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UNDERSTANDING THE LLOYD MORATORIUM AND THE SCIENCE THAT SUPPORTS IT

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I. INTRODUCTION

It is said that good science can make "a valuable contribution to . . . policy makers in both the legislative and executive branches of government."[1] So it is in understanding why the New York State Legislature intervened to protect the Lloyd aquifer on Long Island through the Lloyd Moratorium[2] and why the Lloyd aquifer merits strong protection in the first place. In examining the science behind the Lloyd Moratorium, it becomes clear why the Moratorium is structured as it is and why meeting its mandates is intended to present a high bar to challengers.

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1. Mark S. Frankel, *The Role of Science in Making Good Decisions*, AM. ASS'N FOR THE ADVANCEMENT OF SCI., http://www.aaas.org/page/role-science-making-good-decisions [https://perma.cc/7LDK-8AGQ].

2. N.Y. ENVTL. CONSERV. LAW §15-1528 (McKinney 1986).

This article examines the background to the enactment of the Lloyd Moratorium, the role of science, and a discussion of why limits on certain groundwater use are appropriate. Section Two reviews the history of the Lloyd Moratorium and the challenges to it. The role of the State in implementing the moratorium is also considered. Section Three describes the current guidelines for Lloyd well permits. Section Four reviews the vulnerability of the Lloyd aquifer. Section Five discusses the necessity of setting a high bar for Lloyd aquifer access. Section Six concludes with an outline of how the Long Island aquifer system can benefit from comprehensive, science-based management.

II. THE HISTORY OF THE LLOYD AQUIFER THAT LED TO THE LLOYD MOARATORIUM

The island of Long Island is the largest island in the continental United States and is home to a total population of nearly 7.8 million people. Although there are four counties (Kings, Queens, Nassau and Suffolk) located on the island, the first two counties are boroughs of New York City and are not usually included when discussing Long Island as a region. The population of Nassau and Suffolk Counties is 2.86 million people as of 2014.[3] The island itself is 120 miles long and twenty miles wide with a total area of about 1400 square miles.[4] The Long Island aquifer system extends beneath the full length of the island. It is thinnest in the northern portions of Kings and Queens Counties. The aquifer system has three primary aquifer formations: the top-most Upper Glacial aquifer, the deeper Magothy aquifer, and the deepest and oldest aquifer, the Lloyd.[5] A fourth aquifer, the Jameco aquifer is a small formation found along the south shore of Long Island, sandwiched between the Upper Glacial/Gardeners Clay and the Magothy.[6] It does not play a significant role in water supply issues.

3. *Quick Facts*, U.S. CENSUS BUREAU, http://www.census.gov/quickfacts/table/PST045215/36059,36103,00 [https://perma.cc/2FEA-S2BE].

4. MURRAY GARBER, U.S. GEOLOGICAL SURV., GEOHYDROLOGY OF THE LLOYD AQUIFER, LONG ISLAND, NEW YORK 2 (1986).

5. *Id.* at 15.

6. *Id.*

The first comprehensive assessment of groundwater on Long Island was published by A. C. Veatch et al. in 1906.[7] Veatch was the first to use the name "Lloyd sand" to describe "the material found in a well in Lloyd Neck in northeastern Suffolk County."[8] In 1949, the Lloyd sands were assigned as part of the Raritan Formation, along with the Raritan clay-confining unit overlaying the Lloyd sands.[9] In 1968, the Lloyd sands were first referred to as the Lloyd aquifer.[10] Studies of the Lloyd aquifer contributed to the general scientific understanding of artesian aquifers as far back as 1937.[11] A number of U.S. Geological Survey (USGS) studies between 1956 and 1971 documented the relationship between saltwater intrusion and freshwater in Long Island's aquifers.[12]

7. *Id*. at 3.
8. *Id.* (citation omitted).
9. *Id.* at 4.
10. GARBER, *supra* note 4, at 4.
11. *Id.*
12. *Id*.

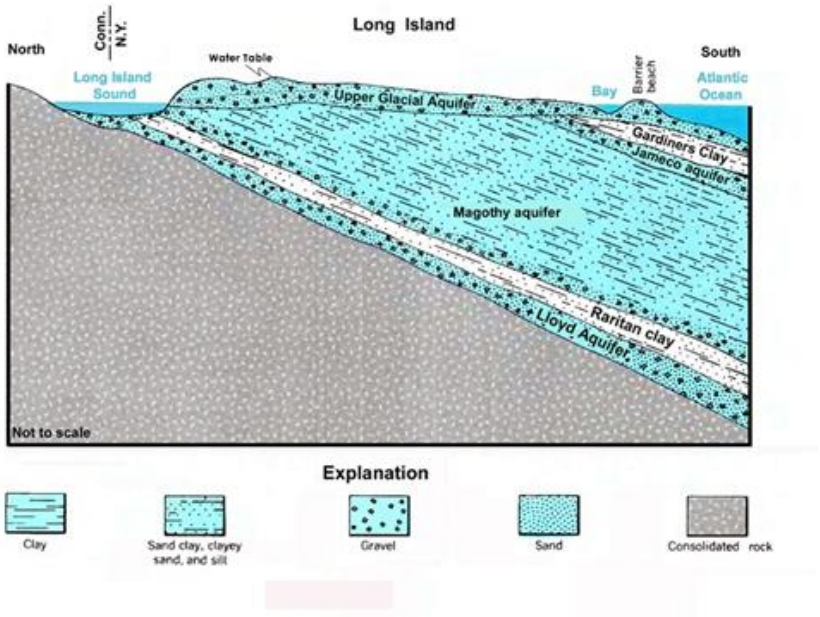

Figure 1. Geologic cross-section of the Long Island Aquifer System beneath Nassau County.[13]

Establishing water-pumping policies for the Lloyd is not a new development. According to Murray Garber, New York State first restricted pumping from the Lloyd by executive order of the Department of Environmental Conservation (or it predecessor) around 1955.[14] The restriction was intended to reserve Lloyd water for "coastal areas of northern and southern Long Island, where in most places it is the only source of potable ground water."[15] The most notable exception is in central Queens County, where the Jamaica Water Supply Company has been

13. *Major Hydrogeologic Units of the Long Island Aquifer*, N.Y. STATE DEP'T OF ENVTL. CONSERVATION, http://www.dec.ny.gov/lands/36231.html [https://perma.cc/8B24-Q4ZN].

14. *Id.* at 1.

15. *Id.*

pumping four to six million gallons per day (mgd) from the Lloyd since the mid-1930s."[16]

A. The Characteristics of the Lloyd Aquifer

Of the three main aquifer formations beneath Long Island, the Lloyd is the only fully "confined" aquifer with the thick Raritan Clay above it and solid bedrock below.[17] The Lloyd is at its thinnest along the north shore and it is missing in some areas of the north shore due to glacial scouring and erosion.[18] The formation depth slopes downward, descending from an elevation close to sea level to a depth of 1500 feet below sea level on the south shore of central Suffolk County.[19] The thickness of the formation also increases from north to south, beginning with a thickness of 100 feet on the north shore and a maximum thickness of approximately 500 feet on the south shore.[20]

There are a number of reasons why the Lloyd is a fragile formation and why it needs special protection and oversight. These include:

- Limited recharge (3.1%);[21]
- Limited quantity of water in storage (nine percent) and slow rate of movement through the Lloyd;[22]
- The nature of confined aquifers (they are different from unconfined aquifers and more sensitive to withdrawals);
- Maintaining an artesian aquifer's pressure levels is important (reduction of pressure in the system makes it especially vulnerable to saltwater intrusion);
- Only source of water for some coastal communities;[23] and

16. *Id.*
17. GARBER, *supra* note 4, at 32.
18. *Id.* at 3.
19. *Id.* at 8.
20. *Id.* at 1.
21. ANTHONY CHU, U.S. GEOLOGICAL SURV., HYDROGEOLOGY OF THE LLOYD AQUIFER ON LONG ISLAND, NEW YORK–A BRIEF SUMMARY OF USGS INVESTIGATIONS 8 (2006).
22. *Id.*

- Important role as an emergency water supply.[24]

The USGS has reported the total amount of groundwater stored in the Lloyd aquifer is approximately nine percent of all the water in the aquifer system, and yet it only receives 3.1 percent of total recharge.[25] The Lloyd has low permeability and transmissivity (the rate at which water moves though the formation) in comparison with the other aquifer formations.[26] Water moves through the Lloyd at about one-third the rate of the water flow rate of the Magothy.[27]

In simple terms, the Lloyd cannot hold much water. It is difficult for water to reach the Lloyd and to move through the system toward discharge at the coast.[28] The time it takes water to flow to and through the Lloyd also demonstrates the difference between Magothy flow and Lloyd flow. While it may take up to 800 years under natural conditions for water to move to the bottom of the Magothy beneath the south shore barrier islands (or 400 years to the north shore), it could take water in the Lloyd 8000 years to reach the same point beneath the south shore barrier islands and 2000 years to reach beneath the limits of the north shore.[29] Today, time of travel is greatly reduced due to pumping water from the aquifers.[30]

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23. *See* Jennifer Barrios, *Ancient Aquifer, Modern Problems*, NEWSDAY (Nov. 3, 2014), http://www.sej.org/sites/default/files/webform/awards2015/Barrios-aquifer.pdf [https://perma.cc/AZ8C-QR3F].

24. *See* Application for a Permit Pursuant to Environmental Conservation Law ("ECL") Article 15, 2007 N.Y. ENV LEXIS 69, DEC Project No. 1-4700-00010/00583 (Oct. 18, 2007).

25. CHU, *supra* note 21, at 8.

26. *Id.* at 4.

27. GARBER, *supra* note 4, at 18.

28. CHU, *supra* note 21, at 8.

29. *Id.* at 9.

30. According to the *Nassau County 1998 Groundwater Study*:

> Groundwater travel times from the land surface to the bottom of the Magothy aquifer have been reduced due to increased groundwater withdrawal. In some areas of the County, the travel time to the deep portions of the Magothy aquifer has been reduced to less than 10 years, whereas under natural conditions (no groundwater withdrawal) the travel time was hundreds of years.

NASSAU CTY. DEP'T OF PUB. WORKS, NASSAU COUNTY 1998 GROUNDWATER STUDY 5-3 (1998).

