Section 5
Data Evaluation and Discussion

The data presented in Section 4 provides the basis for assessing the condition of Nassau County's aquifers and behavior of the overall groundwater system. Only by monitoring such conditions on a continuous basis can the groundwater system be evaluated, and the impacts of man's activities on Nassau's drinking water resource, be determined.

Before proceeding further, it is appropriate to briefly discuss the Long Island Source Water Assessment Program (SWAP). SWAP was created under the federal Safe Drinking Water Act (SDWA) Amendments of 1996, and was intended to evaluate existing and potential threats to the quality of drinking water supplies across the nation.

Long Island SWAP was completed in 2003 under the auspices of The New York State Department of Health (NYSDOH) with the input of local governmental and regulatory agencies from both Nassau and Suffolk Counties. Nassau County DPW was an active participant in the program's steering and technical advisory committees. Through computerized modeling of the groundwater system, SWAP assessed all community and non-community supply wells on Long Island for the potential of being impacted by various types of contaminants. The assessments were based on current classifications of land use and potential contaminant sources within the contributing recharge area (or capture zone) of each supply well, the likelihood of the various contaminant types (VOCs, pesticides, microbials, and nitrates) being present at the ground surface within the contributing area, and the possibility that any such contaminants could migrate downward through the aquifers and eventually enter a public supply well. It is important to note that the assessments only indicated the potential for contamination of a supply well based on the aforementioned conditions, and did not imply that a supply well would necessarily become contaminated even if a particular supply well received a high susceptibility rating. It is also important to note that if any contamination is found at a supply well, the water supplier must either provide treatment or withdraw the well from service to ensure that water supplied to the consumer meets all applicable drinking water quality standards.

SWAP was very specific in that it only assessed the susceptibility of supply wells being impacted from contamination emanating from a point source at the land surface and within the contributing capture zone from the respective supply well. The intent and scope of Nassau County's groundwater monitoring program, on the other hand, is quite different in that all interrelated components of the groundwater system are evaluated individually and collectively, as well as assessing overall raw groundwater quality from a historical perspective and as it exists at present in Nassau County. In essence, SWAP evaluates a hypothetical potential at public supply wells, while the County's groundwater monitoring program assesses actual existing conditions in the overall groundwater system.

5.1 Temperature and Precipitation

Given an essentially stable population, as is the case in Nassau County over the past 20 years, variations in weather patterns are the major variables that influence how water is used and the extent to which groundwater elevations fluctuate. The variations in weather patterns that occurred in Nassau County during the 2000 – 2003 time period were previously presented in Table 4-1. In order to visually display the wide variation in precipitation that occurred during this time period, a plot of cumulative monthly precipitation for each year during this time period is illustrated in Figure 5-1. As shown in the figure, cumulative precipitation during the latter portion of 2001, and continuing through July of 2002, was significantly below the long-term average (calculated as the 60 year moving average).

Figure 5-2 consists of a series of three (3) graphs (temperature vs. time, precipitation vs. time, and public water supply withdrawal vs. time) visually displaying the wide fluctuations in weather conditions and public supply withdrawal for each month during the 2000 – 2003 period. Figure 5-2(a) shows that average monthly temperatures during the year correlate closely to historical average monthly temperatures, with average temperatures during the warmer months typically in the 70 to 80 degree range, and those of the colder months falling in the 30 to 40 degree range. Figure 5-2(b) displays the substantial variations in precipitation from month to month, while Figure 5-2(c) indicates wide fluctuations in public water demand corresponding to different times of the year.

High temperatures and dry conditions during the warmer months result in significantly greater water demand than the base demand months (January, February, March, November, and December) of each year when outdoor water usage is at a minimum. Summer months that are unusually hot and dry, such as the summer of 2002, can push peak summer demand to extreme levels as shown in Figure 5-2(c) when demand peaked at 340 mgd during July of that year.

As shown by the long-term average precipitation line on Figure 5-1, precipitation in Nassau County can be expected to average approximately 44 inches per year, or about 3½ inches per month. However, precipitation is quite variable as indicated in Figure 5-2(b). More importantly, the months during which precipitation events occur each year, and the distribution of precipitation events throughout each month, influences the amount of recharge to the aquifer system, and the extent to which the water table and potentiometric surface elevations fluctuate in succeeding months. During the warmer summer months when storms tend to be intense, a minimal amount of recharge occurs since most precipitation is either lost through evapotranspiration or as surface runoff. During the cooler months (October through March) when vegetation is dormant, and storms tend to produce less surface runoff, the majority of recharge occurs.

As Figure 5-2(b) illustrates, low amounts of precipitation occurred during the latter half of 2001 through the beginning of 2002. Precipitation then picked up considerably and significantly exceeded long-term averages during the latter months of 2002. Precipitation during this time was also distributed more evenly throughout each month. These variations in precipitation patterns resulted in water table and potentiometric head fluctuations throughout the County, which were most evident in the drought indicator wells.

Table 5-1 goes a step further in summarizing the variability inherent in individual rainfall events that have been recorded in Nassau County. The table includes all major precipitation events recorded at the weather stations (during their respective period of record as noted in the table) where total rainfall equaled or exceeded three (3) inches over a continuous 24-hour period. A 3-inch precipitation event was chosen as the criteria since this amount of rainfall is the threshold when flooding issues in the County are most likely to arise. As seen in the table, a number of major one-day precipitation events in Nassau County are commonly associated with hurricanes or tropical storms.

For each precipitation event that met the 24-hour and 3-inch criteria, rainfall amounts that fell within 16, 8, 4, 2, and 1-hour continuous periods during the respective event are also indicated on the table. Finally, the recurrence interval (or return period) for each continuous time period during the precipitation event was determined from frequency-intensity charts that were developed by DPW and are specific to Nassau County precipitation patterns. In this instance, the recurrence interval is defined as the average interval (in years) in which the amount of precipitation associated with the respective time period can be expected to recur or be exceeded.

5.2 Groundwater Quantity and Quality

Every groundwater system can be considered to be in a state of "dymamic equilibrium" in that the aquifers have great capacity to adjust to changing conditions and to reestablish equilibrium so that flow into the groundwater system remains in balance with the flow out of the system. The amount of recharge to the groundwater system and quantity of groundwater withdrawn to satisfy water demand are the main variables that influence system behavior. Changes in these variables cause the groundwater system to constantly strive to reach a new equilibrium state. Continuous monitoring of water table and potentiometric surface elevations displays how the groundwater system adapts to such changing conditions.

Figure 5-3 gives a historical perspective of fluctuating groundwater levels in select water table monitoring wells. These wells are located in close proximity to the groundwater divide, with one in the western portion of the County, one in the central portion, and one in the eastern portion. The locations of these wells can be found on Figures 3-3 and 3-4. The hydrographs of the wells date back to the 1940s and portray the permanent decline in the water table as a result of the installation of sanitary sewers and increased water demand resulting from development that occurred in the County. The hydrographs also reflect the annual variability in weather patterns inherent in Nassau County. The aforementioned monitoring wells, and those that are located close to the groundwater divide, exhibit larger magnitudes of decline than other monitoring wells located farther away. Upon moving away from the groundwater divide and toward the north or south shore, the magnitude of decline in the water table gradually declines and is smallest at the shorelines.

The water table declined first in the western portion of the County where sanitary sewers were initially installed during the 1950s. As the installation proceeded from west to east, the start of the decline in the east became evident shortly after sanitary sewer installation began during the mid 1970s in the eastern portion of the County. Since sanitary sewer installation in Nassau County and southwestern Suffolk County has been completed nearly 20 years ago, the full effect on the water table essentially has been realized. It must be noted that the water table will never rebound to pre-development levels, and therefore, present and future water table fluctuations (and potentiometric heads in the deeper aquifers) should only be compared to the more recent water level information that exhibit the full effects of sanitary sewer installation. Although the installation of sanitary sewers was the major cause of the water table decline, the sewers did provide the single most significant groundwater protection measure for Nassau County – a nearly complete elimination of direct household discharges to the groundwater system as well as a substantial reduction in commercial/industrial discharges.

The raw groundwater quality – *untreated groundwater collected from monitoring wells that are not used as sources of water supply* – is not representative of the quality of water delivered to the consumer. It must be emphasized that the water delivered to the consumer meets all federal, State, and local criteria for drinking water quality. Accordingly, the groundwater quality data presented in this document must not be interpreted as representing the quality of water supplied by any public water supplier in Nassau County. For detailed information about drinking water quality, the reader is referred to his/her respective water supplier and/or the Nassau County Department of Health – the local regulatory agency having jurisdiction for monitoring the quality of water that is supplied to the consumer.

5.2.1 Groundwater Quantity

As previously mentioned in Section 2, the groundwater system that supplies the County's potable water is continually being recharged at an average rate of approximately 341 mgd. From a general overall standpoint, as long as recharge exceeds the amount of water withdrawn for water supply (currently fluctuating in the 200 mgd range), the quantity of groundwater available for water supply purposes will be more than adequate. It is, however, important to continually monitor water levels in monitoring wells in order to detect trends, such as significant and long-term declines in monitoring well water levels that generally would indicate large scale increases in groundwater withdrawal, and/or large-scale reductions in recharge resulting from extended drought conditions. Such a trend would trigger a cause for concern, as would local changes that might signify a concern for a specific area. For example, local increases in public supply withdrawal might impact the movement of the freshwater/saltwater interfaces at specific locations on the north and south shores. For more detail, refer to the chloride and saltwater intrusion discussion of Subsection 5.2.2.

Fluctuating Groundwater Levels

The fluctuations in groundwater elevations that are observed from year to year, month to month, and day to day are to be expected due to the variables inherent with any aquifer system and the aquifer's response to continually seek new equilibrium states. The low amount of precipitation that occurred during the latter half of 2001 and early in 2002, coupled with the effects of high public water demand during the unusually hot, dry summer of 2002 (refer to Figure 5-2) manifested itself in water table elevations and potentiometric heads at numerous monitoring wells that were at historic lows.

