DETERMINATION OF SAFE YIELD FOR PUBLIC SUPPLY WELLS IMPACTED BY SALT WATER UPCONING IN EASTERN LONG ISLAND

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ABSTRACT

The Montauk peninsula, located at the extreme eastern end of Long Island, has experienced unique water supply problems, due both to its varied hydrogeology and its seasonal population. Fresh ground water exists as an isolated lens overlying denser, more saline water. The pumping of public water supply wells induces the upward movement of saltier groundwater beneath the well screens in a process known as upconing. This has resulted in observed seasonal increases in chlorides due to the widening of the zone of transition. Upconing has also produced similar increases in iron, most likely due to the mixing of fresh and saline waters beneath the well screen. Wells exhibit their own unique water quality responses due to seasonal pumping stresses and varying hydrogeological conditions beneath the well. Management alternatives have been devised in an effort to minimize water quality impacts while adequately meeting demand.

HYDROGEOLOGY OF THE MONTAUK PENINSULA

The Montauk peninsula, though small in size, is a geologically and hydrologically complex region. Fresh ground water exists within the upper glacial aquifer as an isolated lens overlying the more dense saline water at depth. A narrow zone of transition exists between the fresh and salt water. The elevation of the water table in the Montauk region ranges from zero at the shoreline to a maximum of about four feet above msl in the area between Fort Pond and Lake Montauk. The elevation of the highest points on the water table varies with precipitation patterns. The Ghyben-Herzberg relationship, which states that for every one foot of freshwater head the salt water interface is forty feet deep, is generally applicable, though anomalous conditions do exist throughout the Montauk area.