The confining Raritan clay that covers the top of the Lloyd acts as a barrier to water moving into the Lloyd from the Magothy.[31] The Raritan clay has an average thickness of 200 feet and it can take approximately 200 years or more for groundwater recharge to naturally move across the clay and into the Lloyd.[32] The confining nature of the Raritan clay also serves to keep water in the Lloyd from moving back into the Magothy in areas where the water pressure in the Lloyd exceeds that in the Magothy.[33] "This confining layer serves to maintain a potable water supply in the underlying Lloyd Aquifer beneath the barrier beaches and along the south shore of Long Island, where the overlying aquifers contain brackish or saline water."[34] This is one reason why keeping the clay cap above the Lloyd intact and not breached by wells is vital to the protection of the Lloyd.

B. Water Recharge and Discharge and How it Affects the Lloyd Aquifer

The process of water slowly infiltrating the aquifers is called *recharge*.[35] Natural loss of water from the aquifers from subsurface flow into the coastal waters is a form of groundwater *discharge*.[36] A few pertinent characteristics of the Lloyd are:

The Lloyd receives its only recharge from the small amount of water (three percent) that moves downward from the Magothy and through the Raritan clay. There is no outcrop of Lloyd sands to receive direct recharge.[37]

The pressure needed to drive groundwater down into the Lloyd is created by the elevation of the water column from the water table to the bottom of the Magothy. The recharge zone (where recharge water originates) for the Lloyd lies in a narrow

31. GARBER, *supra* note 4, at 16.
32. *Id.* at 11, 23.
33. *Id.* at 18.
34. *Id.*
35. *See* W.M. ALLEY, T.E. REILLY & O.L. FRANKE, U.S. GEOLOGICAL SURVEY, SUSTAINABILITY OF GROUND-WATER RESOURCES 15 (1999), http://pubs.usgs.gov/circ/circ1186/pdf/circ1186.pdf [https://perma.cc/45MH-NUJE].
36. *See id.*
37. GARBER, *supra* note 4, at 18.

band running east to west roughly beneath the groundwater divide.[38]

Recharge to the Lloyd is approximately twelve to thirty-five mgd, probably closer to thirty-five mdg.[39] Natural discharge from the Lloyd is approximately forty mgd, plus or minus twenty-five percent.[40]

1. The Changing Recharge Conditions for the Lloyd Aquifer

The natural flow of water into and out of the Lloyd aquifer is "[d]ependent upon the balance between recharge, discharge, and changes in storage in the aquifer."[41] Given the inflow and outflow amounts reported for the Lloyd aquifer, the inflow and outflow values should be equal if the aquifer is in hydrologic balance.[42] When outflow (including pumping) exceeds inflow, the aquifer is destabilized (out of balance). In response, hydrologic changes will occur in the aquifer in order to re-stabilize the system. Such changes likely include loss of pressure and saltwater intrusion along the coastal margins of the aquifer.[43]

As water withdrawal from the Long Island aquifer system has increased over time, the areas that recharge water to the Glacial, Magothy, and Lloyd have also changed. In the past, the land area that generated recharge to the Lloyd extended in a continuous band across the middle of Nassau County (Suffolk County has not been mapped).[44] Today, much of the surface area of Nassau County has become the recharge area for the Magothy aquifer and the areas providing recharge to the Lloyd are now reduced to isolated pockets beneath the groundwater divide.[45]

38. *See infra* Figures 2, 3.

39. *Id.* at 19.

40. *Id.* at 18.

41. *Id.* at 21.

42. This would mean inflow or recharge (approximately thirty-five mgd) should equal outflow (approximately thirty-five mgd).

43. *See* N.Y. STATE DEP'T OF ENVTL. CONSERVATION, LONG ISLAND GROUNDWATER MANAGEMENT PROGRAM, at II-24 to -26 (1986) (discussing how reduction in water table levels can cause saltwater intrusion).

44. *See infra* Figure 2 (dark blue area).

45. *See infra* Figure 3 (dark blue areas).

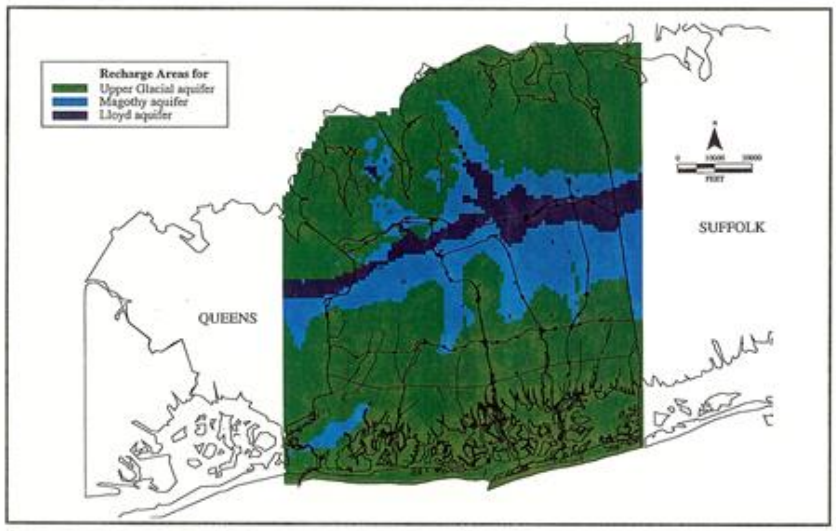

Figure 2. Recharge areas for three main aquifers under pre-development conditions, Nassau County.[46]

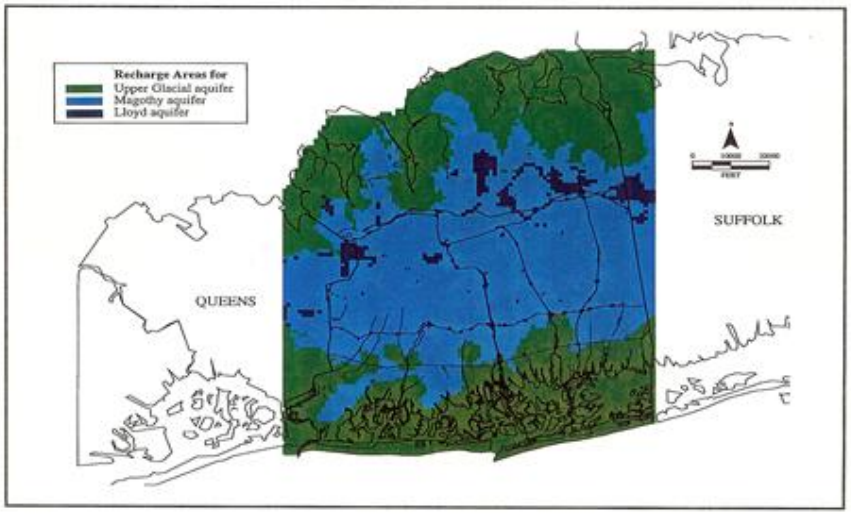

Figure 3. Recharge areas for three main aquifers today, Nassau County.[47]

46. NASSAU CTY. DEP'T OF PUB. WORKS, *supra* note 30, at 4-6.
47. *Id.*

C. New Analysis of the Location of the Saltwater Interface Between the Lloyd and Seawater

Historically, most water (eighty percent) pumped from the Lloyd aquifer was for public water supply use.[48] The greatest impact on the Lloyd has been pumpage in Queens County, mainly from the former Jamaica Water Supply Company.[49] A cone of depression in the pressure elevation of the Lloyd reached twenty-five feet below sea level by 1975.[50] The impact of this serious drawdown in the Lloyd extended into Nassau County, including areas of Long Beach Island on Nassau's south shore.[51] Similarly, pumping at Jamaica from Magothy wells was a significant factor in saltwater intrusion into the Magothy in the southwest corner of Nassau County.[52]

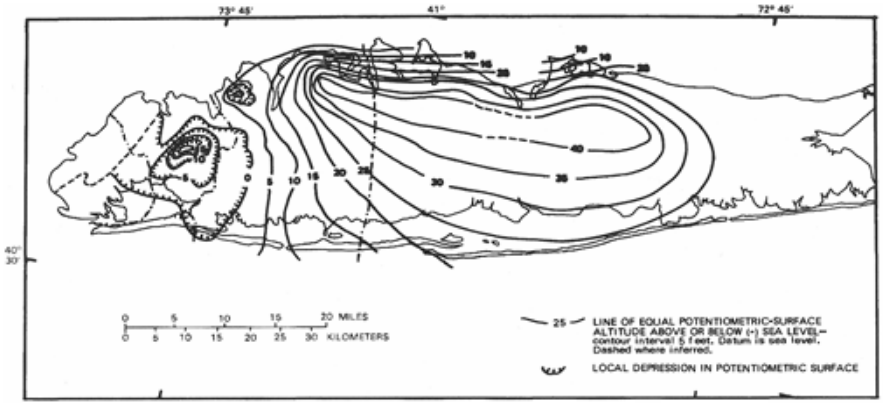

Figure 4. Depression in Potentiometric Surface in the Lloyd Aquifer, 1975.[53]

Lloyd pumpage in Queens County was in the range of 4.1 to 6.8 mgd (1.5 to 2.5 billion gallons per year).[54] Lloyd aquifer use increased in Nassau County, reaching 13.7 mgd by 1952.[55]

48. GARBER, *supra* note 4, at 23.
49. *Id.*
50. *See infra* Figure 4.
51. *See* GARBER, *supra* note 4, at 21.
52. N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 43, at II-26.
53. GARBER, *supra* note 4, at 26 fig.15c.