However, the higher precipitation amounts that occurred during the latter half of 2002 and into 2003, coupled with cooler temperatures and a more normal public water demand throughout the warmer months, resulted in a rebounding of both the water table and potentiometric surfaces as illustrated in the hydrographs of the drought indicator and southwest indicator wells (refer to Figures 5-4 and 5-5 discussed later), and water table/potentiometric surface contour maps of Figures 4-1 through 4-6. The hydrographs show that 2003 groundwater elevations recovered from the 2002 lows to levels at or above those observed during 2000.

Water Table and Potentiometric Surfaces

The water table and potentiometric surface contour maps presented in Section 4 were constructed with the regional water level data collected during September of the respective years. This time was chosen for construction of the maps since the water levels in monitoring wells will generally be lowest at this time of year due to the stresses exerted on the groundwater system during the summer months. The contour maps therefore represent the lowest water tables and potentiometric surfaces during the year – in essence, a "worst case scenario." The aforementioned stresses include substantially increased water demand during hot-dry weather conditions typical of the summer months, and reduced recharge to the groundwater system as a result of increased evapotranspiration. During the cooler fall months, water demand decreases, while recharge increases (corresponding to a decrease in evapotranspiration). During the winter months, significant recharge also occurs provided that frozen soil conditions do not exist. This increase in recharge translates into higher water elevations that generally are observed during early spring.

Drought Indicator Wells

Figure 5-4 includes hydrographs for the 24 drought indicator wells. These hydrographs portray the widely fluctuating water elevations in the respective monitoring wells each month during the 2000 – 2003 period. As would be expected, due to the weather patterns and higher public water supply withdrawal experienced during 2001 and into the first portion of 2002, low water levels were observed during late summer/early fall 2002. However, groundwater elevations observed at the end of 2003 rebounded from the 2002 lows to levels at or above those observed during 2000.

Southwest Indicator Wells

Figure 5-5 includes hydrographs for the 19 southwest Nassau indicator wells. These hydrographs also show wide fluctuations in water levels; however, since these monitoring wells are farther to the south than the drought indicator wells, the range of fluctuations are not as pronounced.

5.2.2 Raw Groundwater Quality

Previous groundwater studies have identified volatile organic chemicals as the most significant countywide groundwater quality issue in Nassau County due to the observed or potential impacts on public supply wells. Hence, the main focus of raw groundwater quality monitoring was on VOCs during the 2000 – 2003 period. Other parameters that were monitored to a lesser extent included pesticides, pharmaceuticals, and perchlorate. Chlorides in monitoring wells along the shorelines in communities that are susceptible to saltwater intrusion were assessed during this period as well.

This section demonstrates that the County's raw groundwater, for the most part, is of high quality. Raw groundwater quality has shown continued improvement over the last 10 to 15 years due to the installation of sanitary sewers and the various programs instituted on the federal, State, and local levels to safeguard the groundwater supply, in particular, the disposal of hazardous substances and clean up of contaminated sites. Sanitary sewers and the groundwater protection programs have been effective in greatly reducing the contaminant loading to the groundwater system such that far fewer contaminants are entering the County's aquifers than was the case years ago.

Water delivered by the public water suppliers in Nassau County is of excellent quality and satisfies all federal, State, and local criteria for drinking water quality. If any contamination is found, the public supply well is either removed from service or treatment is installed to continue using the well. The high quality of Nassau's raw groundwater has resulted in the majority of public water supply wells in the County providing water that satisfies drinking water criteria with little or no treatment for health related substances.

Public water suppliers are required under New York State Sanitary Code and local health department requirements to routinely monitor their systems by testing the water at both the source (at the well head of the public supply well) and within the distribution system for a wide range of bacteriological and chemical parameters. In addition to the monitoring conducted by the public water suppliers, the Nassau County Department of Health conducts similar surveillance on the public water supply systems. The monitoring performed by both the public water suppliers and NCDH assures that the highest quality drinking water is served to Nassau County residents.

As was mentioned in Section 1, Table A-2 of the appendix contains a tabulation of drinking water maximum contaminant levels (MCLs) specified in the New York State Sanitary Code (10 NYCRR), along with Class GA fresh groundwater standards from the New York State Environmental Conservation Rules and Regulations (6 NYCRR). Under 6 NYCRR, Class GA fresh groundwater is defined as those groundwaters that are best used as a source of potable water supply.

It is noted that the MCLs apply specifically to drinking water. Class GA groundwater standards, on the other hand, are utilized by the New York State Department of Environmental Conservation (NYSDEC) to protect and manage the groundwaters of the State. The Class GA standards are typically applied to wastewater and site remediation discharges to groundwater, and are regulated by NYSDEC under the State Pollution Discharge Elimination System (SPDES) permit process – the goal being to prevent the degradation of a groundwater resource from such discharges. While neither the MCLs nor Class GA groundwater standards are directly applicable to Nassau's raw groundwater, they are nevertheless useful as a guide for assessing the ambient groundwater quality of the County's aquifers.

Volatile Organic Chemicals

Of the 522 raw groundwater quality samples that were analyzed for VOCs during the 2000 – 2003 period (encompassing 391 monitoring wells of the entire network), only 49 monitoring wells (67 samples) had TVOC concentrations detected above 5 ppb. Figures 5-6 to 5-8 depict these detections in the aquifer in which they were found, and as Table 4-4 indicates, concentrations vary widely in the monitoring wells where VOCs were detected. The most commonly occurring VOC compounds in Nassau's raw groundwater, based on their frequency of detection (at any concentration) in samples collected from network monitoring wells, are summarized as follows:

2000 – 2003		**1990 – 1999**	
Compound	Frequency	Compound	Frequency
Tetrachloroethene	62%	1,1,1-Trichloroethane	41%
Trichloroethene	43%	Tetrachloroethene	38%
c-1,2-Dichloroethene & 2,2-Dichloropropane	32%	Trichloroethene	37%
1,1-Dichloroethane	30%	Chloroform	25%
1,1,1-Trichloroethane	26%	1,1-Dichloroethane	25%
Methyl Tertiary Butyl Ether (MTBE)	22%	c-1,2-Dichloroethene & 2,2-Dichloropropane	16%
1,1-Dichloroethene	19%	1,1-Dichloroethene	15%
Chloroform	15%	Methyl Tertiary Butyl Ether (MTBE)	5%

In the preceding tabular summary, during the 2000 – 2003 period, 522 total samples were analyzed, with 95 (18%) of those samples showing some detectable level of TVOCs. During the 1990 –1999 period, 3435 total samples were analyzed with 938 (27%) of those samples showing some detectable level of TVOCs.

With respect to Figures 5-6 through 5-8, it is noted that some monitoring wells were sampled and analyzed for VOCs on more than one occasion during the 2000 – 2003 period (refer to Table 4-4). In these instances, the symbol corresponding to the most recent sample result is plotted on top of the symbol(s) corresponding to any previous sample result(s). For example, 19 ppb TVOC was detected in monitoring well N-09469 during 2000, while analyses of subsequent samples collected during 2001 and 2003 were below detection limits. This is represented on Figure 5-6, where the small blue circles (there are actually two blue circles, one plotted on top of the other) corresponding to no detections in 2001 and 2003 are plotted above the yellow star symbol corresponding to the earlier detection of 19 ppb TVOC during 2000.

Figures 5-9 and 5-10 depict VOC detections in the raw groundwater from monitoring wells sampled during the 1985 – 1987 time period in the Upper Glacial and Magothy aquifers, respectively. Comparing these figures to Figures 5-6 and 5-7, the changes in overall raw groundwater quality in these aquifers from two distinct time periods are evident, and further, show that there has been a very significant improvement in raw groundwater quality in the Upper Glacial aquifer, and to a lesser extent in the Magothy aquifer. As the Magothy aquifer continues to be recharged from the Upper Glacial aquifer, it is expected that continued improvement in raw groundwater quality in the Magothy aquifer will occur. During the 1985 –1987 time period, Lloyd aquifer sampling did not occur, precluding the creation of a Lloyd aquifer VOC detection map for this period.

A series of bar graphs are presented in Figure 5-11 to visually display the percentage of monitoring well samples in each aquifer with TVOC concentrations greater than 5 ppb, back to the 1985 – 1987 period. Since all wells in the monitoring network cannot, nor need to be sampled on an annual basis, the years corresponding to each bar are comprised of a sufficient number of spatially distributed monitoring wells to give an overall representation of the raw groundwater quality in each aquifer. Prior to 1992, the spatial distribution of Lloyd aquifer monitoring wells throughout the County was limited, thereby preventing a representative portrayal of countywide raw groundwater quality in this aquifer. Additionally, the bars on the Lloyd and North Shore aquifer graph during subsequent periods only result from a few monitoring wells in these aquifers at the north shore areas where aquifer depths are in the range of 400 feet, not the significant depth (on the order of 1000 feet or more) that is typical of the Lloyd aquifer elsewhere in the County.

Figures 5-12 through 5-14, represent TVOC concentration distributions for the raw groundwater samples collected from each aquifer that correspond to the years represented in the bar graphs. Review of these figures, along with the bar graphs, clearly indicates that raw groundwater quality in Nassau County is improving with respect to VOCs. This improving trend was discussed in detail in the "Nassau County 1998 Groundwater Study" and continues to the present.

As discussed previously, the installation of sanitary sewers and the regulatory programs governing the use and disposal of VOCs, have been instrumental in achieving this improving trend by reducing the contaminant loading on the groundwater system. In addition, the regulatory programs that require the cleanup of soil and groundwater contamination and control the storage of toxic and hazardous substances have also contributed greatly to reducing the contaminant loading. While much of the Upper Glacial and Magothy aquifers show non-detectable to low concentrations of TVOCs, contaminated aquifer segments currently exist in certain areas of the County. The location of contamination in the aquifer is influenced by the affects of water supply withdrawal on the flow patterns of groundwater throughout the aquifer system. Most public supply wells are located deep in the Magothy aquifer and tend to draw contaminants downward from the shallower depths more rapidly than would naturally occur. However, the supply wells that rely primarily on the deeper Magothy aquifer are able to benefit from the natural processes of dilution, retardation, and biodegradation to attenuate VOC contamination as groundwater flows through the aquifers. During the mid 1980s, 50% of raw groundwater quality samples from Upper Glacial monitoring wells and 50% of samples from Magothy monitoring wells exhibited TVOC contamination in excess of 5 ppb. At present, only 20 years later, approximately 15% of samples in each of these aquifers exhibit VOC impacts.

