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# Below C-Level: Louisiana's Failure to Regulate Industrial Groundwater Withdrawal-Driven Subsidence

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## INTRODUCTION

Imagine coming home one evening after a long day of work. All you want to do is take off your shoes, have a glass of wine, cook dinner, and relax. You start preparing dinner by turning on your gas oven. BOOM, there is an explosion in your kitchen. A small Metairie community faced this reality eight times between 1972 and 1977.[1] The reason for this grim actuality: land subsidence. Years later, in the aftermath of Hurricane Katrina, New Orleans and Gulf Coast communities struggled to find the cause of the immense destruction of an area filled with such life and light. The blame for the infrastructural failure in New Orleans, most notably the levee system of the MR-GO in the Intercoastal Waterway, ultimately fell on the Army Corp of Engineers and the federal government, who faced an influx of claims as a result of their roles in the destruction. But was it really the fault of the Army Corps? What if, in a haste to place blame, the community not only overlooked the long-time, unaddressed problem of land subsidence, but contributed to it as well?

Land subsidence[2] in deltaic regions is an issue both in the United States and internationally. While it affects communities on all coasts of the United States, the issue is most notably found in the deltaic regions[3] surrounding New Orleans. Land subsidence can have both natural and anthropogenic[4] causes, including sea-level rise, rapid urbanization, and

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1. Richard Campanella, *Cityscapes: When Soil Subsidence Hits Home, Suburban Houses Explode*, https://perma.cc/C5JG-YB7M.

2. Sinking or settlement of the land surface, due to any of several processes. As commonly used, the term relates to the vertical downward movement of natural surfaces although small-scale horizontal components may be present. The term does not include landslides, which have large-scale horizontal displacements, or settlements of artificial fills. *"Subsidence"* Devin Galloway, U.S. GEOLOGICAL SURVEY CIRCULAR 1182: *Land Subsidence in the United States, Part I Mining Ground Water* 163 (D. Galloway et. al. eds., 2013).

3. A delta is an area of low, flat land shaped like a triangle, where a river splits and spreads out into several branches before entering the sea. *Delta,* MERRIAM-WEBSTER DICTIONARY (11th ed. 2016).

4. Of, relating to, or resulting from the influence of human beings on nature anthropogenic pollutants. *Anthropogenic,* MERRIAM-WEBSTER DICTIONARY (11th ed. 2016).

unmitigated groundwater pumping.[5] However, on a local scale, land subsidence is mainly induced by human activity.[6]

The lack of regulation of groundwater removal or of a strategy to mitigate land subsidence in New Orleans and the surrounding Mississippi River Delta is surprising, especially in light of the fact that other countries and even other coastal states in the U.S. have started to regulate groundwater pumping.[7] Land subsidence causes severe localized damage, including loss of functional integrity of critical infrastructure, increased flood risk, and disruption of drainage.[8] The effects of land subsidence lack visibility until a catastrophic event occurs, but New Orleans cannot ignore the great risks lurking beneath the surface of deltaic metropolitan areas as sea-levels continue to rise.

Recent floods and future projections of subsidence in New Orleans and along the Mississippi River highlight the need for local and statewide regulation of groundwater pumping. The City of New Orleans has a right to use and enjoy its land. It also has the ability to adequately protect the city and the land upon which it sits. Based on this right, New Orleans and the surrounding area have a cause of action for infrastructural damages against those currently pumping or who have pumped groundwater within a certain period prior to the damage. This cause of action includes, but may not be limited to: levee breakage, hindered drainage, and catastrophic flooding. The recent increase in catastrophic urban flooding in large deltaic cities, most notably New Orleans and Houston, highlights the issue of land subsidence due to groundwater withdrawal. Implementation and utilization of regulatory programs at both the state and local levels could stop, slow, or even reverse land subsidence.

To assess how the law applies to land subsidence, Part I of this Comment addresses the need to understand the basics of the science behind the natural and man-made vulnerabilities of river deltas and the surrounding areas and compares the differences in speed and effect between the two. Part II explains Entergy's use of groundwater instead of river water in its cooling process and draws the connection to groundwater pumping. Part II also addresses the possible contribution to flooding in New Orleans from lowering part of the city and complicating drainage. Part III discusses the legal theories of negligence and nuisance in suggesting the city might apply either in a possible action against Entergy

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5. *Id*.

6. *Id.*

7. Deltares - Taskforce Subsidence, *Sinking cities: An integrated approach towards solutions*, at 6 (2013), https://perma.cc/7MJ3-MVHH (last visited Aug. 25, 2018).

8. *Id*. at 1-3.

for the industrial use of groundwater removal. Part III explicates the elements of negligence and nuisance, their differences, and how the courts have applied each to subsidence-related claims. Part IV addresses future regulatory possibilities that could prevent further subsidence as well as how to implement these regulations.