As New York State began to limit further access to the Lloyd aquifer in the 1950s and 1960s, withdrawals from the Lloyd stabilized.[56] By 1971, overall water withdrawals from the Lloyd were attributed as follows:

- Long Beach (thirty-five percent);
- Central Queens (twenty-nine percent);
- Great Neck peninsula (sixteen percent); and
- The remaining twenty percent was due to pumping from other wells in Nassau County and a few wells in northwest Suffolk County.[57]

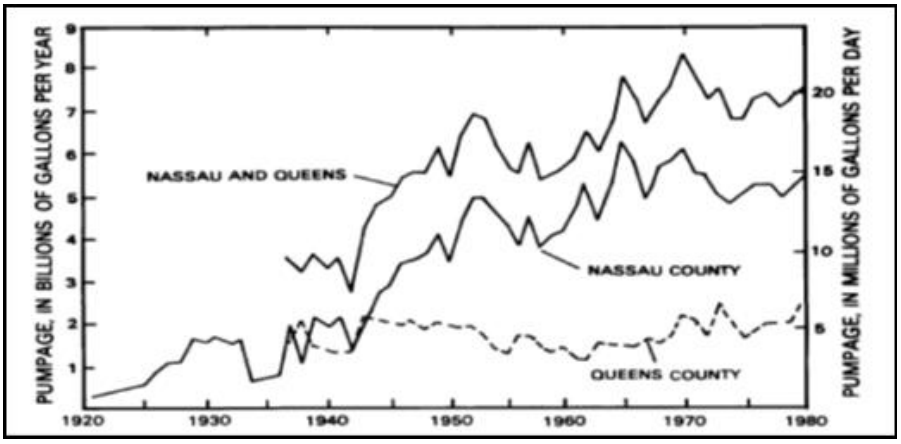

Figure 5. Annual pumpage from the Lloyd aquifer in Queens and Nassau Counties, 1920–1980 according to the NYS Department of Environmental Conservation.[58]

The USGS is the primary agency investigating conditions in the Lloyd aquifer.[59] In recent presentations and publications, the

54. LEE E. KOPPELMAN, LONG ISLAND REG'L PLANNING BD., THE LONG ISLAND COMPREHENSIVE WASTE TREATMENT MANAGEMENT PLAN 25 (1978). The Long Island 208 Study estimated that total pumpage from all aquifers in Queens was about sixty mgd in the late 1970s. *Id.*

55. GARBER, *supra* note 4, at 23.

56. *Id.*

57. *Id.*

58. GARBER, *supra* note 4, at 29 fig.17.

USGS has reported on changing conditions in the Lloyd aquifer regarding saltwater intrusion.[60] There have been notable increases in saltwater intrusion along both the north shore and south shore of Nassau County.[61] Saltwater intrusion has increased on both the Great Neck and Manhasset Neck peninsulas as well as at locations on Long Beach Island.[62] The USGS also re-analyzed information from a Lloyd monitoring well (Q3657) north of John F. Kennedy Airport in Queens and determined that there was saltwater intrusion into the well.[63] The analysis suggests that "80 percent of the Lloyd aquifer was intruded with saltwater."[64] Chloride levels in the well were cited at 10,700 mg/L in the Lloyd aquifer.[65] The drinking water standard for chlorides is 250 mg/L.[66]

Historically, the point where the fresh water of the Lloyd met the saltwater from the ocean was at a point well south, beyond the coastal boundary of Long Island. However, based on recent monitoring well data from the USGS, it appears that the

59. *See* CHU, *supra* note 21, at 2; *Groundwater Availability of the Northern Atlantic Coastal Plain: Description of Study*, U.S. GEOLOGICAL SURVEY, http://ny.water.usgs.gov/projects/NACP/ [https://perma.cc/BG47-LGHN] (last modified Mar. 10, 2014).

60. *See* CHU, *supra* note 21, at 4, 12.

61. *See* FREDERICK STUMM & PAUL MISUT, U.S. GEOLOGICAL SURVEY, ANALYSIS OF THE HYDROGEOLOGIC FRAMEWORK, GROUNDWATER AVAILABILITY AND WATER-SUPPLY SUSTAINABILITY OF WESTERN LONG ISLAND, NEW YORK 1 (2016); *see also* CHU, *supra* note 21, at 1, 9.

62. FREDERICK STRUMM, U.S. GEOLOGICAL SURVEY, WATER RESOURCES INVESTIGATIONS REPORT 99-4280, HYDROGEOLOGY AND EXTENT OF SALTWATER INTRUSION OF THE GREAT NECK PENINSULA, GREAT NECK, LONG ISLAND, NEW YORK 33 (2001); FREDERICK STRUMM ET AL., U.S. GEOLOGICAL SURVEY, WATER RESOURCES INVESTIGATIONS REPORT 00-4193, HYDROGEOLOGY AND EXTENT OF SALTWATER INTRUSION ON MANHASSET NECK, NASSAU COUNTY, NEW YORK 35 (2002); Ronald Busciolano & Stephen Terracciano, U.S. Geological Survey, Presentation on Saltwater Intrusion and Water Resource Monitoring by the USGS on Long Island, NY (2013) (slides on file with author).

63. *See* RICHARD A. CARTWRIGHT, U.S. GEOLOGICAL SURVEY, WATER RESOURCES INVESTIGATIONS REPORT 01-4096, HISTORY AND HYDROLOGIC EFFECTS OF GROUNDWATER USE IN KINGS, QUEENS, AND WESTERN NASSAU COUNTIES, LONG ISLAND, NEW YORK, 1800'S THROUGH 1997, at 51 (2002); STUMM & MISUT, *supra* note 58, at 1.

64. STUMM & MISUT, *supra* note 61, at 1.

65. CARTWRIGHT, *supra* note 63, at 51.

66. N.Y. COMP. R. & REGS. tit. 10 § 170.4(5) (McKinney 2012).

saltwater front has moved shoreward on the south shore and is immediately offshore of Long Beach Island.[67]

D. Confined vs. Unconfined Aquifers: Why it Matters

As a confined aquifer, the Lloyd responds differently to water withdrawals than the unconfined Magothy and Upper Glacial aquifers. Unconfined aquifers have the water table feature (the top of the groundwater), which can rise and fall in elevation as the amount of water stored in the aquifer changes.[68] With more recharge, the water table goes up; with more water removed from the system, the water table falls. In this respect, the unconfined aquifers behave like water in a bathtub. In confined aquifers, the system operates like water in a pipe under pressure. When water is removed, the system responds with a change in pressure. The impact to pressure levels in a confined system radiates from the pumping location for a greater distance than does the impact to drawdown in the unconfined aquifers.[69] Thus, pumping in the Lloyd can have a more destabilizing impact over a greater distance than a similar level of withdrawal in an unconfined aquifer. This makes the Lloyd more sensitive to withdrawals generally and helps create conditions that increase saltwater intrusion.

III. LLOYD AQUIFER OVERSIGHT AND PASSAGE OF THE LLOYD MORATORIUM

Beginning in the late 1970s, groundwater became a major issue of public and political concern on Long Island. *The Long Island 208 Study* was released in 1978 and it highlighted the impacts of human activity on groundwater quality and

67. *See* Busciolano & Terracciano, *supra* note 62.

68. GARBER, *supra* note 4, at 16.

69. *See* N. M. PERLMUTTER & J.J. GERAGHTY, U.S. GEOLOGICAL SURVEY, WATER-SUPPLY PAPER 1613-A, GEOLOGY AND GROUND-WATER CONDITIONS IN SOUTHERN NASSAU AND SOUTHEASTERN QUEENS COUNTIES, LONG ISLAND, N.Y.: RELATION OF SALT WATER TO FRESH GROUND WATER A18 (1963) ("Interference effects have been detected at wells as much as 7 miles from centers of pumping.").

quantity.[70] The main focus of the Study was on the Upper Glacial and Magothy aquifers along with coastal water quality conditions,[71] but, as a result of the wide publicity it received, the public was alerted to the declining conditions in the groundwater system in general.

A. The Roosevelt Field Water District

Since the establishment of the first policy (1955) by New York State to reserve access to the Lloyd for coastal areas at risk of saltwater intrusion,[72] there has been tension between inland water suppliers and coastal communities over use of the Lloyd aquifer. In nearly every instance since that time, when access to the Lloyd aquifer was sought by inland (non-coastal) water supplies, such efforts have been met with strong public and political opposition because the Lloyd has long been regarded as a water supply of last resort.

In 1979, the Roosevelt Field Water District in central Nassau County (a part of the Town of Hempstead Water Department) applied for a permit to drill two wells into the Lloyd Aquifer (later reduced to one well).[73] The Water District was facing a problem where ambient water quality was deteriorating.[74] Rather than treating the water, the District planned to drill into the Lloyd aquifer since it was the quickest and easiest alternative. The Water District predicted a short-fall in capacity to meet projected summer peak demand unless they could access additional clean

70. NASSAU-SUFFOLK REG'L PLANNING BD., INTERIM REPORT NO. 7, SUMMARY PLAN 6 (1978).

71. *See id.* at 5–10. After the *Long Island 208 Study* and the discovery of serious contamination by VOCs in the wells in the City of Glen Cove, the New York State Legislative Commission on Water Resource Needs of Long Island was established, co-chaired by State Senator Caesar Trunzo and Assemblywoman May W. Newburger in 1980. *See* N.Y. LEGIS. LAW § 83-L (McKinney 1980). The two co-chairs sponsored the Lloyd Moratorium in 1986. *See* N.Y. ENVTL. CONSERV. LAW § 15-1528 (McKinney 1986).

72. *See* CHU, *supra* note 21, at 2.

73. Town of Hempstead v. Flacke, 441 N.Y.S.2d 487, 488 (App. Div. 2d Dep't 1981).

74. City of Long Beach v. Flacke, 430 N.Y.S.2d 131, 132 (App. Div. 2d Dep't 1980).

water from the Lloyd.[75] With little fan-fare, the application was granted by the NYS Department of Environmental Conservation (DEC) without adequate public notice or a public hearing.[76] In the aftermath of the decision, there were significant objections from interested parties and agencies that such an important decision had been made without sufficient public review or comment.

The City of Long Beach, New York, challenged the decision on the grounds of constitutionality, failure to provide public notice, and the lack of public necessity, noting that the Water District had other viable options.[77] The DEC decision to grant the permit was ultimately overturned by the Appellate Division, noting the significant issues raised by the Nassau County Department of Health and the failure to allow input by interested parties and the public.[78] Subsequently, an adjudicatory hearing on the application was held.[79] After the hearing, findings, and recommendations were presented to the DEC Commissioner Robert Flake, the application to drill into the Lloyd aquifer was denied.[80]

Commissioner Flacke's decision was then challenged by the Town of Hempstead.[81] The Appellate Division upheld Commissioner Flacke's decision in 1981.[82]

In its review of *Town of Hempstead v. Flacke*, the Appellate Division examined the issue of *public necessity*, the traditional standard for requesting public well permits.[83] The Administrative Law Judge had found that the project was

75. *See id.* at 132 ("Essentially, the application demonstrated that due to contamination in the wells which had already been closed, there existed the probability of a severe water shortage in the district, which could only be resolved satisfactorily by granting the RFWD a permit to deepen an existing well from the Mathoy Aquifer to the Lloyd Aquifer . . . .").