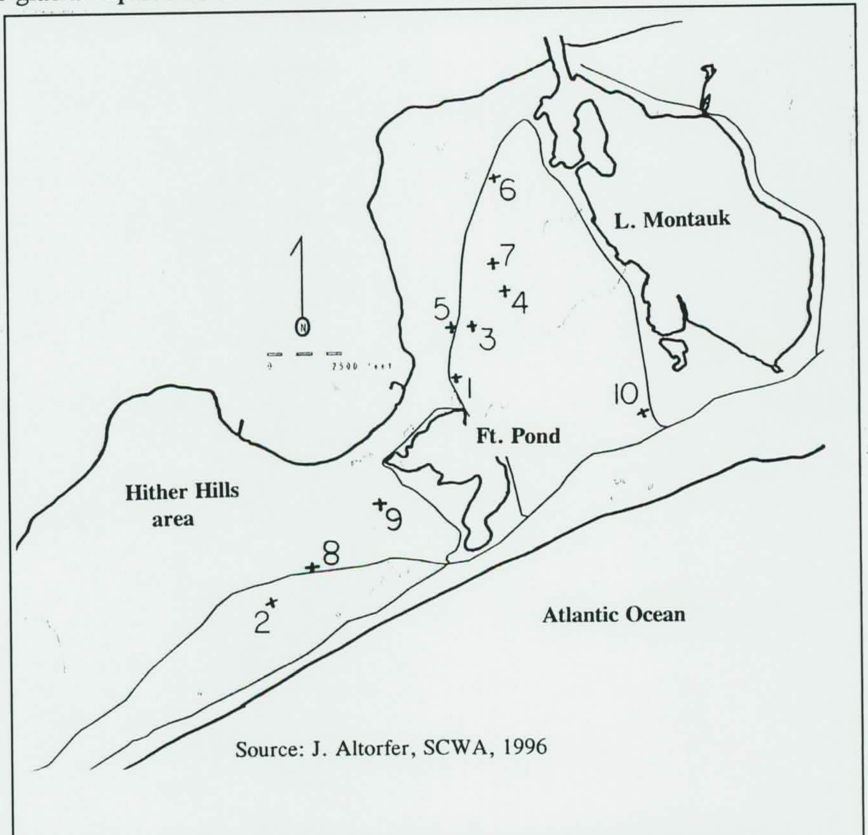


Figure 1: Locations of Montauk Area Public Supply Wells

Surface topography is dominated by the Ronkonkoma terminal moraine. The subsurface has characteristic glacial features such as large boulders and hard clay and till units, as well as coarse sand and gravel strata which are ideal for screening a productive well. The interrelationship of sandy and clayey strata play an important role in determining the upconing behavior of a particular well. In wells that have lower permeability units (i.e. silts and clays) below their screens, the upward movement of the salt water interface is suppressed, and chloride increases in the produced water are less pronounced. Where no such intervening clay and silt units are present, chloride increases due to pumping are more pronounced.

PUBLIC WATER SUPPLY IN MONTAUK

The Suffolk County Water Authority, Long Island's largest water purveyor, supplies potable water to the Montauk area via a network of 10 wells (all screened in the upper glacial aquifer). Figure 1 shows the locations of each of the public supply wells serving the Montauk area. Since the Montauk distribution system is not interconnected to the remainder of the SCWA well network, all potable water must come from the Montauk area's isolated and fragile aquifer. Water use in Montauk corresponds to seasonal population fluctuations. The highest water use occurs between May and September, with much lower pumpage throughout the rest of the year. Table 1 below lists the public supply wells that constitute the Montauk water supply system.

TABLE 1. S.C.W.A. MONTAUK SYSTEM PUBLIC SUPPLY WELL DATA

Well	N.Y. S. well #	Screen setting (ft. below grade)	Screen elevation (ft. below msl)	Capacity (gpm) permitted	Capacity (gpm) actual
1. Edgemere Street	S-51274	35 to 52	-27 to -44	250	150
2. Edison Drive	S-84848	180 to 220	-24 to -64	300	150
3. Fairmont Ave.	S-98350	146 to 166	-29 to -49	350	300
4. Farrington Road	S-30208	154 to 174	-24 to -44	300	300
5. Flamingo Avenue	S-100204	85 to 100	-15 to -30	300	200
6. Flamingo Ave. North	S-70008	116 to 136	-53 to -73	300	150
7. Flanders Road	S-30207	156 to 176	-38 to -58	300	300
8. Montauk Pt. St. Blvd.	S-70155	199 to 239	-42 to -82	300	250
9. South Davis Avenue	S-51275	155 to 175	-31 to -51	300	150
10. South Fulton Drive	S-57357	62 to 89	-30 to -57	300	100

Source: Leggette, Brashears, and Graham, 1987, p.26 and S.C.W.A. well field data sheets

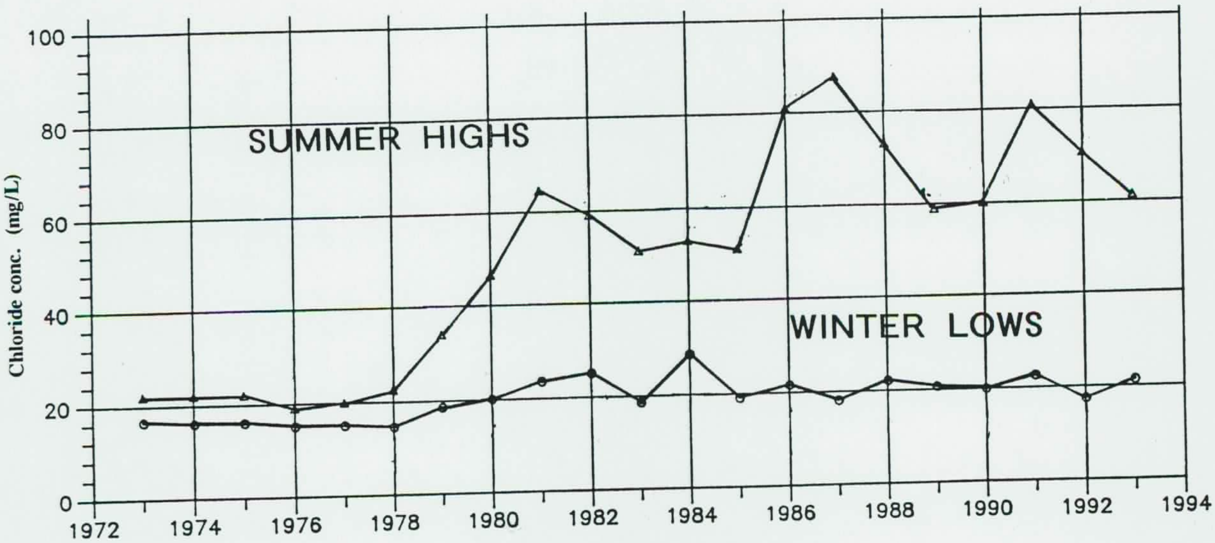
Well water samples are analyzed for all New York State drinking water parameters by the Authority's own State-certified laboratory located in Hauppague. For wells in Montauk, particular attention is given to chloride data, since they indicate potential movement of the salt water interface below the screen of a particular well. Though the New York State drinking water standard for chlorides is 250 mg/L, the Authority voluntarily restricts pumpage from its wells when the chloride levels approach 80 mg/L. The nature of these self imposed pumpage restrictions is the subject of the remainder of this report.