## I. SINKING INTO THE FACTS

Land subsidence, as defined by Professor Roy Dokka, is the downward movement of the Earth with respect to a piece of information or point of reference.[9] This movement results from many natural and anthropogenic processes. Subsidence varies in and by space, area, and size over time. For accurate measurements of land subsidence, it is critical that the measurements include the specific time and space to which process observations and measurements pertain.[10] Land subsidence is the gradual settling or sudden sinking of the Earth's surface due to subsurface movement of earth materials.[11] Land subsidence has both natural and anthropogenic causes; natural causes—tectonics, glacial isostatic adjustment, and natural sediment compaction—and anthropogenic causes—such as compaction due to heavy construction and drainage. [12]

Spanning more than 17,000 square miles, forty-five of the United States experience the effects of subsidence.[13] Current subsidence rates in large coastal cities range from 6–100 millimeters per year, a range projected to hold steady through 2025.[14] New Orleans' mean cumulative subsidence between 1900 and 2014 was 1,130 millimeters, with a mean current subsidence rate of six millimeters per year and a maximum subsidence rate of twenty-six millimeters per year.[15] At this rate, the estimated additional cumulative subsidence is greater than 200 millimeters until 2025.[16] Coastal-

9. Roy K. Dokka, *The Role of Deep Processes in Late 20th Century Subsidence of New Orleans and Coastal Areas of Southern Louisiana and Mississippi*, at 2, 116 J. GEOPHYSICAL RES., June 2011.

10. *Id.*

11. DEP'T OF INTERIOR, U.S. GEOLOGICAL SURVEY: USGS GROUNDWATER INFORMATION, LAND SUBSIDENCE, https://perma.cc/6VYY-K59W (last visited Aug. 25, 2017).

12. Glacial isostatic adjustment is defined as the ongoing movement of the land. NATIONAL OCEAN SERVICE, *What is glacial isostatic adjustment?*, https://perma.cc/2VW6-BA66 (last visited Aug. 25, 2018). Deltares, *supra* note 7, at 3.

13. DEP'T OF INTERIOR, *supra* note 11.

14. Deltares, *supra* note 7, at 2.

15. *Id.*

16. *Id.*

plain areas, initially one to five meters above mean sea level, are susceptible to severe impact if substantial land subsidence develops.[17] Land subsidence affects cities all over the world, especially low-lying coastal and delta areas, due to the physical characteristics of the alluvial[18] sediments and fertile soil that these cities sit upon.[19]

### *A. Causes of Land Subsidence*

Natural processes like sediment compaction and consolidation happen over time. These processes occur due to the nature of soil, direction of natural water flow, drainage in deltaic regions.[20] Anthropogenic causes such as groundwater removal and rapid urbanization tend to contribute the most to land subsidence in deltaic regions.[21]

#### *1. Sediment Compaction and Consolidation*

Compaction and consolidation are fundamental natural processes that affect sediments when they accumulate, resulting in their rearrangement.[22] In compaction, rearrangement occurs with the expulsion of intergranular air, while consolidation occurs with the expulsion of water.[23] These two processes lead to significant changes in dimension and density over time.[24] Forced drainage of areas protected by levees can greatly accelerate both compaction and consolidation.[25] Almost all permanent subsidence occurs because of the irreversible compaction or consolidation during the slow-

17. Poland, Joseph F., *Guidebook to studies of land subsidence due to ground-water withdrawal: 6 Economic and social impacts and legal considerations* (1984).

18. Clay, silt, sand, gravel, or similar detrital material deposited by running water. *Alluvium,* MERRIAM-WEBSTER DICTIONARY (11th ed. 2016).

19. NATIONAL OCEAN SERVICE, *supra* note 12.

20. *Id.*

21. *Id.*

22. Dokka, *supra* note 9, at 14.

23. *Id*.

24. *Id*.

25. *Id*.

draining process of aquitard[26] drainage.[27] It is possible for compaction to continue for years, even decades, after groundwater reduction.[28]

*2. Anthropogenic Causes*

Land subsidence is mainly induced by human activity and can significantly outpace rises in sea-level.[29] More than 80% of the identified subsidence in the nation has occurred because of exploitation of underground water. The increase in the development of land and water resources threatens to initiate new land subsidence problems while exacerbating existing ones."[30]

*a. Rapid Urbanization*

Urbanization is an issue that many deltaic regions face. As of 2014, 54% of the world's population lived in urban areas; a number expected to increase to 66% by 2050.[31] A river delta's elevation above sea-level depends on four factors: ocean global volume, sediment compaction, aggradation,[32] and vertical movements resulting from plate tectonics.[33] The weight of this rapid increase in urban infrastructure, such as levees and other flood control structures, compacts the underlying soil and prevents surface water from returning into the earth and restoring the

26. A saturated, but poorly permeable, geologic unit that impedes a ground-water movement and does not yield water freely to wells, but which may transmit appreciable water to and from adjacent aquifers and, where sufficiently thick, may constitute an important ground-water storage unit. "*Aquitard"* Devin Galloway, U.S. GEOLOGICAL SURVEY CIRCULAR 1182: *Land Subsidence in the United States, Part I Mining Ground Water* 159 (D. Galloway et. al. eds., 2013).

27. *Id*. at 7.

28. DEP'T OF INTERIOR, USGS: *Land Subsidence and Relative Sea-Level Rise in the Southern Chesapeake Bay Region* 11 (2013).

29. Charles B. Schmidt, *Delta Subsidence: An Imminent Threat to Coastal Populations*, 123 ENVIRONMENTAL HEALTH PERSPECTIVES A 204, A 205 (2015) (discussing the causes of land subsidence).

30. DEP'T OF INTERIOR, USGS: *Land Subsidence* (Aug. 2017), https://perma.cc/S9TR-XN5B.

31. THE UNITED NATIONS, *World's population increasingly urban with more than half living in urban areas*, https://perma.cc/X53V-LYPD.

32. A modification of the earth's surface in the direction of uniformity of grade by deposition. *Aggradation,* MERRIAM-WEBSTER DICTIONARY (11th ed. 2016).