76. *Id.* at 133.

77. *Id.* at 131.

78. *Id.* at 133.

79. Town of Hempstead v. Flacke, 441 N.Y.S.2d 487, 490 (App. Div. 2d Dep't 1981).

80. *Id.*

81. *Id.* at 487.

82. *Id.* at 491.

83. *Id.* at 490–91.

justified by the public necessity claimed by the Water District.[84] Commissioner Flacke rejected this finding based upon a proper weighing of the needs of the Water District versus the long-term needs of the affected community, as well as those areas especially dependent on the Lloyd aquifer for their water supply.[85] The Appellate Division affirmed the reasoning of the Commissioner and upheld the permit denial.[86]

In discussing its rationale and the decision of Commissioner Flacke, the Appellate Division articulated the standard to be used for decisions regarding the Lloyd aquifer. The court stressed that "[t]he potential for additional applications to tap Long Island's aquifers, particularly the limited Lloyd aquifer, dictates a need for *extreme care* to be taken in evaluating new water supply applications."[87]

The 1980 and 1981 decisions regarding the Roosevelt Field Water District case led to a new institutional standard for evaluating applications for Lloyd aquifer water—that of *extreme care*.[88] The court also cited both the perils of saltwater intrusion and the spread of chemical contamination into the Lloyd as proper considerations.[89] The 1980 and 1981 decisions continued the earlier State policy to reserve the Lloyd aquifer for coastal communities that need or may need the Lloyd aquifer. The court wrote, "[a] major increase in pumpage from the Lloyd could cause the point of saltwater intrusion to move shoreward, jeopardizing the water supplies of the barrier beach communities."[90]

84. *Id.* at 489–90.

85. *Town of Hempstead*, 441 N.Y.S.2d at 490.

86. *Id.* at 491.

87. *Id.* at 489 (emphasis added) (quoting Administrative Law Judge Robert P. O'Connor).

88. For example, Commissioner Grannis used the extreme care standard in deciding the Suffolk County Water Authority Lloyd well application. Application for a Permit Pursuant to Environmental Conservation Law ("ECL") Article 15, 2007 N.Y. ENV LEXIS 69, DEC Project No. 1-4700-00010/00583, at 21–22 (Oct. 18, 2007) ("In light of the limited nature of [water from the Lloyd Sands], extreme care must be taken in considering any withdrawal from the Lloyd Sands."); see also *infra* Part III(D)(1) for a further discussion on Commissioner Grannis' decision.

89. *Town of Hempstead*, 441 N.Y.S.2d at 490.

90. *Id.* at 488.

Commissioner Flacke rejected the public necessity claim proffered by the Roosevelt Water District, and the court concurred.[91]

1. A Stronger Standard Regarding the Lloyd Aquifer

Pursuant to the Roosevelt Field Water District cases, a standard for review was outlined for Lloyd aquifer well permit applications. First, a routine showing of public necessity is not sufficient when seeking access to the Lloyd.[92] Commissioner Flacke determined, and the Court agreed, that access to the Lloyd is not justified by public necessity where a project rests on "too narrow a definition of that term."[93]

The Roosevelt Field Water District well application relied upon *projections of future need during peak summer demand*, including potable water needs and non-potable water needs such as air conditions and firefighting requirements.[94] Commissioner Flacke ruled that "a determination of public necessity must entail a consideration of (1) the nature of the present use (potable or nonpotable) and (2) *the importance of the water supply source*."[95] In the case of the Lloyd aquifer, routine public necessity for an inland water supplier does not outweigh the long-term need to reserve the Lloyd for those coastal communities that already rely or may rely on the Lloyd in the future.[96]

Further, the court addressed the concern of increased demand for the Lloyd by inland water systems.[97] Excessive water pumpage had already resulted in saltwater intrusion in the Upper Glacial and Magothy Aquifers.[98] The court noted that even if a specific application indicates little danger to the Lloyd in

91. *Id.* at 490.

92. *See id.*

93. *Id.* at 490.

94. *See id.* at 488, 490 (noting the well application was to meet "peak demands within the RFWD" over the next three years as well as ensure adequate flow to fight potential fires while also meeting cooling demands).

95. *Town of Hempstead*, 441 N.Y.S.2d at 490 (emphasis added).

96. *Id.* at 491.

97. *See id.* at 488, 490 (noting that "future demand for Lloyd water is expected to increase" and that extreme care will be necessary when evaluating new well applications).

98. *Id.* at 488.

and of itself, the larger risk of promoting saltwater intrusion due to a "major increase in withdrawals from the Lloyd could cause the same problem in [the Lloyd]."[99] Prevention of such an undesirable result was of paramount concern.

The court also commented on the risk from other pollutants if inland Lloyd wells are permitted. It noted that the Raritan Clay is no longer the impenetrable barrier it was once believed to be.[100] Thus, by allowing the Raritan Clay to be breached in areas where the Magothy is already contaminated, as the Roosevelt Field Water District wanted to do by deepening their well #3, the court writes, "[t]he imposition of stringent conditions on the use of the deepened well 3 is also an acknowledgment that its use could potentially harm the Lloyd aquifer."[101]

Finally, the court remarked that the statue itself, the Environmental Conservation Law (ECL) Section 15-1503,[102] mandates consideration of whether "the project is just and equitable to all affected municipalities and their inhabitants and in particular with regard to their present and future needs for sources of water."[103] The court is directly saying it is incumbent upon the DEC to look beyond the needs of the individual inland applicant and to take into consideration the "long-term needs of the barrier beach communities (and perhaps, eventually, all of Long Island) for pure Lloyd water."[104] In order to do this, the court and the Commissioner agree that extreme care is to be taken in evaluating new water supply applications for inland Lloyd aquifer wells.[105]

In summary, the Roosevelt Field Case established five issues regarding the Lloyd aquifer:

99. *Id.* at 490.

100. *Id.*

101. *Town of Hempstead*, 441 N.Y.S.2d at 491.

102. ECL Section 15-1503 addresses water supply permits and outlines the type of issues the DEC should consider in determining whether or not to grant a permit. *See* N.Y. ENVTL. CONSERV. LAW § 15-1503(2)(c) (McKinney 2012).

103. *Town of Hempstead*, 441 N.Y.S.2d at 491 (citing N.Y. ENVTL. CONSERV. LAW § 15-1503(2)(c)).

104. *Id*.

105. *Id.* at 490.

1. The usual standard of "public necessity" is not a sufficient basis to grant a permit for a Lloyd well for an inland (non-coastal) water supplier.

2. DEC must use "extreme care" when reviewing applications by inland water systems for Lloyd wells.

3. The Lloyd aquifer is still reserved for the long-term water needs of coastal communities.

4. Courts look unfavorably at situations where the Magothy aquifer is highly contaminated at the site of a proposed Lloyd well due to the risk that pollutants can seep into the Lloyd.

5. Granting a new inland Lloyd well may promote greater demand for Lloyd water which would ultimately be damaging to coastal communities that rely on the Lloyd.

B. The Long Island Groundwater Management Plan

Following the Roosevelt Field Water District controversy, the DEC promised it would protect the Lloyd and this would be evident in the forthcoming Long Island Groundwater Management Plan that was initiated shortly after the litigation over Roosevelt Field was concluded. Under the DEC's leadership, the Management Plan was completed in 1986.[106] During the development of the plan, it became obvious to members of the legislature that a strong position on the Lloyd, which reflected the warnings expressed by the court, would not be contained in the Plan.[107]

Accordingly, in the absence of strong guidelines and a more rigorous scientific approach for managing the Lloyd aquifer, the State Legislature moved to preserve the Lloyd from further new drilling until the deficiencies in DEC oversight were resolved and eliminated.[108]

106. N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 43.

107. *See Water Quantity Issues Affecting Long Island's Water Resources: Proceedings of a Hearing Before the N.Y. State Legis. Comm'n on Water Res. Needs of Long Island* 57, 61–62 (1986) [hereinafter *Legislative Commission Hearing*] (on file with author).

108. *See* Letter from May W. Newburger, Assemblywoman, State of N.Y., to Mario M. Cuomo, Governor, State of N.Y. (July 14, 1986) (on file with author); *see also* Letter from Caesar Trunzo, Senator, State of N.Y., to Evan A. Davis, N.Y. State Capitol (July 14, 1986) (on file with author).

C. Evolving Lloyd Aquifer Policy

The Roosevelt Field Water District litigation reiterated and strengthened the State policy that the Lloyd is reserved for coastal communities.[109] When the pending Long Island Groundwater Management Plan did not reflect the rulings on the Lloyd, the State Legislature amended the Environmental Conservation Law in 1986.[110] The amendments limited the ability of the DEC to grant new permits into the Lloyd Aquifer for inland water users, legislatively strengthening the State's Lloyd aquifer policy.[111]

The legislation (Chapter Law 773 of the Laws of 1986) was passed unanimously by both the Assembly and the State Senate and signed by Governor Mario Cuomo on August 2, 1986.[112] Among other things, it added Section 1528 to Title 15 of the ECL.

The new Section 1528 bolstered protection of the Lloyd aquifer. It made the following changes:

1. Placed a moratorium on the ability of the DEC to issue new well permits for the Lloyd aquifer except for wells for coastal communities.[113]

2. Provided a definition of "coastal community" and "Lloyd sands."[114]

3. Directed the DEC to identify coastal communities.[115]

4. Established a waiver process for non-coastal communities seeking a Lloyd well.[116]

5. Sharply elevated the burden of proof for inland applicants for a Lloyd well to that of "just cause and extreme hardship."[117]

109. S.B. 6156-C, 1986 Leg., Reg. Sess. (N.Y. 1986); *see also* Letter from May W. Newburger, *supra* note 108.

110. *See Legislative Commission Hearing*, *supra* note 107, at 57, 61–62.

111. S.B. 6156-C, 1986 Leg., Reg. Sess. (N.Y. 1986); *see also* Letter from May W. Newburger, *supra* note 108; Letter from Caesar Trunzo, *supra* note 108.

112. S.B. 6156-C, 1986 Leg., Reg. Sess. (N.Y. 1986) (bill jacket on file with author).

113. N.Y. ENVTL. CONSERV. LAW § 15-1528(2) (McKinney 1986).

114. *Id.* § 15-1528(1)–(2).

