# PROCESS CLASSIFICATION OF COASTAL LAND LOSS BETWEEN 1932 AND 1990 IN THE MISSISSIPPI RIVER DELTA PLAIN, SOUTHEASTERN LOUISIANA

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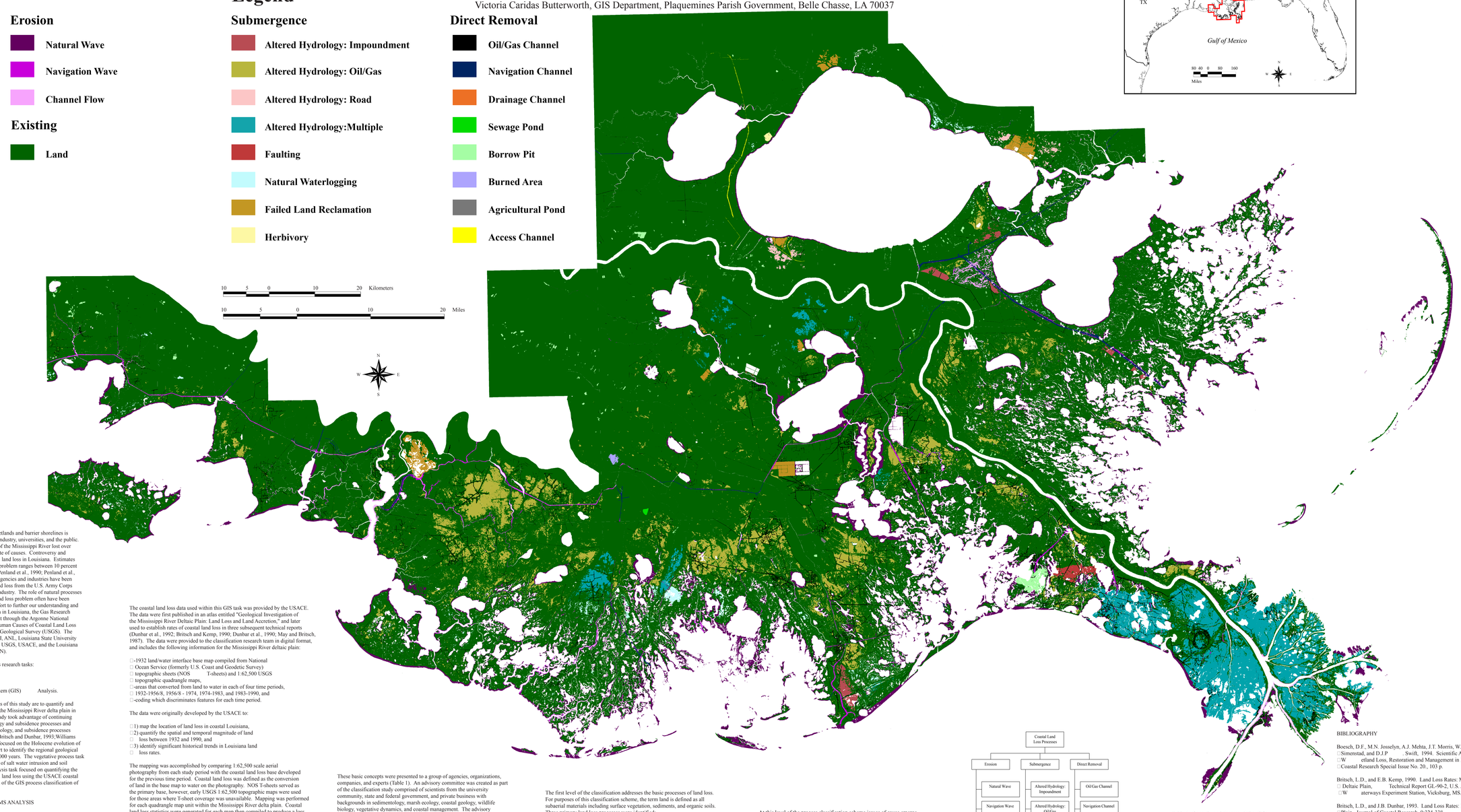