33. Schmidt, *supra* note 29, at A 206 (discussing the causes of land subsidence).

groundwater.[34] Before humans intervened, a combination of sediments deposited during Mississippi River floods and organic solids produced from the decay of wetland vegetation offset natural subsidence.[35] The construction of flood control levees to protect Gulf Coast settlements and their populations interrupted the sediment supply, leading to an overall increase in land subsidence.[36]

*b. Groundwater Withdrawal*

The withdrawal method central to the issue of subsidence in deltaic regions is the withdrawal of groundwater. Groundwater is a valuable resource both in the United States and throughout the world. Where surface water sources, such as lakes and rivers, are scarce or inaccessible, groundwater supplies many hydrologic needs. In the United States, it is the source of drinking water for about half the total population, including nearly all of the rural population. It also provides over fifty billion gallons per day for agricultural needs.[37] Three types of fluid withdrawal methods that contribute to land subsidence are: the withdrawal of oil, gas, and associated water; the withdrawal of hot water or steam for geothermal power; and the withdrawal of groundwater.[38]

Groundwater depletion, defined as long-term water level declines caused by sustained groundwater withdrawal, remains the most critical issue associated with groundwater use. Many areas of the United States experience groundwater depletion because of groundwater's widespread use in homes and industries.[39]

*B. Effects of Land Subsidence*

Land subsidence has major effects on infrastructure and the underlying deltaic system. Unlike the growing public interest in rising sea-levels, public interest in land subsidence is low due to the fact that the

34. *Id*.

35. *Supra* note 31.

36. NASA, *New Study Maps Rate of New Orleans Sinking* (May 2016), https://perma.cc/2FQ4-Z6KU.

37. DEP'T OF INTERIOR, USGS: *Groundwater Depletion* (Dec. 2016), https://perma.cc/LX35-U994.

38. Poland, Joseph F. and Working Group, *Guidebook to Studies of Land Subsidence Due to Ground-Water Withdrawal: 3 Mechanics of Land Subsidence Due to Fluid Withdrawal* (1984).

39. DEP'T OF INTERIOR, USGS: *Land Subsidence and Relative Sea-Level Rise in the Southern Chesapeake Bay Region* 10 (2013).

nature of land subsidence is almost completely imperceptible to the public in real time. Public interest in land subsidence causes billions of dollars in damages worldwide, and does not traditionally manifest until after catastrophic events, namely incidents of large-scale urban flooding.[40]

*1. Weakening of the Functional Integrity of Critical Urban Infrastructure*

Groundwater withdrawal impacts the functional integrity of critical urban infrastructure, like the levee system of the MR-GO in the Intercoastal Waterway in the aftermath of Hurricane Katrina. This is due to changes in relative water levels at both the ground and surface levels, increased flood risk, flood frequency, depth, duration of inundation, and disruption of drainage.[41] Uneven changes in ground level can damage infrastructure both above and below the surface. This includes both underground and above-ground structures, namely; water and sewer pipes, wells, building foundations, roads, bridges, canals, and buildings.[42] These infrastructural damages are a serious effect of land subsidence in urban deltaic regions that rely on levees and other means of river control and flood protection, such as the greater metropolitan areas of Houston and New Orleans.

Where vertically stable benchmarks exist and surveys are repeatedly made, land subsidence is measured fairly easily using professional surveying instruments.[43] The need for vertically stable benchmarks located outside the area affected by subsidence poses a major challenge for detecting and preventing regional land subsidence and preserving the functional integrity of the heavily relied upon urban infrastructure.[44] In an attempt to secure these benchmarks, the National Aeronautics and Space Administration (NASA) uses its Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR), which applies a technique known as interferometric synthetic aperture radar (InSAR). InSAR compares radar images of Earth's surface over time to map surface deformation with centimeter-scale precision. This precision helps measure total surface

40. *Supra* note 26.

41. Deltares, *supra* note 7.

42. Van Quathem, Michelle L., *Land Subsidence Damage Caused by Groundwater Withdrawals in Arizona: Who Pays?*, THE NATIONAL LAW REVIEW (Feb. 24 2015).

43. *Id*.

44. Devin Galloway, U.S. GEOLOGICAL SURVEY CIRCULAR 1182: *Land Subsidence in the United States, The Role of Science* 142 (D. Galloway et. al. eds., 2013).

elevation changes from all sources—human and natural, both deep-seated and shallow.[45] The data must be carefully interpreted to disentangle the differing sources of these phenomena, which operate at different time and space scales. This makes the spatial resolution ideal for measuring subsidence in New Orleans, where human-produced subsidence is both large and localized.[46]

*2. Collapse*

Collapse or near-collapse refers to the situation where a delta cannot be restored to its natural condition. It makes the deltaic area more vulnerable to storm surges that can damage or breach levees and other protectorate walls, possibly resulting in catastrophic flooding.[47] Man-made interference with naturally-changing deltaic systems, excessive groundwater withdrawal due to rapid urbanization, population growth, and the increased frequency of extreme climate events like hurricanes and river flooding all contribute to the possible collapse of entire deltaic systems.[48]

*C. International Response to Land Subsidence*

Several of the world's most heavily populated coastal cities remain vulnerable to inundation because of man's interference with the deltaic process.[49] The negative impacts of groundwater pumping occur in communities across the globe, including regions in Jakarta, Bangkok, and Tokyo. Unlike these regions, New Orleans and the Mississippi River Delta region have no strategy to combat or mitigate subsidence.[50]

The Greater Jakarta area is subsiding at up to ten centimeters per year, which could result in as much as six meters of subsidence by 2100.[51] To combat this, Jakartan metropolitan authorities and technical agencies are phasing out the use of groundwater, implementing taxes on groundwater

45. NASA, *New Study Maps Rate of New Orleans Sinking* (May 2016), https://perma.cc/J5BF-34EW.

46. *Id*.