Given the existence of sanitary sewers that serve over 90% of Nassau County's population and the regulatory programs that are in place, it is expected that raw groundwater quality will improve further as cleaner water from recharge continues to flush through the groundwater system. The continued improvement in raw groundwater quality will occur over many more years and will eventually reach some minimum level. A minimum level will always be present due to the activities of a population of 1.3 million living above their water supply.

Methyl Tertiary Butyl Ether (MTBE)

MTBE has been used at low levels in gasoline to replace lead as an octane enhancer since 1979. Beginning in 1992, MTBE was used at higher concentrations in gasoline to fulfill the oxygenation requirements set by Congress in the 1990 Clean Air Act Amendments. Oxygen helps gasoline burn more completely to reduce harmful automobile tailpipe emissions – the intent of amendments to the Clean Air Act. Unfortunately, MTBE has found its way into Nassau County's groundwater, as well as the groundwater in many other parts of the nation. MTBE has since been banned from use, but persists in the groundwater.

Since 1995, DPW has analyzed 900 raw groundwater samples for the presence of MTBE. During the 1995 – 2003 time period, 48 samples were found to contain MTBE concentrations greater than or equal to 2 ppb. These 48 samples were from 39 different monitoring wells. The locations of all monitoring wells sampled for MTBE, along with their respective concentration ranges, are depicted in Figures 5-15 (for the period 2000 – 2003) and Figure 5-16 (for the period 1995 – 1999). The listing of monitoring wells with the respective concentrations was previously presented in Table 4-5 of Section 4. As described in the VOC discussion, the symbol corresponding to the more recent sample result is plotted on top of the symbol(s) corresponding to results of prior sampling events.

For an interval during the 1995 – 1999 period, the detection limit of the analytical equipment at the DPW Environmental Laboratory was slightly lower than 2 ppb for MTBE. Towards the middle of that time period, the detection limit was recalibrated and set at 2 ppb, which is the detection limit that continues to the present. In the interest of consistency, and to facilitate comparing Figure 5-15 with Figure 5-16, all monitoring wells with MTBE concentrations less than 2 ppb were plotted with small blue circles on both figures.

The sporadic distribution of generally low levels of MTBE in Nassau County's raw groundwater is the result of leaking gasoline storage tanks and associated piping, accidental spills, and to a lesser degree, storm water runoff and fallout of MTBE from the atmosphere resulting from automobile emissions. Although there are several localized sites in Nassau County that have been identified by others where MTBE contamination exists at high levels, the water suppliers are taking appropriate action to safeguard the public supply wells that could potentially be impacted. The source of MTBE at these localized areas has been linked to storage tank leakage from nearby gasoline stations.

Pesticides

Tables 4-6 through 4-8 of Section 4 displayed a wide range of pesticide compounds in low concentrations that were detected in Nassau County's groundwater during the 2001 – 2003 period. The locations of monitoring wells that were sampled for pesticides during this period are shown in Figure 5-17 along with their respective concentration ranges. Any concentration associated with trace (T) detection for a pesticide compound, per tables 4-6 through 4-8, was considered to be the actual concentration at the monitoring well in preparing the figure.

Even though low level pesticide concentrations are widely distributed, it is encouraging that only low levels were detected in targeted areas where pesticide contamination was expected to have the greatest likelihood of occurring – near golf courses, parks, railroad right-of-ways, etc. Table 5-2 summarizes the pesticide compounds that were detected, the number of detections for that particular compound along with the respective concentration ranges, and other information.

The low levels of pesticides and pesticide degradation products in Nassau County's groundwater can be attributed to the virtual disappearance of agriculture by the 1960s as the County developed into a suburban community and to proper pesticide application by major users. This is evidenced by the fact that less than 1% of all active public supply wells in Nassau County require treatment to remove pesticides from groundwater. However, pesticides have been and will continue to be used, to some extent, in recreational and residential settings. Therefore, the continued presence of low concentrations of various pesticide and pesticide degradation products can be expected to be detected in the raw groundwater in future years.

The monitoring well sample results demonstrate that pesticides are not a significant concern in Nassau County groundwater. Further, the results show that applications to recreational and residential areas have not had a significant detrimental effect on groundwater quality.

Pharmaceutical Compounds

Pharmaceutical compounds listed in Table 3-2 were included in the sample analyses conducted by the SCDHS-PEHL during 2002 and 2003. It is noted that there was a single detection of butylated hydroxyanisole, and a single detection of carbamazepine. There were 25 detections of butylated hydroxytoluene (BHT) out of the 42 monitoring well samples that were analyzed for this compound.

Since BHT was detected frequently, a preliminary literature review was conducted to determine potential sources. It was found that BHT is used as an antioxidant in various consumer items that include food products, synthetic rubber and plastic, animal and vegetable oils, and soaps. BHT is also used in the dry cleaning industry as a color inhibitor/stabilizer for reclaimed cleaning solvents. Any one of these uses could be a possible source for the frequent appearance of BHT in the County's raw groundwater. It must be pointed out BHT is a newly analyzed parameter and the findings are based on a small set of testing data. Accordingly, the reliability of the data must be determined, and if the data is found to be accurate, more investigation into sources and potential effects of BHT on the raw groundwater resource is warranted.

Based on the testing conducted during 2002 and 2003, the initial indication is that the extent of different pharmaceutical compounds/consumer products in the County's groundwater is limited. When any were detected, they were found at very low concentrations. The apparent absence of these compounds in Nassau's raw groundwater can be attributed to the presence of sanitary sewers that serve over 90% of the County's population.

Figure 5-18 shows the locations of monitoring wells that were sampled for pharmaceutical compounds/consumer products with their respective concentration ranges. In the event that more than one compound was detected at the same monitoring well, the symbols corresponding to the detected compounds are superimposed at the well location. Additionally, in preparing the figure, any concentration associated with trace (T) detection (per Tables 4-7 and 4-8), was considered to be the actual concentration at the monitoring well.

Perchlorate

Of the 85 monitoring well samples analyzed by the SCDHS-PEHL for perchlorate during the 2001 – 2003 period, only one was found to contain 2 ppb (monitoring well N-09664 in 2003) and only trace amounts were found in five other monitoring wells. Figure 5-19 shows the locations of monitoring wells that were sampled for perchlorate with respective concentrations detected. In the figure, trace detections of perchlorate (per Tables 4-6 through 4-8) were handled in the same manner as trace detections of pesticides and pharmaceutical compounds.

Chlorides and Saltwater Intrusion

The presence of elevated chloride concentrations in groundwater samples obtained from the screen zone of wells located near the shoreline is generally indicative of saltwater intrusion. Other types of data including chloride concentrations in groundwater samples taken during the drilling of a well, area specific hydrogeology, geophysical logs, and potentiometric surface elevations are also useful in evaluating the degree of saltwater intrusion that has occurred, or is anticipated to occur, at an area. As a general guide, present day ambient chloride concentrations in the Upper Glacial aquifer are less than 40 parts per million (ppm), while ambient concentrations are expected to be 10 ppm or less deeper in the Magothy aquifer, and 10 ppm or less in the Lloyd and North Shore aquifers. Concentrations above these levels, or observed increases in chloride concentrations over time at a shoreline well, can be indicative of the occurrence of saltwater intrusion. For a basis of reference, the maximum contaminant level (MCL) for chloride content in drinking water is 250 ppm and the chloride concentration in pure seawater is approximately 19,000 ppm.

Saltwater intrusion has occurred in southwestern Nassau and along portions of the north shore of the County. In Nassau County's aquifers, the interface between freshwater and saltwater is generally clearly defined. Saltwater intrudes into the aquifers in a wedge like fashion. The interface between fresh and salty groundwater is characterized by a thin transition zone – generally referred to as the freshwater/saltwater interface. As the saltwater wedge moves further inland, the chloride concentration at a well in the pathway of the wedge increases from ambient levels and can approach levels indicative of pure seawater.

As a result of the intrusion that has occurred, the Magothy aquifer in southwest Nassau beneath the mainland and barrier beaches is no longer usable for public water supply. Saltwater intrusion in both the Magothy and Lloyd aquifers along the south shore is proceeding at a very slow rate and is a result of the rise in sea level over the last 18,000 years, coupled with the effects of_water supply withdrawal for public supply purposes. The leading edge of the saltwater front in the Lloyd aquifer along the entire south shore lies offshore beneath the ocean floor. In the Magothy aquifer along the rest of the south shore, the leading edge of the saltwater front is also offshore. Even if all pumping along the south shore were to cease, landward saltwater intrusion would nevertheless still occur due to the need to reach equilibrium with the rise in sea level.

On the north shore, saltwater intrusion has occurred at localized areas on the Great Neck and Manhasset Neck peninsulas, in Bayville, and in Centre Island. As a result of the saltwater intrusion, portions of the Lloyd, North Shore, and Upper Glacial aquifers have become unusable for public water supply purposes. Saltwater intrusion along the north shore is driven by groundwater withdrawal from public supply wells located near the shorelines. Water suppliers in the north shore areas where localized saltwater intrusion has affected some public supply wells have taken action to deal with the saltwater intrusion problem. Such actions included the development of public supply well management plans to reduce pumping from certain existing wells, seeking new public supply well locations to replace lost capacity of impacted wells, and implementation of water conservation measures.

The saltwater intrusion monitoring well networks were depicted in Figures 3-9 and 3-10 of Section 3, and chloride sample results were presented in Tables 4-9 and 4-10 of Section 4. Monitoring wells N-12508, N-12793, and N-12895 located on the Manhasset Neck peninsula, and monitoring well N-12790 located in Bayville, have shown chloride concentrations above ambient levels that have been consistently increasing since the first samples were collected during the 1990s. Although not indicative of widespread saltwater movement along the entire north shore, it is nevertheless an indication that the saltwater front is most likely advancing at these locations.