## INTRODUCTION

The dramatic loss of Louisiana's coastal wetlands and barrier shorelines is well recognized by government agencies, industry, universities, and the public. Between 1932 and 1990, the deltaic plain of the Mississippi River lost over 680,000 acres of land due to a complex suite of causes. Controversy and debate continues as to the causes of coastal land loss in Louisiana. Estimates of the contribution of man to the land loss problem ranges between 10 percent and 90 percent (Britsch and Kemp, 1990; Penland et al., 1990; Penland et al., 1992; Turner, 1997). Several government agencies and industries have been targeted as the primary cause of coastal land loss from the U.S. Army Corps of Engineers (USACE) to the oil and gas industry. The role of natural processes and the multiple causality of the coastal land loss problem often have been overlooked (Boesch et al., 1994). In an effort to further our understanding and knowledge of the coastal land loss problem in Louisiana, the Gas Research Institute (GRI) sponsored a research project through the Argonne National Laboratory (ANL) entitled "Natural and Human Causes of Coastal Land Loss in Louisiana" in cooperation with the U.S. Geological Survey (USGS). The study team consisted of scientists from GRI, ANL, Louisiana State University (LSU), University of New Orleans (UNO), USGS, USACE, and the Louisiana Universities Marine Consortium (LUMCON).

This study focuses on three major land loss research tasks:

□1) Geologic Processes,
□2) Vegetative Processes, and
□3) Spatial Geographical Information System (GIS) Analysis.

Through these research tasks, the objectives of this study are to quantify and rank the causes of coastal land loss within the Mississippi River delta plain in southeastern Louisiana (Figure 1). This study took advantage of continuing research by the USGS in framework geology and subsidence processes and the USACE in GIS analysis, framework geology, and subsidence processes (Dunbar et al., 1990; Dunbar et al., 1992; Britsch and Dunbar, 1993;Williams et al., 1993). The geological process task focused on the Holocene evolution of the Mississippi River delta plain in an effort to identify the regional geological controls on coastal land loss of the last 18,000 years. The vegetative process task conducted field investigations into the role of salt water intrusion and soil inundation in plant dieback. The GIS analysis task focused on quantifying the geomorphic forms and processes of coastal land loss using the USACE coastal landloss database. In this report the results of the GIS process classification of coastal land loss are presented.

## GEOGRAPHIC INFORMATION SYSTEMS ANALYSIS

The GIS analysis task sought to quantify the geomorphic forms and processes of coastal land loss using new digital data. The study area for the GIS analysis is the Mississippi River delta plain in southeast Louisiana and does not include the chenier plain (Figure 1). The GIS analysis captures the local types and causes of coastal land loss interwoven with regional land loss processes like subsidence. The GIS analysis highlights coastal land loss *Hot Spots* and change trends in the land loss pattern. Processes such as flood control, diversion control, subsidence, and eustacy generally lack spatial attributes that can be mapped and used in a GIS analysis. As a result, the GIS analysis allows the quantification of site specific processes and does not fully capture the regional effects of subsidence, eustacy, and river control.

Much of the coastal land loss controversy can be attributed to a lack of spatial quantitative land loss data. Recent land loss data collection efforts undertaken by the USACE have worked to address this need for information by providing maps and statistics which can be used to characterize baseline conditions of coastal land loss in Louisiana. The USGS National Coastal Marine Geology Program supports Louisiana coastal land loss studies which address issues such as barrier island erosion and wetland loss. Collectively, these programs provide needed resources for the development of this coastal land loss data set.

The purpose of the GIS analysis task is to expand upon baseline data collection efforts by providing quantitative information about coastal land loss geomorphology and process. We have developed a classification scheme capable of delineating the geomorphologically distinct forms of coastal land loss and the process of change (Wayne et al., 1993).

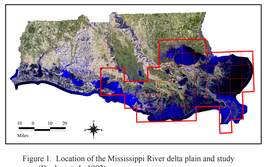


Figure 1. Location of the Mississippi River delta plain and study area (Dunbar et al., 1992).

The coastal land loss data used within this GIS task was provided by the USACE. The data were first published in an atlas entitled "Geological Investigation of the Mississippi River Deltaic Plain: Land Loss and Land Accretion," and later used to establish rates of coastal land loss in three subsequent technical reports (Dunbar et al., 1992; Britsch and Kemp, 1990; Dunbar et al., 1990; May and Britsch, 1987). The data were provided to the classification research team in digital format, and includes the following information for the Mississippi River deltaic plain:

□-1932 land/water interface base map compiled from National
□ Ocean Service (formerly U.S. Coast and Geodetic Survey)
□ topographic sheets (NOS T-sheets) and 1:62,500 USGS
□ topographic quadrangle maps,
□-areas that converted from land to water in each of four time periods,
□ 1932-1956;8, 1956;8 - 1974, 1974-1983, and 1983-1990, and
□-coding which discriminates features for each time period.