47. *Supra* note 26.

48. Irina Overeem and James P. M. Syvitski, *Dynamics and Vulnerability of Delta Systems*, FUTURE EARTH COASTS, IPO. (2009)

49. Virginia Burkett, *U.S. Geological Survey Subsidence Interest Group Conference: proceedings of the Technical Meeting, Galveston, Texas, November 27-29, 2001*: *Sea-Level Rise and Subsidence: Implications for Flooding in New Orleans*, LOUISIANA 63 (V.R. Burket et al. eds., 2001).

50. *Id.*

51. H. Z. Abidin et al., *Study on the Risk and Impacts of Land Subsidence in Jakarta*, 372 PROC. INT'L ASS'N HYDROLOGICAL SCI. 115, 117 (2015).

consumption, and advocating for the reduction of groundwater extraction in vulnerable areas.[52]

Bangkok implemented regulations and restrictions on groundwater extraction through groundwater use charges and the passage of the 1977 Groundwater Act, resulting in the successful reduction of extreme land subsidence.[53] Efforts in Tokyo and Shanghai demonstrated that with active and substantial recharge[54] of groundwater, sustainable groundwater use is possible without severe subsidence. Of course, average yearly pumping rates must be balanced with the average yearly recharge.[55]

## II. WITHDRAWING THE PROBLEM

Groundwater withdrawal suspected of contributing to subsidence in the New Orleans area[56] exposes several regions to increased risks of surface fracturing because of the reactivation of preexisting faults.[57] For the purpose of this Comment, the city refers to the metropolitan area of New Orleans, which according to the New Orleans region's Chamber of Commerce, GNO, Inc., includes the following parishes: Jefferson, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Tammany, Tangipahoa, and Washington.[58] The majority of the New Orleans metropolitan area is protected by levees constructed by local sponsors and the United States Army Corps of Engineers under five different Congressional authorizations beginning in 1879.[59] While the levee design height ranges from 4.5 to 6 meters above mean sea level and is designed to withstand the surge and waves of a Category 3 hurricane, the current levee design criteria assumes no increase in the mean sea level or subsidence.[60] Levee wall protection criteria in New Orleans centers around the T-wall. T-walls primary function in the New Orleans area is flood protection. T-walls are pile-founded structures that are made up of a

52. Deltares, *supra* note 7, at 6.

53. *Id.*

54. The process involved the addition of water to the saturated zone: naturally by precipitation or runoff, or artificially by spreading or injection. Devin Galloway, *Recharge*, U.S. Geological Survey Circular 1182: *Land Subsidence in the United States, Part I Mining Ground Water* 159 (D. Galloway et. al. eds., 2013).

55. Deltares, *supra* note 7, at 7.

56. *Supra* note 9, at 14.

57. *See* DEP'T OF INTERIOR, *supra* note 11 at 16.

58. GREATER NEW ORLEANS, INC., https://perma.cc/WH8H-B869 (last visited Aug. 25, 2018).

59. Burkett, *supra* note 49, at 67.

60. *Id.*

reinforced concrete wall and base with steel sheet pile cut-off.[61] There are three permanent benchmarks for protection heights required for design/construction and verification of a sound levee system: I-Walls with a four-foot maximum; T-Walls, which have no height limit but are typically four feet and greater; and L-Walls and Kicker Pile Walls with an eight-foot maximum (includes required overbuild), all of which are permitted heights on the protected side of the wall.

Subterranean action along the Michoud Fault, a geological fault line running through New Orleans East, coincides with changes in the water level relative to major urban development and groundwater pumping in the Michoud area.[62] Before the June 2016 closure of Entergy's New Orleans Power Station, located in Michoud, the plant, constructed in the 1960's, used groundwater for cooling purposes.[63] The highest rates of sinking in New Orleans, observed between 2009 and 2012 at fifty millimeters per year of sinking, took place around major industrial areas in Michoud and Norco.[64] Groundwater pumping and dewatering caused the majority of this subsidence.[65] Radar imagery revealed that sections of levees by the Michoud plant, which were rebuilt higher after Hurricane Katrina by the Army Corps, continued to subside by as much as two inches per year.[66] The $1.1 billion barrier built after Katrina is nearby. The barrier is nearly two miles long and designed to stop hurricane surges, but the study did not discuss whether that structure had subsided.[67]

In 2016, Entergy filed an application with the New Orleans City Council for approval to renovate, restore, and re-open the New Orleans Power Station as a new, modern power plant at the existing Michoud site in an industrial area in New Orleans East.[68] The Power Station is to re-

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61. USACE, *Hurricane and Storm Damage Risk Reduction Guidelines: 5.2 T-wall & L-wall Design Criteria,* https://perma.cc/G7XJ-PBR2 (last visited Aug. 25, 2018).

62. *Supra* note 12, at 20.

63. Cain Burdeau, *Study: Water-sucking industry a factor as New Orleans sinks* (May 2016), https://perma.cc/AY87-U7G3.

64. *Supra* note 9.

