern	Moderate	25 year	$1.4	7	$0.4
	Moderate	50 year	$1.8	10	$0.6
	Less Optimistic	25 year	$1.7	9	$0.6
	Less Optimistic	50 year	$14.7	78	$4.6
100 Year	Moderate	25 year	$2.4	13	$0.7
	Moderate	50 year	$3.9	20	$1.2
	Less Optimistic	25 year	$3.6	19	$1.1
	Less Optimistic	50 year	$8.7	45	$2.6
Western	Moderate	25 year	$2.2	11	$0.7
	Moderate	50 year	$3.2	16	$1.0
	Less Optimistic	25 year	$3.4	17	$1.0
	Less Optimistic	50 year	$6.5	33	$2.0

Source: Authors' calculations using 2012 IMPLAN data model inputs. Note: All monetary results presented in 2012 dollars.

Table G.22

Total Loss of Output, Employment, and Wages From Increased Storm Damage					
Storm	Environmental Scenario	Time Horizon	Total Output Impact ($ billions)	Total Employment Impact (thousands)	Total Wages Impact ($ billion)
Eastern	Moderate	25 year	$4.6	33.4	$1.6
	Moderate	50 year	$6.1	46.6	$2.2
	Less Optimistic	25 year	$5.7	42.5	$2.1
	Less Optimistic	50 year	$51.5	417.4	$19.1
100 Year	Moderate	25 year	$7.5	55.8	$2.7
	Moderate	50 year	$12.2	89.2	$4.4
	Less Optimistic	25 year	$11.3	82.1	$4.1
	Less Optimistic	50 year	$29.1	219.6	$10.6
Western	Moderate	25 year	$7.1	48.7	$2.6
	Moderate	50 year	$10.5	73	$3.8
	Less Optimistic	25 year	$10.8	75	$3.8
	Less Optimistic	50 year	$20.8	157.9	$7.8

Source: Authors' calculations using 2012 IMPLAN data model inputs. Note: All monetary results presented in 2012 dollars.