115. *Id.* § 15-1528(1).

116. *See id.* § 15-1528(3)–(4).

117. *Id.* § 15-1528(4).

6. Outlined the detailed requirements that the DEC must satisfy in order to lift the Lloyd moratorium.[118]

In the letters of support submitted by the Senate[119] and Assembly[120] sponsors, the key issues that frame the foundation for this higher standard of protection for the Lloyd aquifer are presented. They are:

1. A key concern is the risk of saltwater intrusion into the Lloyd if limits are not placed on inland Lloyd wells. Increased inland use could harm coastal areas where the Lloyd aquifer is the sole or major source of water for the community.[121]

2. There is a heightened appreciation of the potential for other pollutants to invade the Lloyd aquifer where the Magothy and Upper Glacial are already seriously contaminated.[122]

3. There is an acknowledgment that the current well permit program is not adequate to provide the type of comprehensive oversight that is necessary for the long-term protection of the Lloyd and the coastal communities that need it.[123]

4. A waiver provision is accompanied by a new, higher standard for an inland Lloyd well applicant. The very high

118. The DEC Commissioner can lift the moratorium based on his findings regarding a number of elements essential to proper management of the Lloyd. The findings must ensure that:

> sufficient research has been conducted so as to provide a sound working knowledge of the details, dynamics, water volume and levels of safe withdrawal appropriate to maintain a safe quantity of Lloyd Sands water. Further, the commissioner must find that a workable program is in place that can properly administer a well permit program for the Lloyd Sands water. Such program shall take into account both the localized and regional aspects and implications of Lloyd Sands water withdrawals, with special attention given to the prevention of water contamination and salt water intrusion. The program must ensure that a safe level of withdrawal from the Lloyd Sands is not exceeded.

Id. § 15-1528(3).

119. Letter from Caesar Trunzo, *supra* note 108.

120. Letter from May W. Newburger, *supra* note 108.

121. *Id.*

122. Letter from Caesar Trunzo, *supra* note 108; Letter from May W. Newburger, *supra* note 108.

123. Letter from Caesar Trunzo, *supra* note 108; Letter from May W. Newburger, *supra* note 108.

burden of proof, that of "just cause and extreme hardship," is intended to ensure that inland Lloyd wells are rare and necessitated only by emergency-type situations.[124]

Thus, the New York State policy regarding the Lloyd aquifer after the adoption of the Lloyd Moratorium can be summarized as follows:

1. The Lloyd aquifer is reserved exclusively for the use of coastal communities.

2. The DEC must use extreme care in reviewing permit applications, especially for inland applicants.

3. The DEC is barred from granting new permits for Lloyd wells for inland water systems until it has met the requirements of ECL Section 1528(3).

4. Inland water systems may obtain Lloyd wells only under extreme circumstances. The burden of proof on the applicant is raised to a standard of "just cause and extreme hardship," which is equivalent to an extreme emergency situation.

5. The DEC is directed to identify those areas that are coastal communities within the meaning of the law.

A consistent line of policy, court rulings, and state law have made it clear the Lloyd aquifer is not available where a conventional "public necessity" argument is presented by an inland water system. The State Legislature established a far higher standard, the existence of an "extreme hardship," to guide access to the Lloyd for inland water systems. In setting this exceptionally high standard, the State Legislature and the Governor concurred that the traditional practice of drilling deeper into the aquifer system to find clean water would not be an acceptable solution when deeper meant accessing the Lloyd Aquifer.

D. The SCWA Lloyd Well Case of 2007 and Guidance from Commissioner Grannis's Decision

Nearly twenty years passed from the enactment of the Lloyd Moratorium (1986) to the 2003 Lloyd well application by the

124. Letter from May W. Newburger, *supra* note 108.

Suffolk County Water Authority (SCWA).[125] During that time, the DEC made no effort to lift the moratorium. The Middleville Road well application by SCWA was the first attempt by an inland water system to obtain a moratorium waiver based on the very high burden of proof of "just cause and extreme hardship."[126] The Middleville Road well field is in East Northport, New York, just north of the Veterans Administration Hospital and approximately two miles from Long Island Sound.[127] Two Magothy wells were in the well field. Well #1 had been closed due to high nitrate levels in the deep Magothy.[128] The second well was also at risk due to high nitrates plus VOCs and perchlorate in the groundwater.[129]

In many ways, the situation presented by SCWA was strikingly similar to that of the Roosevelt Field Water District. SCWA had an inland well field (the Northport Intermediate Pressure Zone) in Huntington Township experiencing poor groundwater quality in the Upper Glacial and Magothy aquifers.[130] Rather than treat the water to remove the nitrates or bring in water from other locations, SCWA planned to tap the pure waters of the Lloyd to augment current supplies by blending Lloyd water with Magothy water.[131] It would be treatment by dilution for well #1. The need SCWA presented in its well permit application was a projection of future demand during peak summer conditions that included water for both potable and non-

125. Suffolk County Water Authority is the largest water utility in Suffolk County and on Long Island. It serves a population of over 1.2 million people and has virtually the entire county as its groundwater watershed. *See About Us*, SUFFOLK COUNTY WATER AUTHORITY, http://www.scwa.com/about_us/ [https://perma.cc/UL3V-WHZQ]. It relies totally on groundwater and is a public benefit corporation, authorized by New York State law. *Id.*

126. Application for a Permit Pursuant to Environmental Conservation Law ("ECL") Article 15, 2007 N.Y. ENV LEXIS 69, DEC Project No. 1-4700-00010/00583, at 2 (Oct. 18, 2007).

127. LEGGETTE, BRASHEARS & GRAHAM, INC., LLOYD AQUIFER PUMPING TEST VETERANS ADMINISTRATION HOSPITAL WELL FIELD NORTHPORT, NEW YORK app. A figs.1, 5 (2001); Suffolk County Atlas 6 (Hagstrom 6th ed. 2000).

128. 2007 N.Y. ENV LEXIS 69, at 5–6.

129. *See id.* at 4–5.

130. *Id.*

131. *Id.* at 5–6.

potable (e.g., fire-fighting) purposes.[132] Similar conditions were insufficient in the Roosevelt Field cases and they proved to be equally insufficient in the SCWA application.

As with the Roosevelt Field case, a high-visibility public water supply well application had problems of adequate public notice leading up to the adjudicatory hearing in May 2005 and the notification process had to be repeated.[133] The adjudication took several years and had several diversions such as the issue of party status for Nassau County.[134] The final decision was issued by DEC Commissioner Alexander (Pete) Grannis on October 18, 2007.[135] The hearing and subsequent decision provided an opportunity to finally give clarity on the intent and interpretation of the statute. It also demonstrated that at the staff level the Department still did not demonstrate in its review process the "extreme care" called for by the court when it came to the Lloyd aquifer.[136]

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132. SUFFOLK CTY. WATER AUTH., ENGINEER'S REPORT – WATER SUPPLY APPLICATION 11 (2003).

133. Application of Suffolk County Water Authority for a Permit Pursuant to Environmental Conservation Law ("ECL") Article 15, 2005 N.Y. ENV LEXIS 64, DEC Project No. 1-4700-00010/00583, at 13–14 (Nov. 9, 2005).

134. Application for a Permit Pursuant to Environmental Conservation Law ("ECL") Article 15, 2007 N.Y. ENV LEXIS 69, at 9–10.

135. *Id.* at 1.

136. *See id*. at 7, 21–35. In Commissioner Grannis' decision, he noted that the staff, as well as the hearing officer, recommended that the SCWA well permit be granted. *See id.* at 7. They advised that SCWA had met the "just cause and extreme hardship" standard and SCWA should be granted a waiver. *Id*. at 3, 7. They were not deterred by the numerous flaws in the permit application nor the weakness of the justifications that had similarly been rejected by the Court in the Roosevelt Field case. Finally, the Commissioner's decision pointed out the numerous inadequacies of staff review of the application. The Commission stated:

> [i]n light of the deficiencies previously discussed, the pump test conducted by SCWA was insufficient for determining safe yield and for making determinations under ECL 15-1503(2), 15-1527(4)(g), and 6 NYCRR 601.6(b). Because of the divergence from the Department's established pump test procedures, staff's review of SCWA's water supply permit application was not sufficiently "vigorous" to establish compliance with permit issuance standards applicable to the proposed well . . . .

Id. at 37. The decision also called out examples of staff failure to vigorously evaluate other aspects of the permit such as safe yield, proper construction of the well, protection of the watershed, and the absence of certain requirements in

As ordered by the Administrative Law Judge, the issues to be addressed at the adjudicatory hearing were:

1. "[W]hether the SCWA's application met the standard set forth in ECL Section 15-1528(4) for a grant of an exemption from the moratorium, based upon just cause and extreme hardship; and
2. "[W]hether the Well is located in a 'coastal community' within in meaning of ECL Section 15-1528(1) and thus is not subject to the moratorium."[137]

Three sub-issued were also to be addressed:

A. "Whether the proposed pumping is within the safe yield of the Aquifer," also considering the characteristics of the Aquifer and water supply needs;
B. "Whether the proposal poses a risk of contamination of the Aquifer from saltwater intrusion or other constituents," also considering chloride levels in the Magothy aquifer; and
C. "Whether the SCWA took into account appropriate alternatives to the proposal, including alternatives to blending, and the costs of those alternatives."[138]

1. Guidelines Established by the Grannis Decision

Several important details for protecting the Lloyd aquifer resulted from Commissioner Grannis's decision. First, he defined what "just cause and extreme hardship" means in the context of the ECL:

> Based upon the plain meaning of the words "just cause and extreme hardship," the limited nature of the Lloyd Sands' water resources, the clear intent of the State Legislature to be extraordinarily protective of the Lloyd Sands, and this record, I determine that an extreme condition or emergency must be

the draft permit such as the development of watershed rules and regulations and sufficient planning for the water system. *Id.* at 37–39.

137. Application of Suffolk County Water Authority for a Permit Pursuant to Environmental Conservation Law ("ECL") Article 15, 2005 N.Y. ENV LEXIS 64, DEC Project No. 1-4700-00010/00583, at 70 (Nov. 9, 2005).

138. *Id.* at 70–71.