Other than these localized areas, the chloride sampling results presented in Tables 4-9 and 4-10 are not indicative of any new and significant landward movement of saltwater. However, these results represent chloride concentrations from very specific positions in the groundwater system – namely the zones in the aquifers where the monitoring wells are screened. Although these monitoring wells were installed at a depth and position most likely to pick up the first signs of saltwater intrusion and movement of the saltwater front, it is possible that saltwater could intrude above the screen zone. Under the cooperative agreement with the USGS, electromagnetic-induction logging will be used at select monitoring wells. This logging technique will be used to profile chloride concentrations along the entire length of the well casing that is located within the saturated zone of the groundwater system.

5.3 Water Usage

Population and weather patterns are the main factors that determine the amount of water used by the public. Figure 5-20 shows the Long Island Power Authority's (LIPA) population estimates for

Nassau County and the County's average annual groundwater withdrawal rates in millions of gallons per day (mgd), going back to 1990. (For simplicity purposes, water usage is generally discussed in terms of mgd – which is easily obtained by considering the total gallons withdrawn in a given year and dividing by the number of days in that year, and then dividing by one million.)

LIPA's annual estimates of Long Island's population are derived from United States census data, utility records of active residential meters, and the relationships with residential households, condominiums/apartments and group living quarters. LIPA's annual population estimates are used by DPW to evaluate per capita water usage each year. Population has remained relatively stable since 1990 and it is noted that the increase between census years, 1990 to 2000, was less than 4% which is a small increase over a 10 year period.

Public water demand can vary widely from year to year depending largely on summer weather conditions. Unusually hot, dry summers have resulted in annual water demand exceeding 200 mgd in Nassau County. During years with cool and rainy summers, annual water use has typically hovered around 185 mgd. During peak summer months, water demand can exceed 300 mgd, as seen during the summer of 2002. During the cooler fall and winter months, commonly referred to as the base months (November, December, January, February, and March), water use generally has fallen within the 135 to 145 mgd range over the past 10 years.

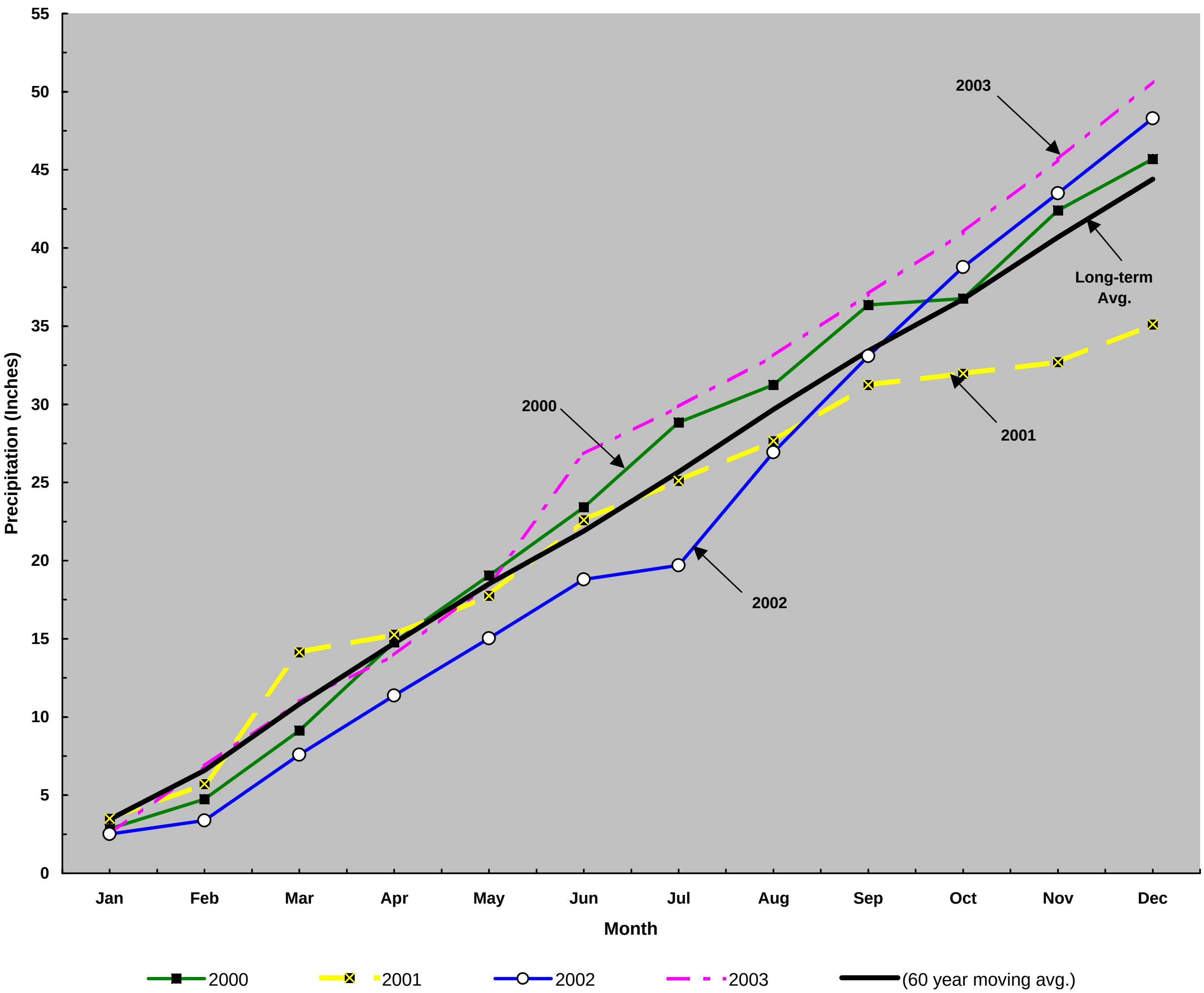
In addition to evaluating total public water usage on an annual or monthly basis, DPW has also examined seasonal variations in water use by considering per capita usage (gallon usage attributable to each person and defined as gallons per capita per day, or gpcd) during different times of the year. Figure 5-21 contains multiple graphs showing per capita usage based on (1) total groundwater withdrawn for public supply purposes throughout the year, (2) withdrawal during the base pumping months, and (3) withdrawal during the peak pumping months. It is interesting to note that the per capita demand during the base months remained relatively stable at approximately 107 gpcd, while the monthly demand during peak months varied widely (due to weather patterns during the warmer months) and reached 190 gpcd during 1999. As shown in the figure, annual per capita demand generally averages in the 145 to 150 gpcd range. The obvious reason for the large increase in water demand during peak pumping months is the outdoor activities characteristic of warmer weather. Lawn watering is clearly the most significant contributor to the increased demand during the peak months, and the proliferation of in-ground sprinkler systems most certainly exacerbates warmer weather water usage.