METHOD OF ANALYSIS AND RESULTS OF INVESTIGATION

In an effort to quantify the effects of pumping on the vertical movement of the salt water interface at each of SCWA's well sites in Montauk, pumpage and chloride data were analyzed. First, four day moving averages of daily pumpage were tallied for each well field from 1980 to the present. This method evened out sharp peaks and valleys in the data resulting largely from meter reading inconsistencies. The data were then plotted graphically. A second set of plots was made for each well showing the variations in chloride concentration over time. The two data sets were plotted together so that trending was more easily seen..

As expected, chlorides invariably increase during summer pumpage peaks for most Montauk wells, and then return to their background levels during the winter. Data plots for each well were analyzed individually, and deviations from the expected pattern were noted. Additionally chloride and water level data were collected from an existing network of regional monitoring wells, located outside the area of influence of the SCWA pumping wells. Background water quality and water table elevations were thus analyzed for any long term regional trends. No degradation of ambient water quality was observed during the entire study period. Figure 2 is a graph showing seasonal fluctuations in chloride concentration over time for the Farrington Road well.

Immediate increases in chlorides are indicative of the sensitivity of a particular well to daily fluctuations in pumpage, while more subtle chloride increases indicate sensitivity to longer term average pumpage increases. Some wells showed increased chloride levels during the off peak months, indicating a widened zone of transition beneath the screen of that well. After all of the pumpage and water quality data were analyzed, maximum daily, monthly, and seasonal pumpages were recommended for each well in the Montauk supply system, starting in 1988.



Source: Leggette Brashears, and Graham, Inc., 1995

Figure 2: Seasonal chloride concentration vs. time for a typical Montauk well

In general, the wells located between Fort Pond and the Hither Hills area had the slowest chloride response, and are able to handle the bulk of the pumpage loads, particularly in the off peak months. Wells located in the area between Lake Montauk and Fort Pond showed more rapid responses to pumpage. These wells are pumped more sporadically, in an effort to use them as little as possible during periods of low demand. All wells are purposely pumped at below their permitted capacities, and some wells in this area are turned off completely during the winter months. Table 2 lists each well in the Montauk system and its recommended daily, monthly, and seasonal pumpage.