> shown to satisfy the "just cause and extreme hardship" standard.[139]

His decision outlined the considerations that must be evaluated when reviewing an application to drill into the Lloyd by inland water users.[140] The three pertinent criteria are "the extent to which an extreme water supply condition or emergency has been demonstrated; the potential environmental impacts of the proposed Well upon the Lloyd Sands" (including the issue of safe yield and adequate watershed protection); "and the availability of technically and economically feasible alternatives to the proposed withdrawal of water from the Lloyd Sands."[141]

In the case of the SCWA Lloyd well application, the Water Authority failed to satisfy any of the criteria laid out by Commissioner Grannis.[142] In addition, SCWA claimed that its well site was a coastal community as defined by Section 15-1502.[143] This claim was rejected by the Commissioner and the Administrative Law Judge.[144]

The Grannis decision addressed the question of justification by "public necessity."[145] The Commissioner determined that in the case of Lloyd well applications seeking a waiver:

> [t]he necessity for a public water supply system is be measured by immediate need, not need in the distant future. For purposes of an exemption to the moratorium, it is significant that the State Legislature did not simply use the traditional "public necessity" standard, but rather chose to impose the requirement of "just cause and extreme hardship" which reflects a much more stringent threshold.[146]

139. Application for a Permit Pursuant to Environmental Conservation Law ("ECL") Article 15, 2007 N.Y. ENV LEXIS 69, at 22.

140. *Id.* at 19.

141. *Id*. at 22–23.

142. *Id.* at 35.

143. *Id.* at 6–7.

144. *Id.* at 7, 15.

145. Application for a Permit Pursuant to Environmental Conservation Law ("ECL") Article 15, 2007 N.Y. ENV LEXIS 69, at 19–20.

146. *Id*. at 20 (citation omitted).

Another aspect of the second criteria discussed by Commissioner Grannis is that concerns for the vulnerability of the Lloyd Sands to contamination and saltwater intrusion were central to the adoption of the moratorium.[147] He quotes the Legislature's finding that "*certain limitations in the use of portions of the aquifer are necessary* in order to ensure the long term quality and quantity of the water supply."[148]

The Grannis decision continues by stating that:

> any proposal to use water from the Lloyd Sands must demonstrate that such contamination or intrusion would not likely occur, and that the Lloyd Sands would not be significantly impaired or otherwise compromised. In light of the limited nature of this resource, extreme care must be taken in considering any withdrawal from the Lloyd Sands. In this regard, the feasibility of potential alternatives that can avoid depleting or otherwise impact this limited aquifer resource must be thoroughly evaluated.[149]

As for the question of what constitutes contamination by chlorides, Grannis agreed with the ALJ.[150] He wrote that since the Legislature did not specify a numerical limit in the statute, he found it to be the legislative intent for the Department to "exercise its discretion and arrive at a 'reasonable, case by case interpretation of the term'. . . thereby allowing for the consideration of the 'unique circumstances of each application.'"[151]

While the question of what constitutes contamination by chloride is still unsettled, it is worth noting that the USGS has observed that once saltwater intrusion has reached a level of 250 mg/L (parts per million), the process of saltwater intrusion has

147. *Id.*
148. *Id.* (emphasis added).
149. *Id.* at 21–22 (citation omitted).
150. *Id.* at 15.
151. Application for a Permit Pursuant to Environmental Conservation Law ("ECL") Article 15, 2007 N.Y. ENV LEXIS 69, at 17 n.9.

begun.[152] From that point on, it is only a matter of time until the chloride levels reach the drinking water standard and beyond.

IV. VULNERABILTY OF LLOYD AQUFIER BEFORE AND AFTER THE SCWA CASE

The science of Long Island's groundwater, its productivity and its fragility, began accumulating at least fifty years before Brooklyn became a borough of New York City in 1898.[153] While Manhattan started receiving surface water from the Croton Reservoir (Westchester County) in 1842, Brooklyn maintained its reliance on groundwater, first within its borders and then beyond.[154] By the 1850s, it tapped groundwater from Queens and then looked farther into Nassau County.[155] The 1851 Committee on Water for Brooklyn saw great promise in the south shore outwash plain that stretched for sixty square miles.[156] The Committee report described the Long Island water resource in poetic terms:

> Layers of fine, uniform-grained sand, beds of pebbles and gravel, and occasionally local deposits of clay in thin strata, characterized the ground to great depths. Through this porous material the waters flow toward the ocean, bursting forth at various points in springs, forming streams of singular clearness and purity. The rainfall of many centuries saturated the sand and from the extreme slowness with which the water finds its way through the water-bearing stratum the flow from the springs does not appear to be affected by either storm or drought.[157]

152. HERBERT T. BUXTON & PETER K. SHERNOFF, U.S. GEOLOGICAL SURVEY, WATER-SUPPLY PAPER 2498, GROUND-WATER RESOURCES OF KINGS AND QUEENS COUNTIES, LONG ISLAND, NEW YORK 53 (1999); *see also* FREDERICK STRUMM ET AL., U.S. GEOLOGICAL SURVEY, WATER-RESOURCES INVESTIGATIONS REPORT 00-4193, HYDROGEOLOGY AND EXTENT OF SALTWATER INTRUSION ON MANHASSET NECK, NASSAU COUNTY, NEW YORK 35 (2002).

153. Jeffrey A. Kroessler, *Brooklyn's Thirst, Long Island's Water: Consolidation, Local Control and the Aquifer*, LONG ISLAND HIST. J., 2011, ¶ 3.

154. *Id.*

155. *Id.*

156. *Id.* ¶ 8.

157. *Id.*

As the population and water demand grew in Brooklyn, its water collection system stretched across southern Queens and into southern Nassau County.[158] Newspapers of the day reported that, by 1896, Brooklyn was pumping fifty mgd from the wells and ponds of Long Island.[159] The impact caused Long Islanders to "dig deeper wells to compensate for the lower water table."[160]

Residents of Queens and Nassau pointed out that the streams were being affected by the lower water table.[161] The low stream levels and the loss of flow to the bays damaged the oyster harvests.[162] A Queens newspaper reported Long Island is "literally pumped dry" as the water supply could not keep up with an ever increasing demand in Brooklyn.[163] By 1899, water demand in Brooklyn reached ninety-two mgd and the newly consolidated City of New York spoke of extending a pipeline to the Pine Barrens of Suffolk County.[164] Suffolk County succeeded in having a state law passed that prevented Brooklyn from drawing water from Suffolk County without Suffolk's approval.[165] Seeing the expanded use of Long Island groundwater blocked, New York City began construction of the Catskill aqueducts in 1907.[166] In 1916, just before the Catskill water was extended to Queens, peak pumpage from Long Island reached approximately 188 mgd.[167]

The heavy groundwater pumping in Brooklyn and Queens produced dramatic changes in the groundwater system beneath these two boroughs and beyond. In Brooklyn, the water table was about twenty feet above sea level prior to heavy pumpage.[168] By 1936, a deep cone of depression had developed in the water table in central Brooklyn that extended to thirty-five feet below sea

158. *Id.* ¶¶ 14–16.
159. Kroessler, *supra* note 153, ¶ 18.
160. *Id.*
161. *See id.* ¶¶ 17–24.
162. *Id.* ¶ 18.
163. *Id.*
164. *Id.* ¶ 25.
165. Kroessler, *supra* note 153, ¶ 27.
166. *Id.* ¶ 30.
167. *Id.* ¶ 31.
168. *Id.* ¶ 18.

level.[169] "The decline in the water table was due to excessive pumping from both shallow and deep aquifers,"[170] including Lloyd. Salt water invaded the full extent of the aquifer system, affecting both the shallow aquifers and the Lloyd. Once pumping stopped in Brooklyn in 1947, the groundwater system began to recover.[171] However, fifteen years after pumpage ceased in Brooklyn, chloride levels in the Lloyd remained at several thousand parts per million (ppm) and as much as 14,000 ppm in the shallow aquifer.[172]

In Queens, the water table was about sixty feet above sea level at its maximum elevation.[173] Between 1950 and 1961, the Queens water table developed a significant cone of depression that reached fifteen feet or more below sea level in the Jamaica area of the borough.[174] Groundwater underflow from Nassau into Queens reached as much as thirteen mgd by 1961.[175] Perlmutter predicted in 1962 that it might take up to forty years to "flush out the remaining saltwater that intruded the aquifers."[176] Today, it is clear that the saltwater in the Queens portion of the aquifer system is still not free of chlorides.[177]

A. Saltwater Intrusion Has Increased with Overall Groundwater Pumpage

The pattern of saltwater intrusion into the Long Island aquifer system, including the Lloyd aquifer, progressed from west to east as groundwater pumping rose. Saltwater intruded beneath Brooklyn where heavy pumpage began in the 1850s.[178]

169. N. M. Perlmutter & Julian Soren, *Effects of Major Water-Table Changes in Kings and Queens Counties, New York City*, *in* GEOLOGICAL SURVEY RESEARCH 1962, at E136, E138 (1963).

170. *Id.*

171. *Id.*

172. *Id.*

173. *Id.* at E136.

174. *Id.* at E138.

175. Perlmutter & Soren, *supra* note 169, at E138.

176. *Id*. at E139.

177. *See* CARTWRIGHT, *supra* note 63, at 32–36; STRUMM & MISUT, *supra* note 61, at 1.

178. *See* Kroessler, *supra* note 153, ¶ 2.

As Brooklyn reached into Queens and southern Nassau, intrusion in the Glacial and Magothy aquifers was noted.[179] As the Lloyd aquifer began to be tapped in the same regions, changes in chloride levels were noted there as well. Perlmutter reported the beginning of intrusion into the Lloyd in Queens in 1956 but not yet in Nassau beneath Long Beach.[180]

By 2015, saltwater in the Lloyd is being detected beneath the barrier islands in Nassau County. Examples of chlorides levels beneath Long Beach Island, as reported by the USGS, are:

- 42 ppm, Atlantic Beach;
- 110 ppm, Central Long Beach;
- 15 ppm, East Long Beach;
- 18 ppm, Jones Beach; and
- 6 ppm, Tobay Beach.[181]

Saltwater intrusion is more dramatic along the north shore of Nassau County. For example, on the Manhasset Peninsula (Port Washington and Sands Point), chlorides levels have reached the following levels:

- 150 ppm, Sands Point observation well
- 102 ppm, Port Washington, public water supply well
- 922 ppm, Port Washington observation well
- 111 ppm, Port Washington observation well[182]

Great Neck and Bayville in northern Oyster Bay have also experienced saltwater intrusion in the Lloyd aquifer.[183]

There are presently forty-four public water supply wells permitted in the Lloyd aquifer.[184] The wells are concentrated in western Nassau County.