Figure 5-1

Weather Monitoring

CUMULATIVE MONTHLY PRECIPITATION

2000 to 2003



Prepared by: Nassau County Dep't. of Public Works

FIGURE 5-2

TEMPERATURE, PRECIPITATION AND PUBLIC SUPPLY WITHDRAWAL 2000-2003

FIGURE 5-2(a)
AVERAGE MONTHLY TEMPERATURE

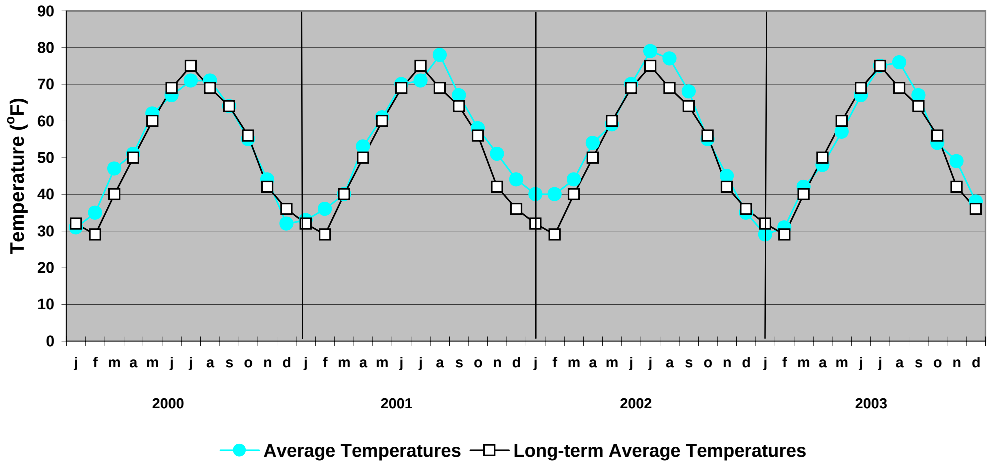


FIGURE 5-2(b)
MONTHLY PRECIPITATION

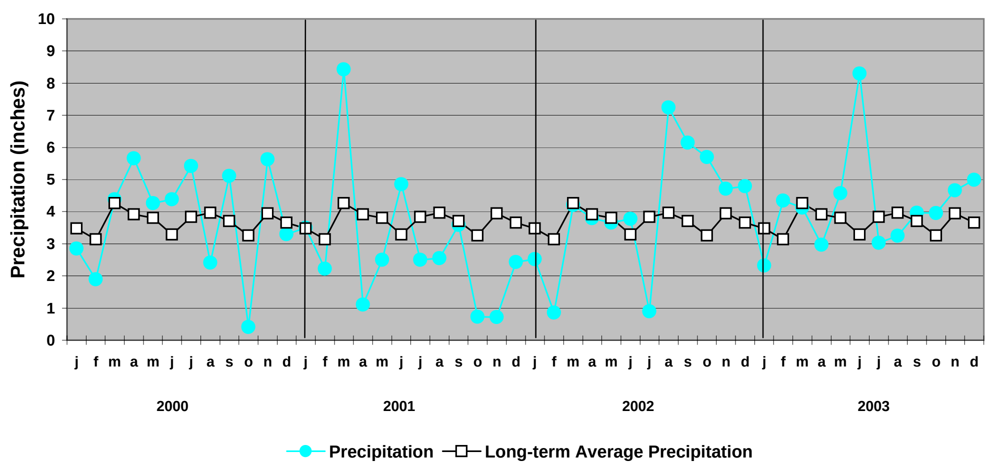


FIGURE 5-2(c)
MONTHLY PUBLIC WATER SUPPLY WITHDRAWAL

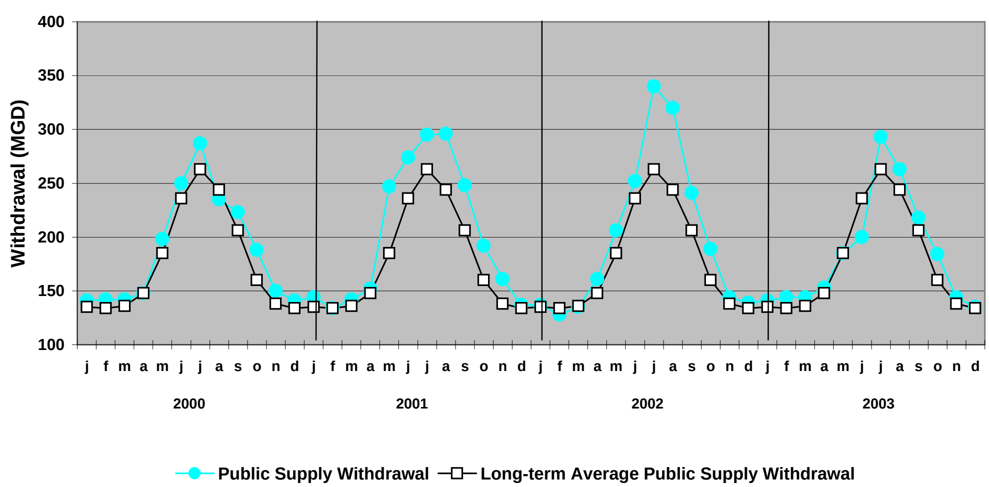
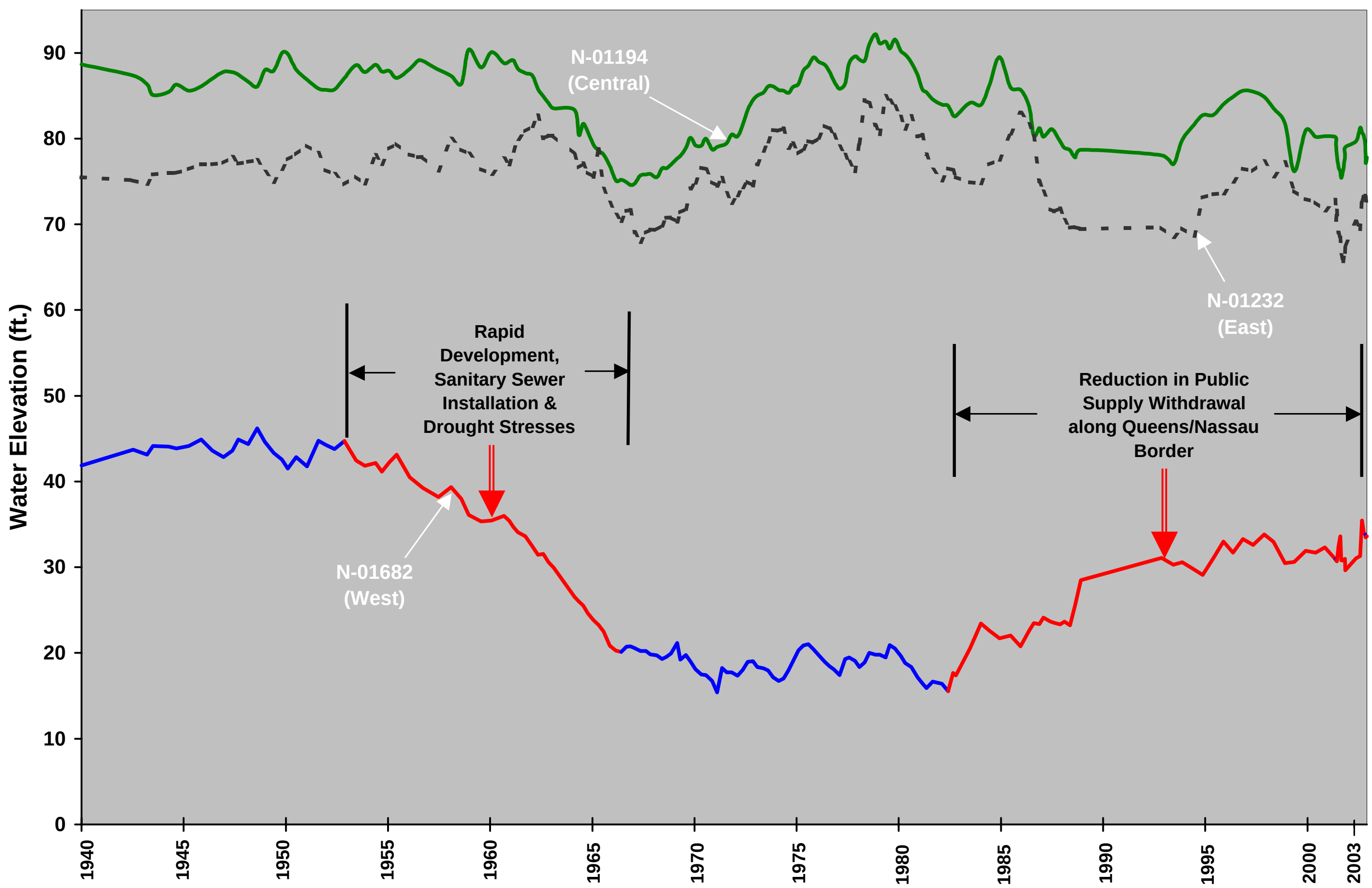


FIGURE 5-3

Monitoring Well Network

HISTORIC WATER TABLE FLUCTUATIONS
AT SELECT MONITORING WELLS
(elevations in feet above mean sea level)



Prepared by: Nassau County Dep't. of Public Works

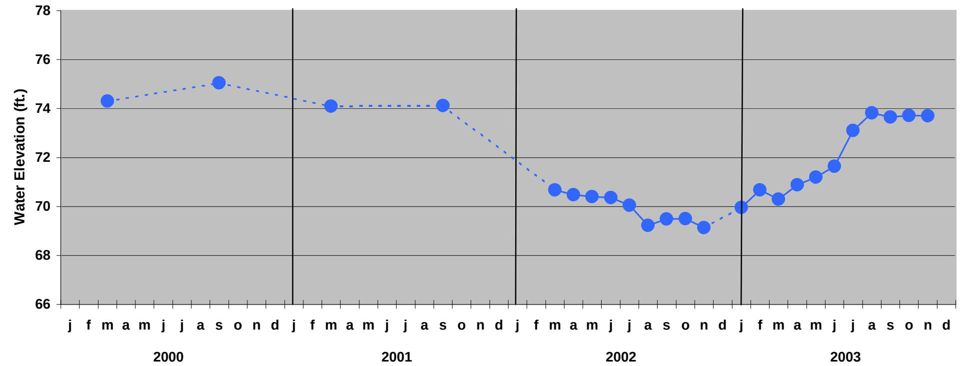
FIGURE 5-4

Drought Indicator Monitoring Well Network

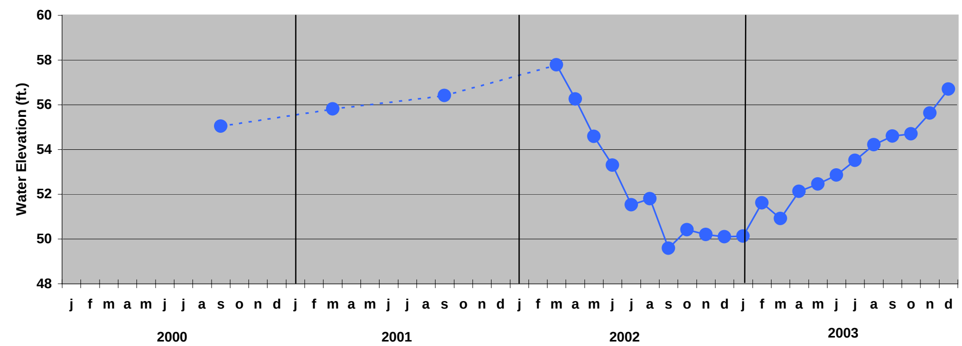
HYDROGRAPHS FOR DROUGHT INDICATOR WELLS

(elevations in feet above mean sea level)

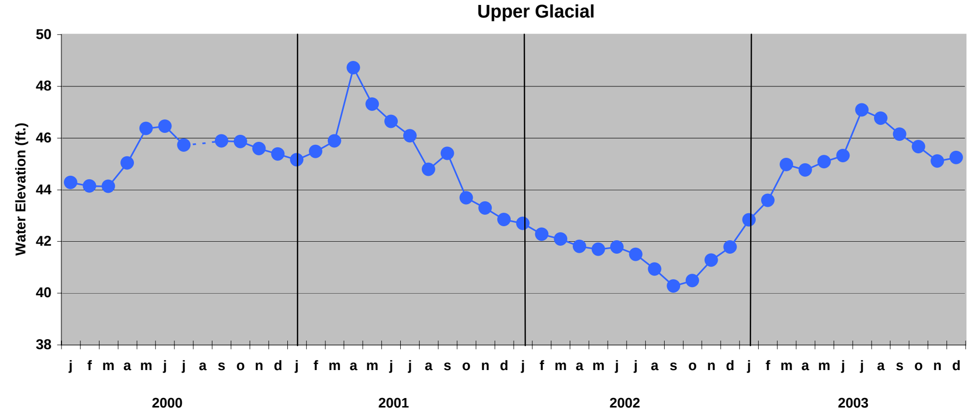
N-01195
Upper Glacial



N-01234
Magothy (wt)