TABLE 2. RECOMMENDED PUMPAGES FOR MONTAUK PUBLIC SUPPLY WELLS

Well	Pumpage recommendations- winter/spring			Pumpage recommendations-summer		
	max. day (gal.)	max. month (mg)	season total (mg)	max. day (gal.)	max. month (mg)	season total (mg)
1. Edgemere Street	15,000	.45	1.8	200,000	6.0	15.0
2. Edison Drive	100,000	4.0	12	250,000	7.0	20
3. Fairmont Ave.	30,000	1.0	4.0	150,000	4.0	10
4. Farrington Road	50,000	1.5	6.0	400,000	1172	30
5. Flamingo Avenue	15,000	.75	3.0	100,000	3.0	12
6. Flamingo Ave. North	0	0	0	50,000	1.5	6.0
7. Flanders Road	50,000	1.5	6.0	125,000	4.0	10
8. Montauk Pt. St. Blvd.	200,000	6.0	24	350,000	10	40
9. South Davis Avenue	60,000	1.8	7.2	150,000	4.5	18
10. South Fulton Drive	6,500	.2	.8	25,000	0.75	3.0

Source: Leggette, Brashears, and Graham, Inc., 1995

Water quality and pumpage continued to be monitored up to 1995. Deviations from the recommended pumpages and the resulting water quality responses of those wells were noted so that adjustments in allotted pumpages could be made.

These pumpage recommendations have proven to be sufficient to meet water demand in Montauk while preventing future upconing. However, as the study progressed, another water quality phenomenon was observed in some wells throughout the Montauk system: the levels of dissolved iron were increasing in some wells.

While iron concentrations from all Montauk wells have generally been below the drinking water standard of 0.3 mg/L, prolonged pumping of certain wells has caused the iron concentration to exceed 4.0 mg/L on occasion. An attempt was made to determine the underlying causes of these iron increases. As was the case with chlorides, the relationship between pumping and iron concentrations was examined to determine if iron can be controlled by adjustment of pumping rates.

Four wells appear to have the worst iron problems: Edgemere Street, Flamingo Avenue North, Montauk Point State Boulevard, and South Davis Avenue. The remaining wells have iron concentrations that remain below 0.3 mg/L if pumped at the recommended rates shown in Table 2. An examination of the stratigraphy of each Montauk wells revealed that in the four wells prone to iron increases, the freshwater/saltwater interface beneath the well screen is located above a clay stratum. This allows for the relatively unimpeded upward movement of the interface under pumping stresses and the mixing of fresh and saline waters below the well screen. In theory, this mixing of waters of different redox potentials allows for dissolved iron in equilibrium with its "freshwater" environment to dissolve when mixed with more saline water from below. In the wells not prone to elevated iron concentrations, the interface is located within a clay unit. Since the movement of the interface is restricted by this low permeability unit, there is less mixing of waters of differing equilibrium iron concentrations.

Iron concentrations can potentially be controlled by further restricting pumpage from the four iron-prone wells. However these restrictions are so severe that they would not allow the SCWA to adequately meet customer demand. Therefore, several management alternatives were considered in an effort to either reduce the pumpage load on the Montauk system altogether, or further restrict the upward movement of the interface. They include construction of several wells in the Hither Hills area, replacement of some existing wells with several shallower lower capacity wells, and importation of water via a transmission main connecting the Montauk system to the west. None of these alternatives have been implemented to date, but they do figure prominently in future plans and represent a significant departure from past practices.

CONCLUSION

Water quality changes within the aquifer system in the Montauk area of eastern Long Island have prompted the Suffolk County Water Authority to embark on an extensive study of both the origin of the problem and possible remedial scenarios. The most significant water quality change has been seasonal increases in chloride concentration. Similar increases in iron have also been a problem. All water quality changes are the result of pumpage induced upconing of saline water, which lies below the freshwater lens present throughout the peninsula. Site specific stratigraphy plays an important role in determining which wells are prone to such water quality changes. Chloride and iron increases, and their relationship to pumpage patterns were studied over several years in an effort to quantify and manage potential degradation of the aquifer.

Chloride concentrations have been successfully managed during the past several years by adaptation of a strict pumpage schedule for each well in the Montauk system. However, in order to manage iron concentrations with a similar degree of success, unreasonably strict pumpage restrictions would have to be implemented. The SCWA therefore, is in the process of exploring new water supply alternatives in an effort to reduce the overall pumpage of the Montauk wells.

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