The data were originally developed by the USACE to:

□1) map the location of land loss in coastal Louisiana,
□2) quantify the spatial and temporal magnitude of land
□ loss between 1932 and 1990, and
□3) identify significant historical trends in Louisiana land
□ loss rates.

The mapping was accomplished by comparing 1:62,500 scale aerial photography from each study period with the coastal land loss base developed for the previous time period. Coastal land loss was defined as the conversion of land in the base map to water on the photography. NOS T-sheets served as the primary base, however, early USGS 1:62,500 topographic maps were used for those areas where T-sheet coverage was unavailable. Mapping was performed for each quadrangle map unit within the Mississippi River delta plain. Coastal land loss statistics were generated for each map then compiled to produce a loss rate curve for the entire deltaic plain (Figure 2).

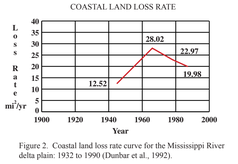


Figure 2. Coastal land loss rate curve for the Mississippi River delta plain: 1932 to 1990 (Dunbar et al., 1992).

The USACE study of coastal land loss rates resulted in the generation of a large, detailed, digital data set. To achieve the objectives of the GIS task a single time period of data for classification was utilized. The cumulative time period (1932-1990) was selected for two primary reasons:

□1) it contained the most diverse coastal land loss conditions and
□ therefore provided the best means of evaluating the range
□ of applicability of the classification schemes, and
□2) the interim data could be used to understand the processes
□ af fecting the loss, and enable researchers to better refine the
□ classification for complex loss scenarios.

The USACE land loss data set was carefully reviewed to derive initial concepts of loss geomorphology and processes. A mosaic of the fifty maps was created on a single wall of the laboratory and used as reference during a series of open discussions in which similarities in coastal land loss configurations were identified and evaluated. Additional information was compiled about coastal land loss processes and landscape activities (cultural and natural) associated with individual areas of loss. This information was used to generate process scenarios for highly expressive coastal land loss formations. Once a familiarity with the regional data set was acquired, a series of examples were extracted to illustrate rough concepts of similarity and disparity with regard to coastal land loss,process and geomorphology.

These basic concepts were presented to a group of agencies, organizations, companies, and experts (Table 1). An advisory committee was created as part of the classification study comprised of scientists from the university community, state and federal government, and private business with backgrounds in sedimentology, marsh ecology, coastal geology, wildlife biology, vegetative dynamics, and coastal management. The advisory committee provided regional and disciplinary insight, and responded to the conceptual presentation by generating a list of terms which more specifically characterized differences in form and process. The terms were organized into logical groupings of process and geomorphology, and the groups were refined into initial classification schemes.

Once the initial classification schemes were derived, the advisory committee reviewed the schemes and provided critical comments. The comments were used to refine the classification schemes. Several land loss committee meetings were held prior to establishing the final land loss geomorphology and process classification schemes.

Table 1. List of agencies, companies and organizations that participated in workshops and reviews of the gis coastal land loss classification maps.

| | |
|---|---|
| Louisiana Department of Environmental Quality | Terrebonne Parish |
| Louisiana Department of Natural Resources | Southern Natural Gas Company |
| Louisiana Department of Wildlife and Fisheries | Natural Resources Conservation Services |
| Louisiana Governors Office | St. Charles Parish |
| Louisiana Land and Exploration Company | Argonne National Laboratory |
| U.S. Army Corps of Engineers | Coastal Wetlands Planning Advisory Committee |
| Louisiana State University | U.S. Fish and Wildlife Service |
| Southern University | National Marine Fisheries Service |
| Louisiana Universities Marine Consortium | Tulane Environmental Law Clinic |
| Coalition to Restore Coastal Louisiana | Louisiana Sea Grant College Program |
| Shell Offshore | Gulf Restoration Network |
| T. Baker Smith and Son, Inc. | Amoco |
| Texaco Exploration and Production Inc. | Times-Picayune |
| Environmental Protection Agency | Morning Advocate |
| Barataria-Terrebonne National Estuary Program | Exxon Company |
| Southern Lafourche Levee District | New Orleans City Planning Commission |
| Lafourche Parish | Southeastern University |
| BP Oil Company | Lake Pontchartrain Basin Foundation |
| Sierra Club Defense Fund | Women for a Better Louisiana |
| Coastal Environments Inc. | Loyola University |
| U.S. Geological Survey | Gas Research Institute |
| William W. Goodell Jr. P.L.C. | Bayou Lafourche Fresh Water District |
| Applied Technology Research Corporation | Louisiana Mid-Continent Oil and Gas Association |
| Jefferson Parish | University of New Orleans |