N-01259
Upper Glacial



Measured water elevation data point
Inferred elevation between data points

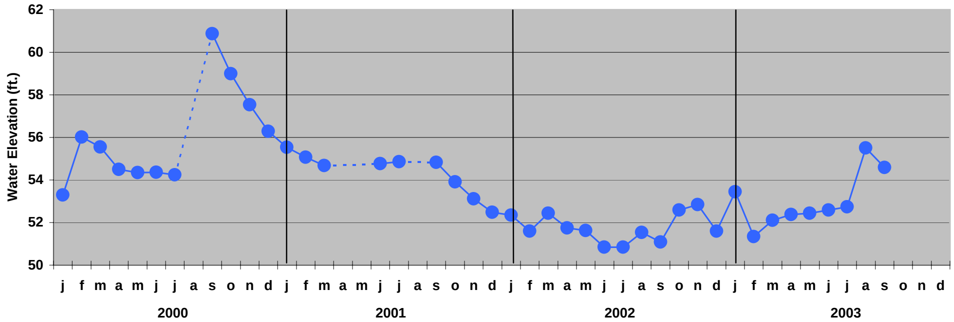
FIGURE 5-4

Drought Indicator Monitoring Well Network

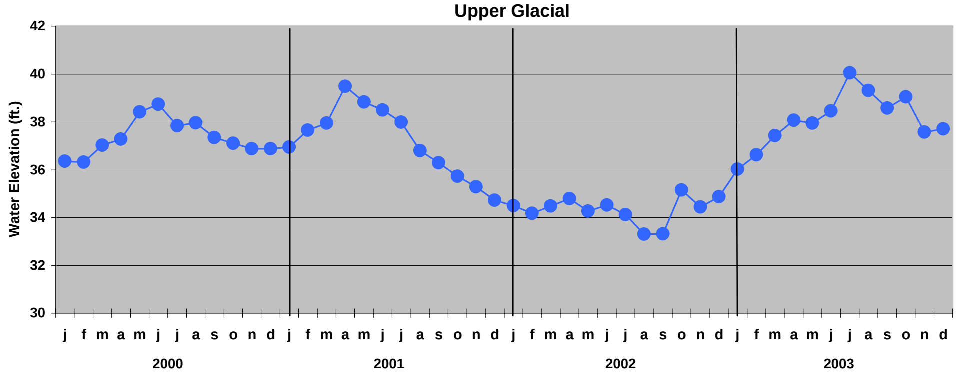
HYDROGRAPHS FOR DROUGHT INDICATOR WELLS

(elevations in feet above mean sea level)

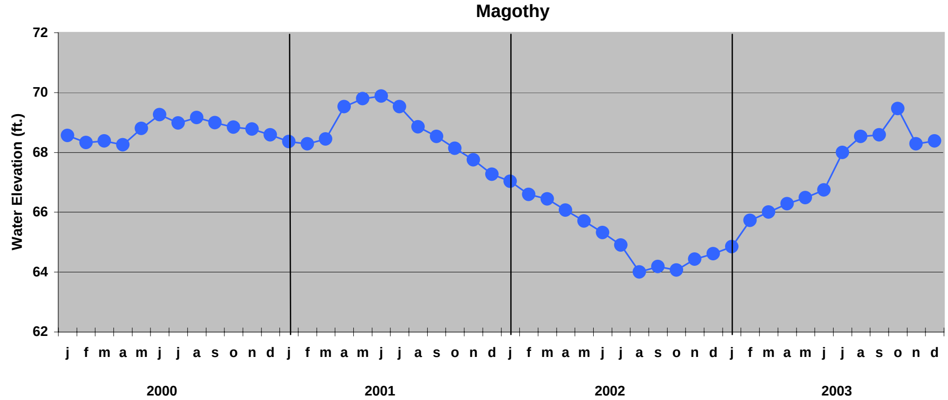
N-01614
Upper Glacial



N-01615
Upper Glacial



N-01616
Magothy



Measured water elevation data point
Inferred elevation between data points

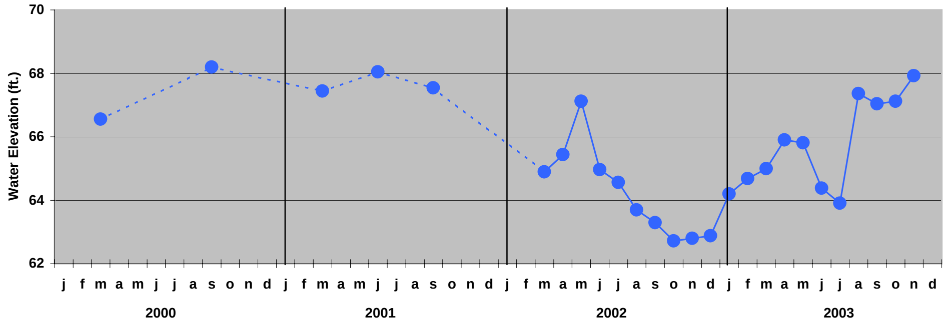
FIGURE 5-4

Drought Indicator Monitoring Well Network

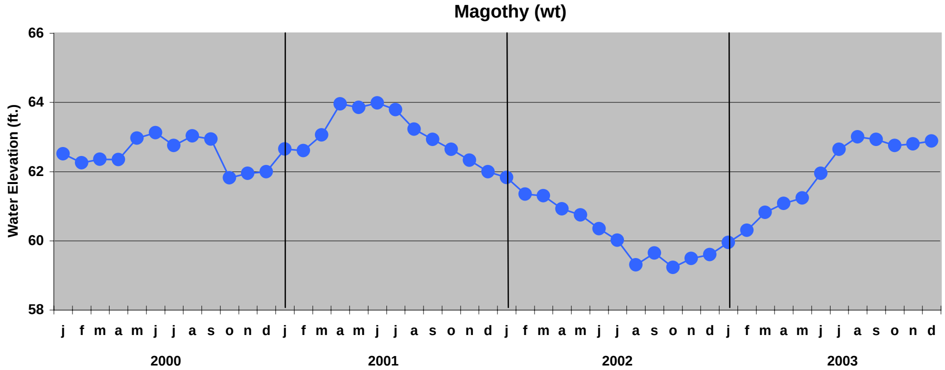
HYDROGRAPHS FOR DROUGHT INDICATOR WELLS

(elevations in feet above mean sea level)

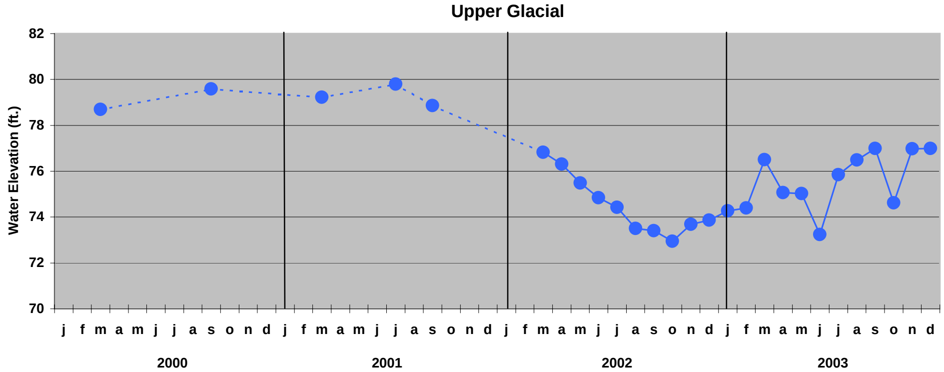
N-07397
Upper Glacial



N-08269
Magothy (wt)



N-08888
Upper Glacial



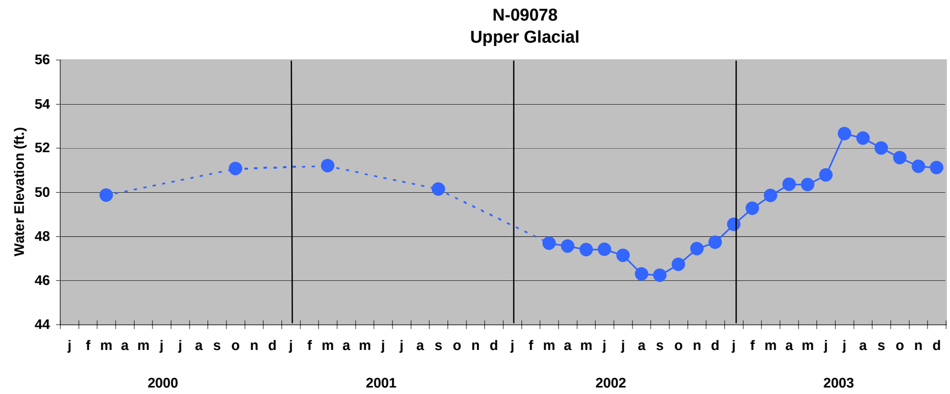
● Measured water elevation data point
- - - - Inferred elevation between data points

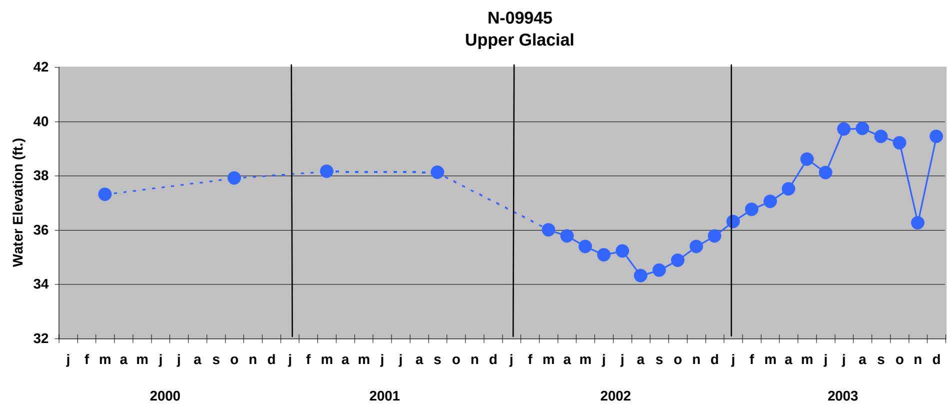
FIGURE 5-4

Drought Indicator Monitoring Well Network

HYDROGRAPHS FOR DROUGHT INDICATOR WELLS

(elevations in feet above mean sea level)