65. Dewatering involves controlling groundwater by pumping, to locally lower groundwater levels in the vicinity of the excavation. GROUNDWATER ENGINEERING, LTD., https://perma.cc/7MMU-NZVQ (last visited Aug. 25, 2017); NASA, *New Study Maps Rate of New Orleans Sinking* (May 2016), https://perma.cc/JA6K-GCZ8 (Dewatering is defined as surface water pumping to lower the water table, which prevents standing water and soggy ground.).

66. *Supra* note 11.

67. *Id.*

68. ENTERGY, *Entergy New Orleans Proposes New Power Plant to Meet City's Growing Needs* (June 20, 2016), https://perma.cc/5QGY-4E6W.

open as a natural gas-fired combustion turbine plant, more commonly known as a CT plant, using high temperatures to fuel efficiency.[69] If the City Council approves the proposed plans, Entergy expects the New Orleans Power Station to fully re-open in the second half of 2019.[70]

Levees and pumping stations protect more than one million people in the New Orleans metropolitan area, where the land is gradually sinking at rates that exceed twentieth century sea level rise, from river floods and storm surge.[71] The 2005 flooding of New Orleans during Hurricane Katrina and the 2017 flood were real-life examples of the effects of natural and man-made vulnerabilities of river deltas and the surrounding areas. This draws comparison and connection to groundwater pumping and the possible contribution to the flooding by lowering part of the city and complicating drainage.

A timeline of New Orleans Flood Control and Protection Infrastructure starting in 1914 shows the navigational and flood protection projects that were first constructed by the State of Louisiana and the Army Corps of Engineers in the New Orleans area: the Inner Harbor Navigation Canal in 1914, the Gulf Intracoastal Waterway in 1925, Lake Pontchartrain and the Hurricane Protection Project in 1955, and the Mississippi River Gulf Outlet Canal (MR-GO) in 1965.[72] It is difficult to factor the projected rate of subsidence into engineering plans and policy, especially in existing flood control structures. This difficulty stems from the hard-to-measure time and space factors that affect subsidence rates that are useful to resource managers and planners.[73] Further, scientific studies report a wide range of subsidence rates, making it difficult to understand the scale of the challenges subsidence presents.[74]

Accelerated sea-level rise and the current altitude of New Orleans, combined with the current high rate of subsidence, foretell serious losses of property in New Orleans unless there are serious improvements made to flood-control levees and pumping stations.[75] The current plans for hurricane protection and coastal restoration planning for the New Orleans and coastal Louisiana-Mississippi region are based on long-term

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69. U.S. DEP'T OF ENERGY'S OFFICE OF FOSSIL ENERGY, *How Gas Turbine Power Plants Work*, https://perma.cc/6B6N-BUWC (last visited Aug. 25, 2018).

70. *Supra* note 61.

71. Burkett, *supra* note 49, at 63.

72. St. Bernard Par. Gov't v. United States, 121 Fed. Cl. 687, 690-91 (2015).

73. Burkett, *supra* note 49.

74. Brendan Yuill et al., *Understanding Subsidence Processes in Coastal Louisiana*, JOURNAL OF COASTAL RESEARCH (SPECIAL ISSUE) 54, 23 (2000), https://perma.cc/C9RR-ZEB5.

75. *Supra* note 65.

subsidence rate estimates that do not reflect modern notions established by geodetic methods and water gauge level measurements. Groundwater extraction in urbanized areas caused the lowering of local flood protection structures and bridges in the New Orleans area by as much as 0.8 meters since 1960.[76]

## III. RAISING THE GRADE: REBUTTING AND REGULATING

Protecting citizens from the effects of subsidence must be of the utmost importance to the City of New Orleans and other deltaic regions. As one scholar stated:

> The effect of withholding by the levees from the great areas of the delta of the annual contributions of sedimentary matters, and the steady, though slow, subsidence of these areas, is one which should be taken into account in deciding the important question of how to protect the people from the flood waters of the river. No doubt the great benefit to the present and two or three following generations accruing from a complete system of absolutely protective levees, excluding the flood waters entirely from the great areas of the lower delta country, far outweighs the disadvantages to future generations from the subsidence of the Gulf delta lands below the level of the sea and their gradual abandonment due to this cause.[77]

New Orleans is far behind other large cities that also struggle with how to protect and prevent the effects of land subsidence. The city currently has two plausible solutions to protect and prevent the effects of land subsidence: the first is legal recourse against those who have contributed and exacerbated land subsidence, and the second involves the implementation of legislative action to prevent, mitigate, and regulate future industrial removal of groundwater.

### *A. Talking Torts: What Cause of Action Does the City Have?*

Plaintiffs filed over 400 lawsuits in the U.S. District Court in the aftermath of Hurricane Katrina. Plaintiffs alleged that the Army Corps' construction and operation of the MR-GO violated the Federal Torts

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76. Dokka, *supra* note 9, at 23.

77. E.L. Corthell, *The Delta of the Mississippi River*, 8 NAT'L GEOGRAPHIC MAG. 351 (1897), https://perma.cc/K2L3-SMDU.

Claims Act and Louisiana negligence laws.[78] Negligence and nuisance both prescribe methods of recovery for New Orleans. The differences between the theories and how courts have applied each to subsidence-related claims across the United States define if and how large-scale urban deltaic regions such as New Orleans can recover.