## PROCESS CLASSIFICATION

Coastal land loss is typically the result of complex interactions among natural and human activities upon the landscape. Therefore, it is difficult to isolate an activity as the singular cause of a specific area of coastal land loss. However, general assumptions can be made for most areas regarding the primary physical process that removed or submerged the land, as well as the primary actions that initiated the process. By employing a classification scheme which graduates from general coastal land loss process to specific cultural and natural landscape activities, each loss area was specifically classified as the available information and scientific consensus allow. The process classification scheme is illustrated in Figure 3.

The first level of the classification addresses the basic processes of land loss. For purposes of this classification scheme, the term land is defined as all subaerial materials including surface vegetation, sediments, and organic soils. Three primary land loss processes were identified:

□1) erosion - physical removal and transport of land by water action,
□2) submer gence - increase of water level relative to ground surface
□ elevation, and
□3) direct removal - physical removal of land by actions other than
□ water

The second level of the process classification scheme identifies the primary actions that are associated with each loss process. This level of the classification includes both natural and cultural actions.

The actions of erosion include:
□1) natural waves - wind generated waves,
□2) navigation waves - waves generated by boat wakes, and
□3) channel flow - suspension and conveyances by water

The actions of submergence include:
□1) altered hydrology: impoundment - submer gence due to
□ impoundment levees,
□2) altered hydrology: oil/gas - submer gence due to presence of
□ oil/gas canals,
□3) altered hydrology: roads - submer gence due to presence of roads,
□4) altered hydrology: navigation - submer gence due to presence of
□ navigation channels,
□5) altered hydrology: multiple - submer gence due to multiple causes of
□ hydrologic alteration; including impoundment, oil/gas canals, roads,
□ and/or navigation
□6) faulting - submer gence due to active faulting,
□7) natural water logging - submer gence due to natural subsidence,
□8) failed reclamation - submer gence due to flooding of former reclamation
□ projects which have subsided, and
□9) herbivory - submer gence due to animals eating the marsh followed by
□ substrate collapse.

The actions of direct removal include:
□1) oil/gas channels - dredging and/or surface excavation
□2) navigation channels - dredging and/or surface excavation
□3) drainage channels - dredging and/or surface excavation
□4) sewage ponds - surface excavation
□5) borrow pits - surface excavation
□6) burned areas - fire
□7) agricultural ponds - surface excavation
□8) access channels - dredging and/or surface excavation

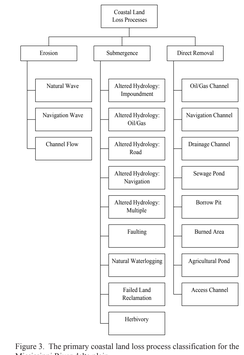


Figure 3. The primary coastal land loss process classification for the Mississippi River delta plain.

At this level of the process classification scheme issues of cause emerge. This level identifies the natural and cultural actions. Natural actions include phenomena such as wind, subsidence, or faulting. Cultural actions include human activities such as navigation, channel dredging, building of impoundments, resource extraction, and excavation of ponds. This level of the process classification identifies the factors known to stimulate natural and human coastal land loss actions. This is a diverse category of information which includes natural and cultural events, activities, and structures.

## PROCESS CLASSIFICATION RESULTS

The results of the GIS task are presented in Tables 2 and 3. Table 2 lists the coastal land loss process statistics for the entire delta plain quadrangle set. Between 1932 and 1990, 690,931 acres of land converted to water. The submergence process class accounted for 375,612 acres of loss or 54.36% of the total coastal land loss mapped in the Mississippi River delta plain. Next, the erosion class accounted for 213,280 acres of loss or 30.87% of acres and the direct removal class accounted for 102,039 acres of loss or 14.77%.

Of the possible process combinations within the erosion process category, three classes were delineated. Natural waves refers to wind generated wave erosion along the outer Gulf shoreline and within inland waters. Navigation waves describes erosion due to boat wakes along navigation channels. Channel flow refers to erosion due to currents generated by the ebb and flood of tides. Within the erosion class natural waves accounted for 26.21% of the total loss, followed by navigation waves at 3.16%, and channel flow at 1.50%.