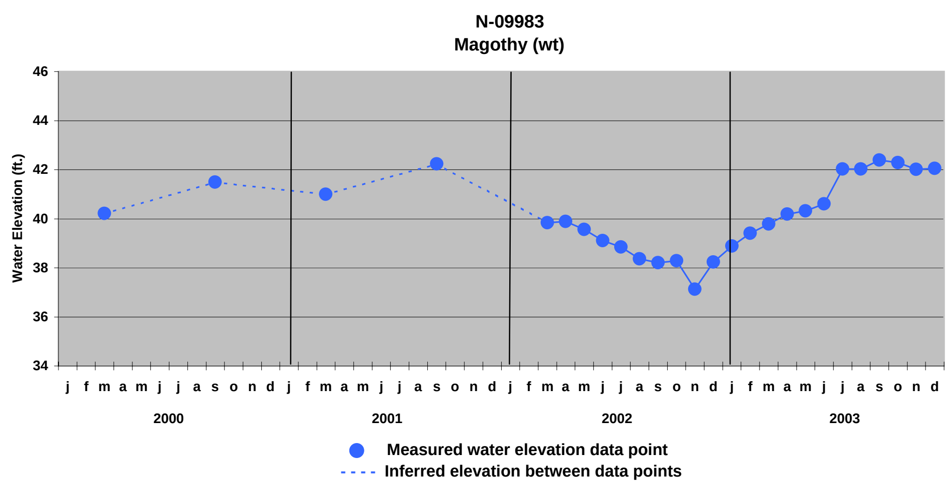
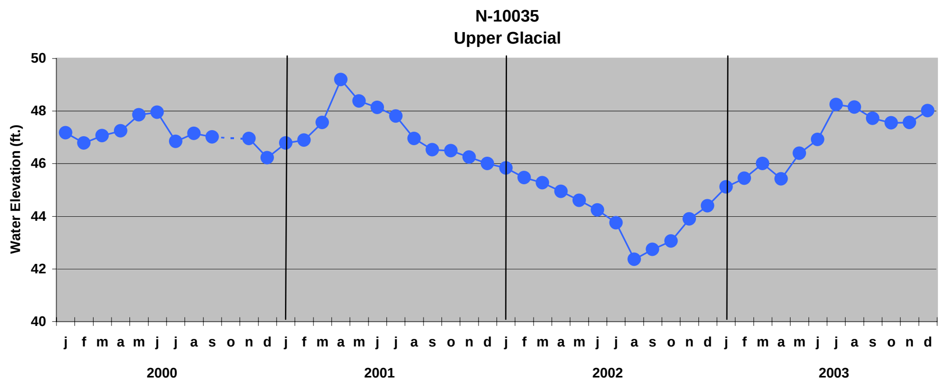


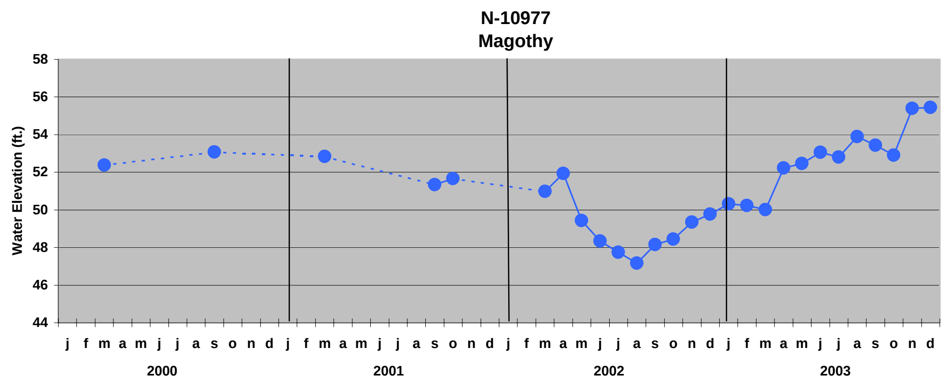
FIGURE 5-4

Drought Indicator Monitoring Well Network

HYDROGRAPHS FOR DROUGHT INDICATOR WELLS

(elevations in feet above mean sea level)





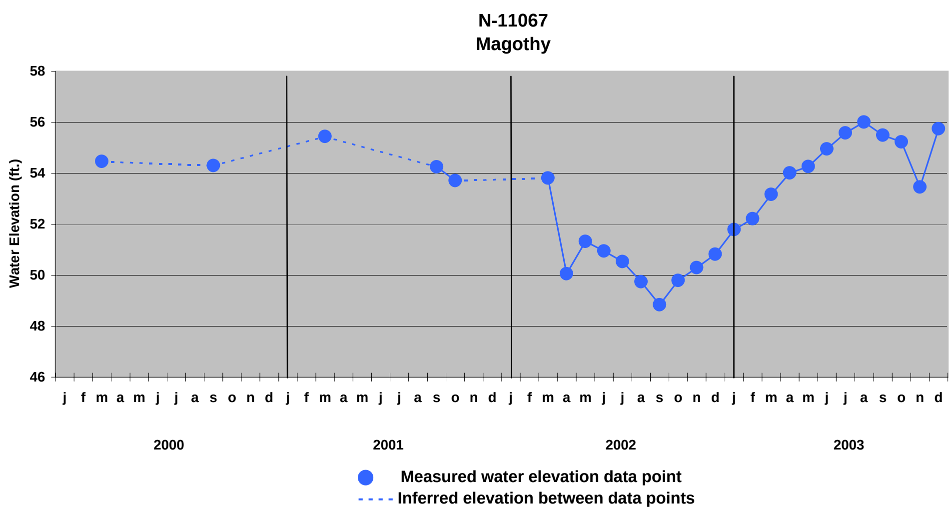
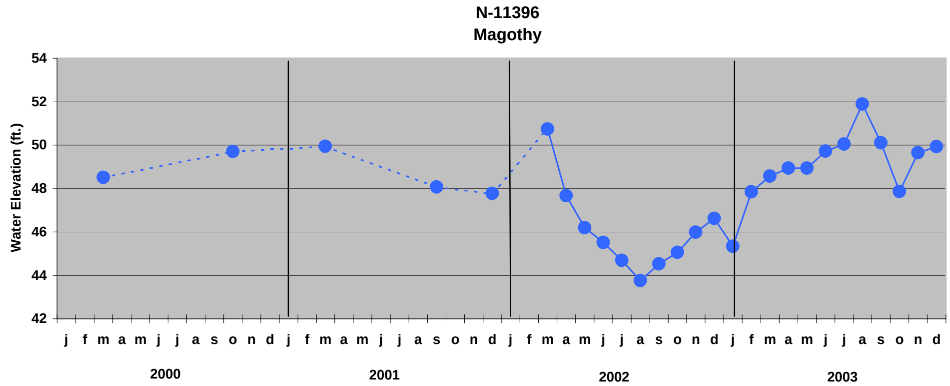
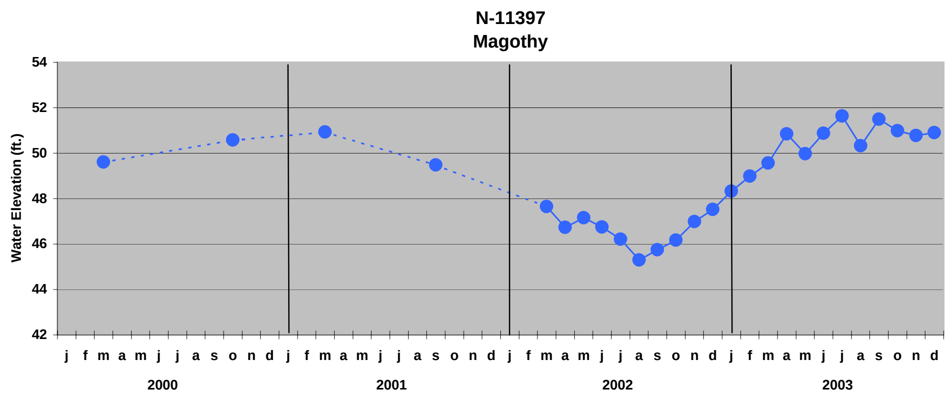


FIGURE 5-4

Drought Indicator Monitoring Well Network

HYDROGRAPHS FOR DROUGHT INDICATOR WELLS
(elevations in feet above mean sea level)