179. *See id.*

180. PERLMUTTER & GERAGHTY, *supra* note 69, at A49.

181. Busciolano & Terracciano, *supra* note 61.

182. PAUL MISUT & OMKAR APHALE, U.S. GEOLOGICAL SURVEY, SIMULATION OF GROUNDWATER FLOW PATHS AND FRESHWATER/SALTWATER TRANSITION ZONE MOVEMENT, MANHASSET NECK, NASSAU COUNTY, NEW YORK 24 (2014).

183. STRUMM, *supra* note 61, at 33; FREDERICK STRUMM ET AL., U.S. GEOLOGICAL SURVEY, WATER RESOURCES INVESTIGATIONS REPORT 03-4288, HYDROGEOLOGY AND EXTENT OF SALTWATER INTRUSION IN THE NORTHERN PART OF THE TOWN OF OYSTER BAY, NASSAU COUNTY, NEW YORK: 1995-98, at 47 (2004).

Table 1: Lloyd wells on Long Island[185]

County	Number of Lloyd Wells
Queens	4
Nassau	37
Suffolk	5

B. Pumpage from the Lloyd Aquifer

Pumpage for public water supply from Kings County consisted of a single well that operated between 1929 and 1946.[186] The maximum annual pumpage occurred in 1931 and reached 1.1 billion gallons.[187] Its lowest withdrawal amount occurred in 1946 totaling eleven million gallons.[188] Pumpage from the Lloyd in Kings County ended in 1946.[189]

In Queens County, public water supply pumpage from the Lloyd began in 1928 and ended in 2008.[190] The maximum annual pumpage between 1920 and 1995 was three billion gallons from five wells in 1944.[191] The mean annual pumpage was 1.5 billion gallons.[192]

According to Chu, pumpage records from the Lloyd aquifer in Nassau County began in 1920.[193] The maximum public water supply withdrawals from the Lloyd from 1920–1995 reached 6.4

184. *See infra* Table 1.

185. Sarah Meyland & Michael Alarcon, The Lloyd Aquifer, *in* Groundwater Resources Management Report 5 tbl.1 (Apr. 2016) (unpublished report chapter) (on file with author).

186. CHU, *supra* note 21, at 7.

187. *Id.*

188. *Id.* at 9.

189. *Id.* at 7.

190. *Id.*

191. *Id.*

192. CHU, *supra* note 21, at 7.

193. *Id.*

billion gallons from thirty-three wells in 1971.[194] The mean annual pumpage was 3.3 billion gallons.[195]

Today, there are thirteen different public water suppliers along the north shore of Nassau County.[196] Groundwater pumpage by water suppliers, industrial and golf course wells combined from all aquifer formations was 46.5 mgd (16.97 billion gallons) from 1991–1997.[197] The average combined pumpage from the Lloyd (including the North Shore aquifers) was 7.4 mgd (2.701 billion gallons).[198]

According to data collected by Stumm, from 1995–1997, a total of *six significant cones of depression* (the area of drawdown due to pumping) were identified in the Lloyd/North Shore aquifers: three cones were in Great Neck, two in Manhasset Neck, and one in Oyster Bay.[199] In the same study, *eight saltwater wedges* (areas of saltwater invasion) into the Lloyd/North Shore aquifers were also identified: four wedges in Great Neck, three on Manhasset Neck and one in Oyster Bay.[200] Chloride levels in the wedges ranged from 180 to 13,750 mg/L (ppm).[201]

As a result of the saltwater intrusion along the Lloyd/North Shore aquifers, three public water supply wells have closed in Great Neck (Lloyd), two (Lloyd and North Shore aquifers) in

194. *Id.*

195. *Id.*

196. Frederick Stumm, U.S. Geological Survey, Hydrology and Extent of Saltwater Intrusion of the Lloyd Aquifer in Northern Nassau County, New York (2006), http://pbisotopes.ess.sunysb.edu/lig/Conferences/abstracts06/Stumm_Lloyd.pdf [https://perma.cc/NZ8H-NXV6].

197. *Id.*

198. *Id.* "The North Shore aquifer is a distinct hydrogeologic formation that rests upon bedrock" and is covered by a thick layer of silt and clay. *Id.* It occurs in buried valleys along the north shore that were originally created by runoff and erosion as the glacial ice melted. They appear as elongated fingers that reach from the shore line into the general aquifer system. *See id.* The rapid response of water levels to tides and pumping indicates that this unit is moderately to highly permeable and hydraulically interconnected with the Lloyd aquifer. *Id.*

199. *Id.*

200. *Id.*

201. *Id.*

Manhasset, and one (Lloyd aquifer) in the Bayville (Oyster Bay Township) have been closed due to elevated chloride levels.[202]

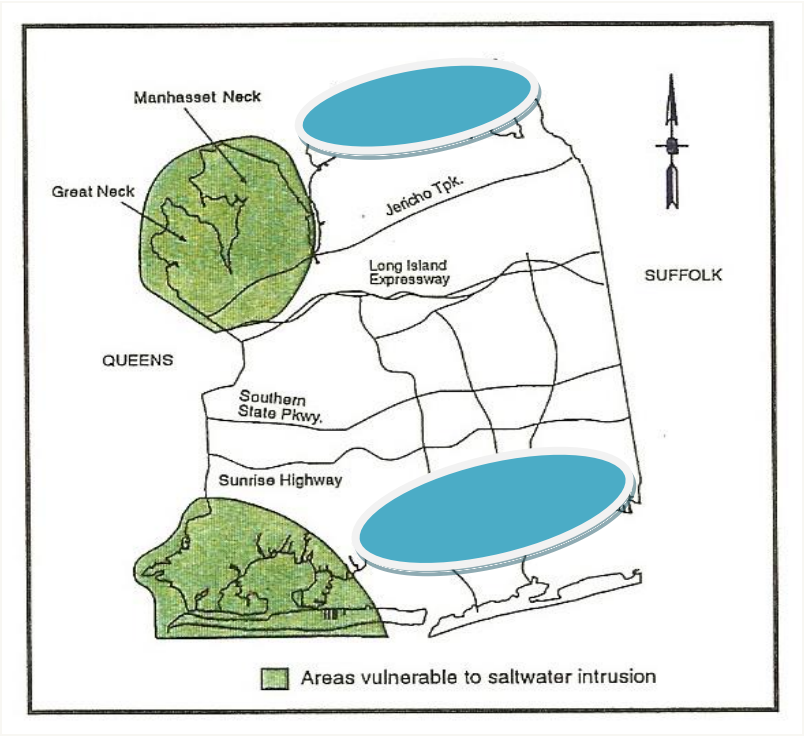

Figure 6. Position of current saltwater intrusion (in green) in Nassau County.[203]

Projected saltwater intrusion (in blue). Affected areas can include all three major aquifers.

V. THE LLOYD MORATORIUM—A HIGH BAR TO INLAND WATER USERS

In reviewing the history of the Lloyd aquifer on Long Island and the groundwater system in general, there are numerous

202. Stumm, *supra* note 196.
203. NASSAU CTY. DEP'T OF PUB. WORKS, *supra* note 30, at 3-16.

examples of damage and abuse of the resource over the past 150 years.[204] The Lloyd has been over-pumped and polluted by saltwater intrusion and anthropomorphic chemicals and activities.[205] This is not a hypothetical risk but a result with ample documentation.

Saltwater intrusion has been the single largest pollutant of concern since Brooklyn began extensive use of groundwater in the 1850s and one that has continued to the present day. Since the litigation over the Lloyd in the 1980s, other pollutants are also a risk to the Lloyd.

Actions to protect the Lloyd and the other aquifers also began over a century ago when Suffolk County sought to deny Brooklyn access to the Pine Barrens (1896).[206] By 1934, the state Environmental Conservation Law was amended, placing strong restrictions on pumping groundwater and giving the State Water Power and Control Commission authority to control of water taken from one county to another.[207] Wells pumping seventy gallons per minute (gpm) or more came under the regulation of the State.[208] New rules required water pumped for air-conditioning and cooling must be returned to the source aquifer.[209] The regulatory threshold was later reduced from seventy to forty-five gpm in 1954, and that remains the threshold for State regulation today on Long Island.[210]

In 1935, the State Commission ruled against New York City's plan to increase groundwater pumping because it would be detrimental to Nassau County.[211] The Commission ruled that "[g]round water conditions on Long Island have been serious for some years and have lately become critical. Enormous drafts by

204. *See generally* Kroessler, *supra* note 153.

205. *See, e.g.*, Meyland & Alarcon, *supra* note 185, at 8–10. *See generally* Kroessler, *supra* note 153.

206. Kroessler, *supra* note 153, ¶ 27.

207. *Id.* ¶ 36.

208. Perlmutter & Soren, *supra* note 169, at E138.

209. *Id.*

210. *Id.*

211. Kroessler, *supra* note 153, ¶ 36.

wells, mostly in New York City, have greatly reduced the water table and a number of wells have gone dry or salty."[212]

A 1937 Report from the Commission confirmed the serious threat to wells from saltwater intrusion in Brooklyn and Queens and into Nassau County.[213] By the mid-1950s, the State took the next step by adopting a policy to reserve Lloyd water for coastal communities that relied exclusively or heavily on its water.[214] That seemed to hold things in check until the attempt in 1980 to drill into the Lloyd at Roosevelt Field.[215] Local outrage of this breach in settled policy produced litigation and a strong ruling by the courts to give the Lloyd aquifer the utmost protection, making it crystal clear what the negative consequences would without stringent protections.[216]

When a strong Lloyd policy consistent with the court rulings from the Roosevelt Field case did not appear in the Long Island Groundwater Management Plan[217], the State Legislature adopted the Lloyd Moratorium.[218] The Moratorium put into law what was thought to be settled policy and imposed additional criteria on when the Lloyd might be used by non-coastal communities—primarily only during an extreme emergency, using the language, "just cause and extreme hardship."[219]

Again, in 2008, when New York City proposed to drill into the Lloyd and use it for a groundwater storage and retrieval system in Queens, the Moratorium statute was amended and a new ban on access to the Lloyd was imposed.[220] This time, the prohibition on the storage or pumping of water into the Lloyd

212. *Id.*

213. *Id.* ¶ 41.