Of the possible process combinations within the submergence process category, nine classes were delineated. Within the submergence class, altered hydrology: oil/gas accounted for 172,174 acres or 24.92% of the total loss, followed by altered hydrology: multiple at 21.52%, natural water logging at 3.05%, failed land reclamation at 2.37%, altered hydrology: impoundment at 1.16%, altered hydrology: roads at 0.70%, faulting at 0.57%, and herbivory at 0.08%.

Of the possible direct removal combinations, eight classes were delineated. Within the direct removal class, oil and gas channels are the highest at 76,978 acres or 11.14% of the total loss, followed by navigation channels at 1.63%, borrow pits at 1.61%, access channels at 0.19%, burned areas at 0.11%, sewage ponds at 0.04%, agricultural ponds at 0.03%, and drainage channels at 0.02%.

In order to rank the processes of coastal land loss, some classes will stand alone and some classes must be combined. To rank oil and gas, the direct removal - oil and gas class must be combined with the submergence - altered hydrology: oil and gas class. This holds true for navigation also. All of the remaining classes will stand alone. Oil and gas ranks the highest process of coastal land loss at 249,152 acres or 36.06% of the total loss ( Table 3). Next is natural wave erosion at 26.21% followed by altered hydrology - multiple at 21.52%, navigation at 4.97%, natural water logging at 3.05%, failed land reclamation at 2.37%, and channel flow at 2.27%. All of the remaining classes are 2% or less and account for less than 6% of the total loss. When discussing the results of the GIS analysis task it is important to keep in mind that these results describe local processes and do not reflect the direct contribution of important regional processes such as river control, subsidence, and eustacy. Within this context, one of the major goals of the GIS analysis was to determine the contribution of natural and human processes to the land loss problem. From a local perspective based on the GIS analysis, 31.33% of the coastal land loss is caused by natural processes and 68.67% is caused by human processes.

Table 2. Coastal Land Process- Delta Plain

| CLASS NAME | ACREAGE | PERCENT |
|---|---|---|
| EROSION | | |
| Natural Wave | 181,090 | 26.21% |
| Navigation Wave | 21,821 | 3.16% |
| Channel Flow | 10,369 | 1.50% |
| Subtotal | 213,280 | 30.87% |
| SUBMERGENCE | | |
| Alt. Hydro Oil/Gas | 172,174 | 24.92% |
| Alt. Hydro Multiple | 148,666 | 21.52% |
| Natural Waterlogging | 21,069 | 3.05% |
| Failed Land Reclamation | 16,403 | 2.37% |
| Alt. Hydro Impoundment | 7,992 | 1.16% |
| Alt. Hydro Roads | 4,825 | 0.70% |
| Faulting | 3,921 | 0.57% |
| Herbivory | 561 | 0.08% |
| Subtotal | 375,612 | 54.36% |
| DIRECT REMOVAL | | |
| Oil/Gas Channel | 76,978 | 11.14% |
| Navigation Channel | 11,293 | 1.63% |
| Borrow Pit | 11,130 | 1.61% |
| Access Channel | 1,312 | 0.19% |
| Burned Area | 729 | 0.11% |
| Sewage Pond | 308 | 0.04% |
| Agricultural Pond | 179 | 0.03% |
| Drainage Channel | 109 | 0.02% |
| Subtotal | 102,039 | 14.77% |
| **TOTAL** | **690,931** | **100.00%** |

Table 3. Delta Plain Coastal Land Loss Ranking

| CLASS NAME | ACREAGE | PERCENT |
|---|---|---|
| Oil and Gas | 249,152 | 36.06% |
| Natural Waves | 181,090 | 26.21% |
| Alt. Hydro Multiple | 147,442 | 21.34% |
| Navigation | 33,114 | 4.79% |
| Natural Waterlogging | 21,069 | 3.05% |
| Failed Land Reclamation | 16,403 | 2.37% |
| Channel Flow | 15,668 | 2.27% |
| Borrow Pits | 11,130 | 1.61% |
| Alt. Hydro Impoundment | 7,992 | 1.16% |
| Alt. Hydro Road | 4,825 | 0.70% |
| Faulting | 3,921 | 0.57% |
| Access Channel | 1,312 | 0.19% |
| Burned Area | 729 | 0.11% |
| Herbivory | 561 | 0.08% |
| Sewage Pond | 308 | 0.04% |
| Agricultural Pond | 179 | 0.03% |
| Drainage Channel | 109 | 0.02% |
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