*1. Negligence*

A significant notion in both codified statutes and case law is that every person is responsible for the damages he not only directly causes by his actions, but also by his negligence, imprudence, or his lack of skill.[79] Negligence is defined as "the failure to observe or perform a legal duty owed another that results in injury to the other," including both acts and omission.[80] There are multiple elements of negligence in Louisiana: duty, breach, cause-in-fact, and scope of the risk. Plaintiffs can utilize Louisiana's law of negligence to recover for structural damages caused by subsidence if they can prove that groundwater pumping by a defendant was the proximate cause of the infrastructural damage. The concept of proximate cause is "generally defined as any cause which, in natural and continuous sequence, unbroken by any efficient, intervening cause, produces the result complained of and without which the result would not [have] occurred."[81] Application of a negligence theory would hold companies or industries that use industrial withdrawal of groundwater liable for pumping damages. Thus, under a negligence theory, Entergy and similar entities could be held liable for the infrastructural damages to surrounding flood protection structures if the City could prove that Entergy's removal of groundwater was the proximate cause.

The doctrine of *res ipsa loquitor*, the legal theory that "the thing speaks for itself," may strengthen the City's negligence claim.[82] "The doctrine of res ipsa loquitur applies in cases where the plaintiff uses circumstantial evidence alone to prove negligence by the defendant."[83] Circumstantial evidence is "evidence of one fact, or of a set of facts, from

78. 28 U.S.C. § 2671 et seq. *Supra* note 68, at 690-91.

79. LA. CIV. CODE. art. § 2316.

80. Michael D. Bradley & Michael C. Carpenter, *Subsiding Land and Falling Ground-Water Tables: Public Policy, Private Liability, and Legal Remedy*, 62 ECON. GEOGRAPHY 241, 244 (1986).

81. Sutton v. Duplessis, 584 So. 2d 362, 365 (La. Ct. App. 1991).

82. Bradley & Carpenter, *supra* note 80 at 243.

83. Linnear v. CenterPoint Energy Entex/Reliant Energy, 41,171 (La. App. 2d Cir. 8/4/06) 945 So. 2d 1, 7 (quoting Cangelosi v. Our Lady of the Lake Regional Medical Center, 564 So. 2d 654 (La. 1989)).

which the existence of the fact to be determined may reasonably be inferred."[84] The use of this doctrine "permits the inference of negligence on the part of the defendant from the circumstances surrounding the injury."[85]

For the City to benefit from the *res ipsa loquitur* doctrine, it must prove that the groundwater removed was under the exclusive control of those using it at the Entergy Michoud Plant. Further, the City must prove that no injury would have occurred under ordinary circumstances, if Entergy were using a different source of water for their cooling system, or if Entergy had exercised proper care. Between general negligence and *res ipsa loquitor*, the law is broad enough to encompass all the situations where defendants did not exercise reasonable care.

In 2005, St. Bernard Parish, a parish in the New Orleans metropolitan area, filed suit claiming a Fifth Amendment temporary taking by Army Corps of Engineers in the construction, expansion, operation, and failure to maintain navigational channel Mississippi River Gulf Outlet (MR-GO).[86] Although the NASA study on land subsidence in New Orleans East, including the area of land under the MR-GO and parts of St. Bernard Parish, became available in 2012,[87] Judge Susan Braden still found in favor of St. Bernard Parish in 2015, holding the Army Corp of Engineers liable for damages based on the Army Corps' inability to foresee the eminent flooding of private property during the construction, expansion, and operation of the MR-GO. Additionally, Judge Braden found that the failure to maintain the MR-GO substantially increased storm surge during severe storms and hurricanes causing flooding, and that a causal link existed between those actions and the damage sustained during and in the aftermath of Hurricane Katrina.[88]

*a. Weight of Defenses*

Defenses against a negligence claim in some jurisdictions include, but are not limited to, contributory negligence on the part of the plaintiff and assumption of the risk.[89] Louisiana, however, is a pure comparative fault state. Louisiana Civil Code article 2323 explains comparative fault, stating that in any action for damages where a person is injured or dies, the

84. *Id.*
85. *Id.*
86. St. Bernard Parish Gov't v. U.S., 121 Fed. Cl. 687 (2015).
87. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, *New Study Maps Rate of New Orleans Sinking* (May 16, 2016), https://perma.cc/2UWX-RE3G.
88. St. Bernard Parish Gov't v. U.S., 121 Fed. Cl. 687 (2015).
89. *Id*.

percentage of fault of anyone causing or contributing to the injury, death, or loss is determined, regardless of whether the person is a party to the action or a nonparty, and regardless of their insolvency, ability to pay, immunity by statute, or if the other person's identity is known or reasonably ascertainable.[90]

Comparative fault dictates that any percentage of fault allocated to the plaintiff is potentially the liability of the plaintiff, which may limit the recovery available to the party bringing suit.[91] Entergy and other industrial users of groundwater may argue that because the City of New Orleans approved the initial construction and plans for the plants, it assumed some liability for the action of the plants. Entergy may argue that the City lacked reasonable care when it approved the plant plans, and thus the subsequent damage to the City's infrastructure and potential loss of life as a result should be partially appropriated to the City. Entergy could also argue that the weight of the infrastructure—in this case, the weight of the flood control levees and other flood mitigating structures constructed by the Army Corps of Engineers at the behest and instruction of the city—could also make the city liable under a comparative fault analysis.

The only way for these potential arguments to have merit is if, at the time of the initial approval of the Entergy Michoud Plant in New Orleans East, Entergy had provided a scientific estimate of what it thought pumping groundwater would do in the future. Without providing the City with projected results of pumping groundwater or possible ways to mitigate or stop subsidence, like use of regular InSAR measurements or a potential partnership with NASA to measure land subsidence in the area over time, the City is without a defense when held comparatively liable for the subsidence and subsequent infrastructure failure. While there is no approach for the City to be held liable for the land subsidence, Entergy may find a claim to hold them liable for the weight of the infrastructure and therefore the resulting land subsidence.