214. GARBER, *supra* note 4, at 1.

215. Daniel Hendrick, *Water Flowing Underground*, N.Y. TIMES (May 16, 2004), http://www.nytimes.com/2004/05/16/nyregion/water-flowing-underground.html?_r=0 [https://perma.cc/T5PK-5ERS].

216. *See* Hempstead v. Flacke, 441 N.Y.S.2d 487, 491 (N.Y. App. Div. 1981).

217. *See* N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 42.

218. *See* N.Y. ENVTL. CONSERV. LAW § 15-1528 (McKinney 2008).

219. *Id.* § 15-1528(4); *see also* Krista M. Tenney, *Denial of Access to the Lloyd Aquifer: The Impossibility of Overcoming the Lloyd Moratorium*, 30 PACE ENVTL. L. REV. 1222 (2013) (providing a thorough review of the moratorium and SCWA case).

220. N.Y. ENVTL. CONSERV. LAW § 15-1528(2).

Sands applied equally to both coastal and inland communities[221] and no exemptions to this ban were authorized.

The first test of the Lloyd Moratorium arose in 2005–2007. The Suffolk County Water Authority applied to drill into the Lloyd aquifer in East Northport, New York.[222] After a contentious adjudicatory hearing, DEC Commissioner Alexander (Pete) Grannis reiterated strong support of the Moratorium goal to protect the Lloyd aquifer and reserve it for coastal communities or extreme emergency situations.[223] His ruling included concern for both saltwater intrusion as well as other pollutants that might enter the Lloyd.[224] He emphasized that there was an intentionally high bar for all applicants who wished an exemption from the Moratorium.[225]

Citing the same vulnerability of the Lloyd to pollution and excessive water withdrawals, expressed by the Moratorium sponsors, Grannis stated in his ruling:

> Accordingly, any proposal to use water from the Lloyd Sands must demonstrate that such contamination or intrusion would not likely occur, and that the Lloyd Sands would not be significantly impaired or otherwise compromised. In light of the limited nature of this resource, extreme care must be taken in considering any withdrawal from the Lloyd Sands. . . .

Based upon the plain meaning of the words, "just cause and extreme hardship," the limited nature of the Lloyd Sands' water resources, the clear intent of the State Legislature to be extraordinarily protective of the Lloyd Sands, and this record, I determine that an extreme condition or emergency must be shown to satisfy the "just cause and extreme hardship" standard.[226]

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221. *Id.*

222. Application of Suffolk County Water Authority for a Permit Pursuant to Environmental Conservation Law ("ECL") Article 15, 2005 N.Y. ENV LEXIS 64, DEC Project No. 1-4700-00010/00583, at 3 (Nov. 9, 2005).

223. Application for a Permit Pursuant to Environmental Conservation Law ("ECL") Article 15, 2007 N.Y. ENV LEXIS 69, DEC Project No. 1-4700-00010/00583, at 22 (Oct. 18, 2007).

224. *Id.* at 14–17, 38–39.

225. *Id.* at 21–22.

226. *Id.*

At this point there is no confusion about the intent of the State Legislature or the hydrologic evidence that the Lloyd aquifer has a limited capability to meet the water needs of certain communities on Long Island—mainly coastal communities. In order to preserve that capability for as long as possible, the strongest possible legal restrictions and policies have been established to protect the Lloyd Sands. It is the intent of the Moratorium that only the most extreme situations will qualify for an exemption from its prohibitions. This does not close the door on all applicants but it does diminish the likelihood of success to an exceedingly small number. This is not an example of being unfair to inland water systems. Rather, it reflects the reality that the Lloyd aquifer can only meet the needs of a limited few and that ability needs to be carefully preserved and prioritized.

VI. MANAGING THE LLOYD AQUIFER AND THE REST OF THE LONG ISLAND GROUNDWATER SYSTEM—WHERE TO GO FROM HERE?

In the end, no matter how limited the access to the Lloyd aquifer is, its fate rests on how the entire groundwater system of Long Island is managed and protected. Since the Lloyd receives only three percent of all recharge, when overall recharge declines or when the total amount of water in storage declines, this affects the amount of water reaching the Lloyd.[227] It is difficult for groundwater to flow down into the aquifers along the groundwater divide flow path.[228] In the past, to reach the bottom of the Magothy and the top of the Raritan Clay would take 400 years of travel time.[229] Another 200 years or more would be needed for groundwater to move through the clay and enter the Lloyd Sands, prior to current day groundwater use.[230]

227. GARBER, *supra* note 4, at 18, 19. Garber estimates Lloyd recharge at twelve to thirty-five mgd and natural subsurface outflow to the coast at approximately forty mgd. *Id.*

228. *See id.* at 23 ("[A] transit time of about . . . 3,000 years rom the groundwater divide to the barrier beaches on the south shore").

229. *Id.*; *see also id.* at 28 fig.16.

230. *Id.* at 23; *see also id.* at 28 fig.16.

A considerable amount of pressure is required to push groundwater through the Magothy and across the Raritan Clay into the artestian pressure system of the Lloyd.[231] Heavy pumping in the Magothy pulls water deeper and faster than it would naturally flow.[232] At the same time, when the volume of water stored in the Magothy declines due to heavy pumping, the ability of groundwater to flow through the Raritan Clay is affected and travel time increases.[233] The Lloyd itself is very sensitive to pumping and changes in pressure.[234] The pressure in Lloyd wells close to the coastline can fluctuation simply by pressure changes caused by the ebb and flow of marine tidal cycles.[235] When a pumping center is created in the Lloyd, the pressure change can be detected as much as seven miles away.[236] In the Magothy, pumping impacts are measured at a distance of several thousand feet or less. As water moves through the Lloyd, it travels at only one-third the rate of groundwater flow in the Magothy.[237]

For the past 150 years, the missing element in protecting the Lloyd and the other aquifers has been comprehensive groundwater management. Over ten different groundwater studies and management plans have been developed since the 1978 Long Island 208 Study.[238] Each one suggested reasonable

231. *Id.* at 1 ("Continuous clay beds overlie the Lloyd and [slow] vertical movement of water between it and the overlying aquifers; this maintains a relatively high artesian pressure in the Lloyd, even in the coasetal areas, and preserves its potability even where the overlying aquifers have been invaded by seawater.").

232. *See* PERLMUTTER & GERAGHTY, *supra* note 69, at A18.

233. *See* GARBER, *supra* note 4, at 2 ("Excessive pumpage could, however, jeopardize the coastal water supply by lowering the potentiometric surface and thereby inducing excessive landward movement of sea water into the aquifer.").

234. *See* PERLMUTTER & GERAGHTY, *supra* note 69, at A18 ("Interference effects have been detected at wells as much as 7 miles from centers of pumping.").

235. *See id.* at A30 ("The drawdowns and recoveries were affected by changes in tides, barometric pressures, and rates of pumping in nearby wells.").

236. *Id.* at A18.

237. *Id.*

238. *E.g.*, LEE KOPPELMAN, *supra* note 54; LEE KOPPELMAN ET AL., LONG ISLAND REG'L PLANNING BD., THE LONG ISLAND COMPREHENSIVE SPECIAL GROUNDWATER PROTECTION AREA PLAN (1992); NASSAU CTY., MASTER WATER PLAN (1980); NASSAU CTY. DEP'T OF PUB. WORKS, *supra* note 30; N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 43; N.Y. STATE DEP'T OF HEALTH, LONG ISLAND

steps to improve groundwater oversight, yet little progress has been made in forty years. Across most the nation and within New York State, where strong oversight and management are needed for a shared water resource, the solution has been the establishment of a dedicated management entity. When given the necessary management tools and authority, such management entities have a track record of successful oversight, problem-solving, science-based policies, and long-range planning.

The major surface water systems in New York State are managed by River Basin Commissions—interstate compacts between states and the federal government to share responsibility and avoid conflict among the stakeholders.[239]

The River Basin Compact model has a track record of success and something like it is needed on Long Island. It would not be a compact in the technical sense of an interstate agreement. Nonetheless, an aquifer compact, the model of establishing a management entity, between the counties of Long Island and the State to manage and oversee the groundwater system for the benefit of all is the best way to finally make progress and to maintain it. Such an independent, professional agency could apply the best science-based policies available consistently and equitably.

The science of groundwater can be complicated. Because the resource is hidden below ground, it takes time and money to study groundwater conditions and then understand what is going on. Without a dedication to performing the work necessary to develop science-based policies, the groundwater resource of Long Island is left unattended and undefended. No area wants to leave a resource as critical as its drinking water supply defenseless and

SOURCE WATER ASSESSMENT (2003); SUFFOLK COUNTY COMPREHENSIVE WATER RESOURCES MANAGEMENT PLAN (2015); *id.* (1987).

239. *See, e.g.*, DEL. RIVER BASIN COMMISSION, http://www.nj.gov/drbc/ [https://perma.cc/85YJ-LHCV]; SUSQUEHANNA RIVER BASIN COMMISSION, http://www.srbc.net/ [https://perma.cc/922Z-UVKY]. The Delaware, Susquehanna, and Great Lakes–St. Lawrence Compacts manage the water resources for approximately seventy percent of the population of the state. *See* Water for Long Island, Briefing Paper on a Long Island Aquifer Management Compact 1 (2013) (unpublished briefing paper) (on file with author). The Long Island region is the largest population in the state without a dedicated, professional entity responsible for managing the water resources of the area.

ignored. A former New York City mayor is fond of saying, "[y]ou can't manage what you don't measure."[240] Without a full-time, professional agency doing the work to sustain the drinking water of Long Island, there is little hope of a good outcome for the Lloyd or any of the aquifers. For now, the Lloyd Moratorium will have to be the last line of defense.

240. Stu Loesner & Jason Post, *Mayor Bloomberg and Commissioner Hirst Announce That Every Major City-owned Building Has Been Benchmarked for Energy Use*, N.Y.C. (May 2, 2010), http://www1.nyc.gov/office-of-the-mayor/news/192-10/mayor-bloomberg-commissioner-hirst-that-every-major-city-owned-building-has-been (quoting Mayor Michael Bloomberg) [https://perma.cc/6Y9J-994T].