*2. Nuisance*

A nuisance is a public or private wrong by a landowner, resulting from unreasonable, unwarrantable, or unlawful use of his own property.[92] An explicitly unlawful act is not always required for a nuisance claim, and the determination is left to the discretion of the court to weigh the circumstances.[93] Under New Orleans ordinances, the removal of groundwater is not unlawful,

90. LA. CIV. CODE art. 2323(A) (2017).
91. *Id.*
92. LA. CIV. CODE art. 667 (2017).
93. *Id.*

but the damage to city infrastructure resulting from the removal of groundwater for cooling purposes at the Entergy Power Station could be considered a nuisance. If the City used the NASA maps to demonstrate that the increased level of subsidence in the area surrounding the Michoud Power Station caused by groundwater removal triggered or contributed to the infrastructural failure of the MR-GO, then the City could attach a nuisance claim to the aforementioned negligence claim, or simply raise the nuisance claim on its own.

*B. The Federal Tort Claims Act (28 U.S.C. 2671 et. al.)*

In most recent jurisprudence, subsidence cases are brought under the theories of nuisance and negligence, both of which are the most common types of torts, along with trespass.[94] According to 28 U.S.C. § 2672,

> The head of each Federal agency . . . in accordance with regulations prescribed by the Attorney General, may consider, ascertain, adjust, determine, compromise, and settle any claim for money damages against the United States for injury or loss of property or personal injury or death caused by the negligent or wrongful act or omission of any employee of the agency while acting within the scope of his office or employment, under circumstances where the United States, if a private person, would be liable to the claimant in accordance with the law of the place where the act or omission occurred . . . .[95]

The Federal Tort Claims Act is applicable to the claims brought post-Katrina. The claims brought under the Act against the Army Corps of Engineers held the Army Corps liable for damages based on the argument that the Army Corps was to blame for the failure of the levees in the aftermath of Hurricane Katrina.[96] Because the Federal Tort Claims Act applies mainly to agencies, Louisiana tort law provides a more feasible remedy to hold corporations that pump groundwater liable for the possible infrastructural damages caused by their industrial practices.

*C. Rule of Capture: Withdrawal of Subterranean Water Regulation*

The Louisiana rule of capture found in Article 8 of the Louisiana Mineral Code allows landowners to "reduce to possession and ownership

94. *Supra* note 80 at 243.
95. 28 U.S.C § 2672.
96. *Supra* note 88.

all of the minerals occurring naturally in a liquid or gaseous state that can be obtained by operations on or beneath his land even though his operations may cause their migration from beneath the land of another."[97] The rule of capture extends back to English law with the case of *Action v. Blundell,* where the English Court of the Exchequer found that the landowner had the right to absolute ownership of the water that he could capture under his land and that there is no cause of action for damage suffered.[98]

However, the rule of capture does not authorize the landowner to cause surface damage to the land of another, and it surely does not authorize any infrastructural damage to the structures existing on another's land.[99] In 1939, the Restatement of Torts § 818 adopted, "To the extent that a person is not liable for withdrawing subterranean waters from the land of another, he is not liable for a subsidence of the other's land which is caused by the withdrawal."[100] The plaintiff would have to prove that the defendant was liable for the removal of the groundwater and was therefore liable for the resulting subsidence in of someone else's land. When read in combination with the Restatement of Torts § 818, Louisiana's capture laws provide a more compelling case for holding Entergy liable for the City's damages. Based on the rule of capture, Entergy is within its right to use the water that gets pumped into their cooling system from the ground. Because the water from below the flood protection infrastructure falls into that category, Entergy becomes liable for the water that they pump, and therefore liable for the resulting infrastructural damage in accordance with the Restatement of Torts § 818.

## IV. HOOK, LINE, AND SINKER: PREVENTION AND MITIGATION

Efforts to curb groundwater withdrawal subsidence are in their early stages in the Gulf Coast region of the United States. Unfortunately, most local governments do little more than implement the land use planning and building regulation that is required by the National Flood Insurance Program (NFIP) or other federal laws, arguing that more regulation would hinder local development or infringe on the private property rights of their constituents. In the aftermath of flooding disasters, however, the loss of businesses and customers also disrupts the local economies, so it is

97. LA. REV. STAT. § 31:8.

98. *Supra* note 80 at 245 (citing Acton v. Blundell, 152 Eng. Rep. 1223 (1843)).

99. LA. REV. STAT. § 31:8.

100. RESTATEMENT OF TORTS § 818 (AM. LAW INST. 1939).

important for local government in deltaic regions to implement protections to avoid economic loss.[101]

The Mississippi Delta does not currently have any regulatory safeguards in place to prevent, mitigate, or manage future industrial pumping of groundwater and the subsidence caused as a result. With Entergy looking to the New Orleans City Council to re-open the Michoud plant by 2019, the City should attempt to implement regulation on this process before approving future activity, especially at the Michoud site.

*A. Avoidance*

The best way to prevent increased subsidence is to avoid pumping groundwater altogether.[102] However, because this is not the most economic practice for most industries—especially those that are already pumping groundwater at their facilities—it would be prudent for the City to offer incentives, such as tax incentives, to the industry producers to find alternative means of cooling, mainly the use of filtered river water as opposed to groundwater.

Avoidance also protects the City of New Orleans from future negligence suits because they will not have to approve plans that could result in the city knowingly exacerbating flooding. In the 1971 case *Eschete v. City of New Orleans*, the Louisiana Supreme Court ruled in favor of the homeowners who sued the City of New Orleans and the Sewerage and Water Board for property damage and personal injury as a result of flooding.[103] The Court found merit in the plaintiffs' argument that the city knew in advance, and therefore both "deliberately" and "maliciously" authorized a new subdivision development in a particular area that would cause flooding.[104] This is further solidified in judge-made law in the Louisiana Fourth Circuit Court of Appeals decision in *McCloud v. Jefferson Parish*.[105] There, the court found the allegation "full knowledge" of the consequences satisfied the reasoning from *Eschete* even without using the terms "deliberate" or "malicious."[106] The court suggested that, even without the mention of deliberation or maliciousness, merely knowing the consequences can bring fault.

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101. James Wilkins, *Is Sea Level Rise "Foreseeable"? Does It Matter?*, 26 J. LAND USE & ENVTL. L. 437 (2011).

102. *Supra* note 80, at 250 (1986).

103. Eschete v. City of New Orleans, 258 La. 133, 245 So. 2d 383 (1971).

104. *Id.*

105. McCloud v. Jefferson Par., 383 So.2d 477 (La. Ct. App. 1980).

106. *Id.*

New Orleans should apply knowledge-based fault to the approval of the re-opening of the Entergy Michoud Power Station. If the city were to approve the plans to re-open the Michoud Power Station and the surrounding area were to flood, homeowners might bring action against the City of New Orleans and argue, such as the widely published NASA InSAR maps, that the City knew that approving the re-opening of a power station that pumps groundwater would lead to land subsidence and flooding.

### *B. Planning Ahead*

New Orleans is a rapidly developing urban deltaic region, especially in the aftermath of Hurricane Katrina.[107] As discussed previously, local governments in areas where flooding is an issue do not often go beyond what the NFIP mandates to limit hindrances to economic development. With the use of InSAR and other measurement tools, however, the City will be able to plan for, slow, and hopefully prevent any future increases in land subsidence. New Orleans would benefit from considering a partnership with NASA or other organizations that consistently measure ground levels to avoid and possibly mitigate future subsidence.

Cities like Houston have implemented "subsidence districts." Subsidence districts are special purpose districts created to provide for the regulation of groundwater withdrawal to prevent land subsidence that leads to increased flooding.[108] These districts accomplish subsidence regulation and mitigation through the careful regulation of groundwater withdrawals, working with surface water suppliers, and highlighting the importance of water conservation throughout the communities.[109] If the City of New Orleans could implement special districts specifically for the regulation of groundwater removal, then the City, with help from NASA, could determine which neighborhoods are at the greatest risk for subsidence as a result of groundwater removal. This would allow the City to better determine what areas need more attention because of land subsidence and would help developers find the best place to expand.

## CONCLUSION

Land subsidence is a major issue affecting communities in the New Orleans area, along the Gulf Coast, and across the United States. Land

107. *See generally*.

108. HARRIS-GALVESTON SUBSIDENCE DISTRICT, *About the District*, https://perma.cc/DJ6C-6XHV (last visited July 29, 2018).

109. *Id.*

subsidence is caused by both natural and anthropogenic causes but is increased substantially by the latter, especially in regard to industrial groundwater removal. Recent NASA maps have proven that the rate of subsidence is higher in areas where there is industrial groundwater removal, highlighting the recently closed Entergy Power Station in the Michoud area of New Orleans East. If these cities do not hold corporations such as Entergy liable for damages previously caused by groundwater withdrawal, and do not implement future regulation and limitation, these cities will continue to leave themselves at risk for future damage and subsidence.

Scientific evidence demonstrates that the Army Corp of Engineers may not be solely liable for the failure of the MR-GO during Hurricane Katrina. The City of New Orleans and the surrounding area have a cause of action against Entergy for infrastructural damages, including levee breakage, hindered drainage, and catastrophic flooding against those pumping or who have pumped groundwater.

New Orleans has many possible remedies against those responsible for groundwater pumping. The City's strongest claim is negligence on the part of Entergy. The City should strive to prove that Entergy's removal of ground water was the proximate cause of infrastructural damage to the surrounding flood protection structure, so that Entergy will take responsibility for damages due to pumping. To strengthen this argument, the City should apply the *res ipsa loquitur* doctrine by proving that the groundwater removed was under the exclusive control of those using it at the Entergy Michoud Plant.

Additionally, if the city uses the NASA maps to demonstrate that the increased level of subsidence in the area surrounding the Michoud Power Station caused by groundwater removal contributed to the infrastructural failure of the MR-GO, then the city could also claim nuisance. Further, by applying both the Louisiana rule of capture and the Restatement of Torts § 818, the City could also hold corporations liable for infrastructural damage as a result of pumping groundwater that may not be from Entergy's source.

It is in the City's best interest to avoid using groundwater removal altogether. Because this is not the most feasible economic option, the City should provide incentives for using alternative water sources. This is also in the best interest of the City to protect itself from future claims due to flooding resulting from the approval of development plans. Subsidence districts or other specialized districts in partnership with NASA or other organizations measuring the rate of subsidence in New Orleans would also be in the best interest of the City to develop a widespread plan to mitigate, slow or prevent land subsidence. Without the implementation of standard

regulation of groundwater withdrawal, New Orleans and other urban deltaic cities will continue to sink, leaving them vulnerable to flooding and other catastrophic water-based events.

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