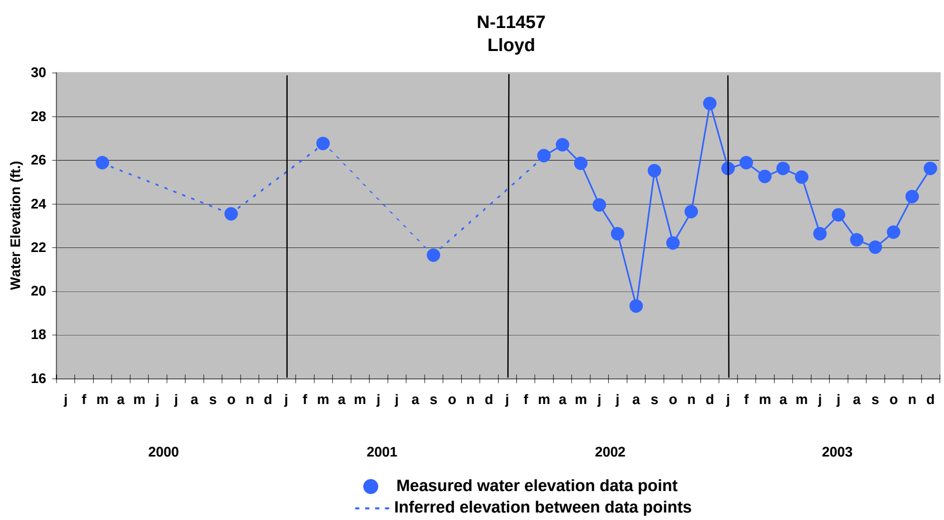


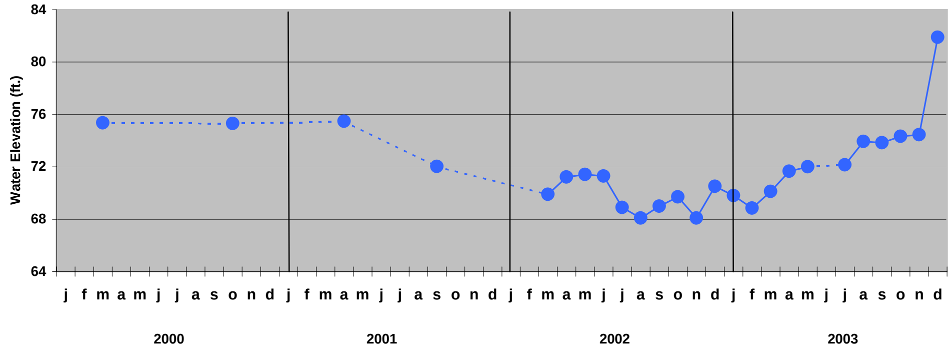
FIGURE 5-4

Drought Indicator Monitoring Well Network

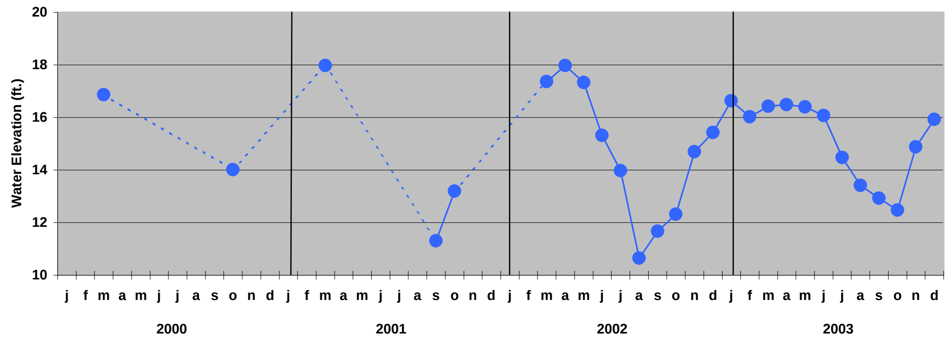
HYDROGRAPHS FOR DROUGHT INDICATOR WELLS

(elevations in feet above mean sea level)

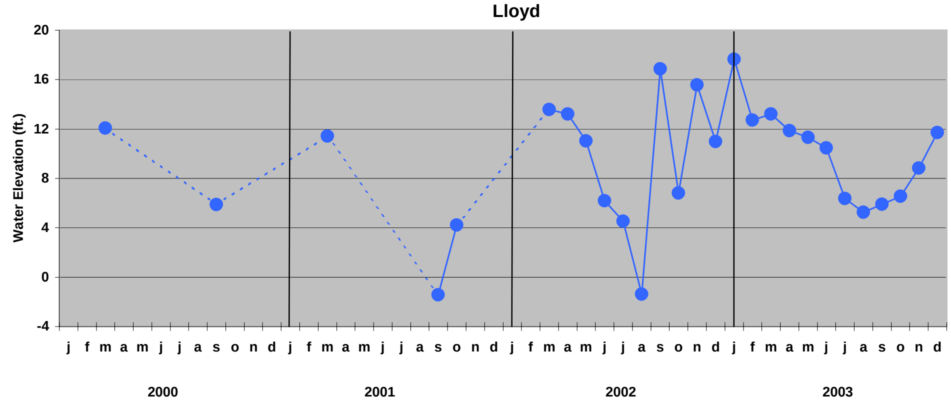
N-11458
Magothy



N-11570
Lloyd



N-11572
Lloyd



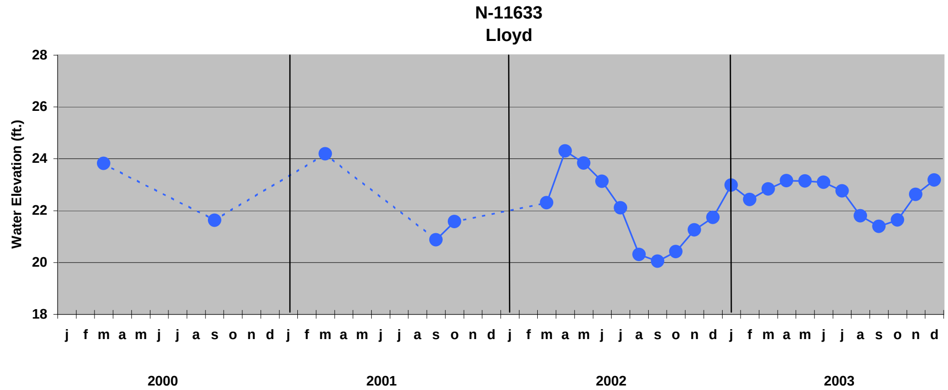
Measured water elevation data point
Inferred elevation between data points

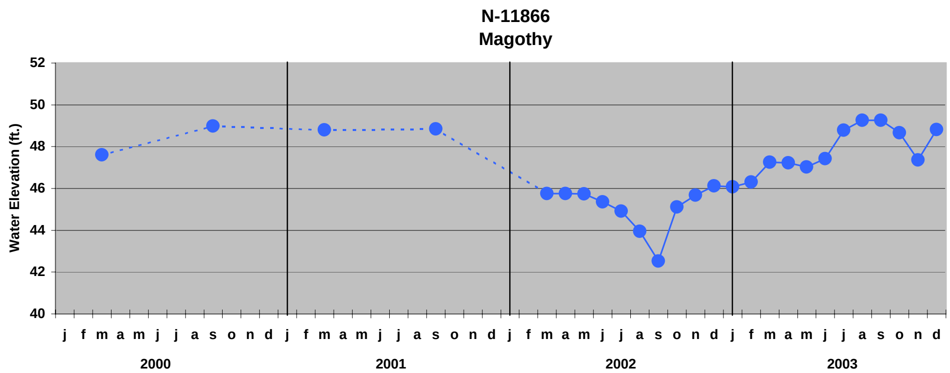
FIGURE 5-4

Drought Indicator Monitoring Well Network

HYDROGRAPHS FOR DROUGHT INDICATOR WELLS

(elevations in feet above mean sea level)





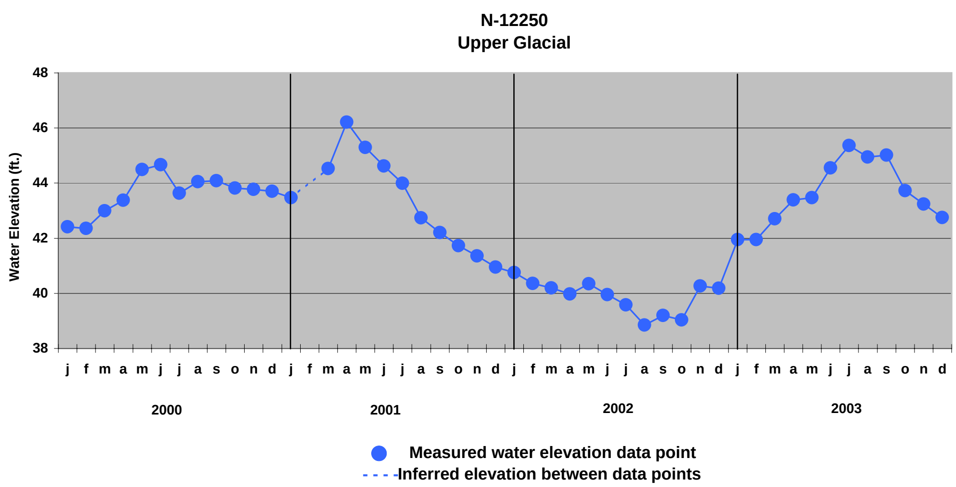
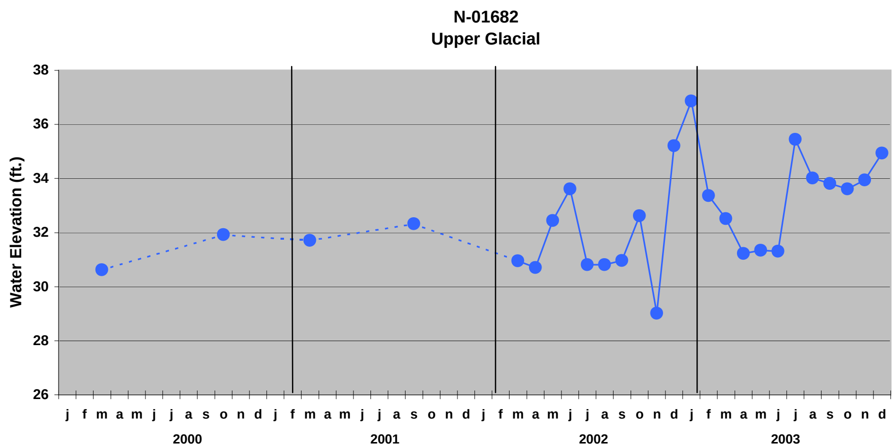


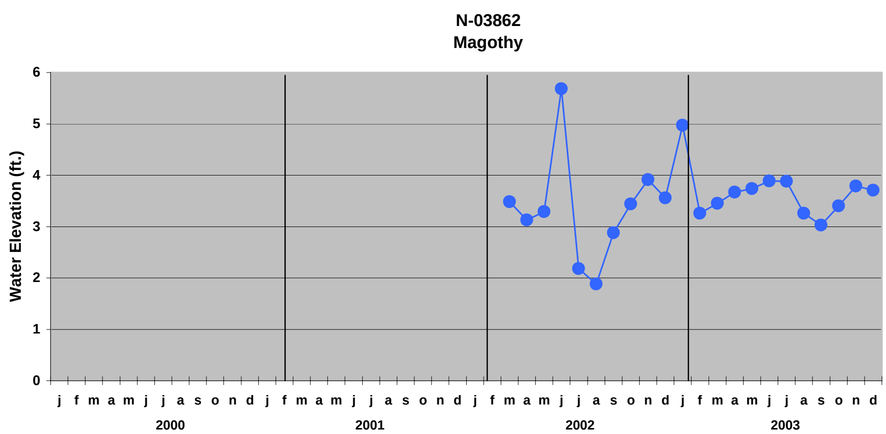
FIGURE 5-5

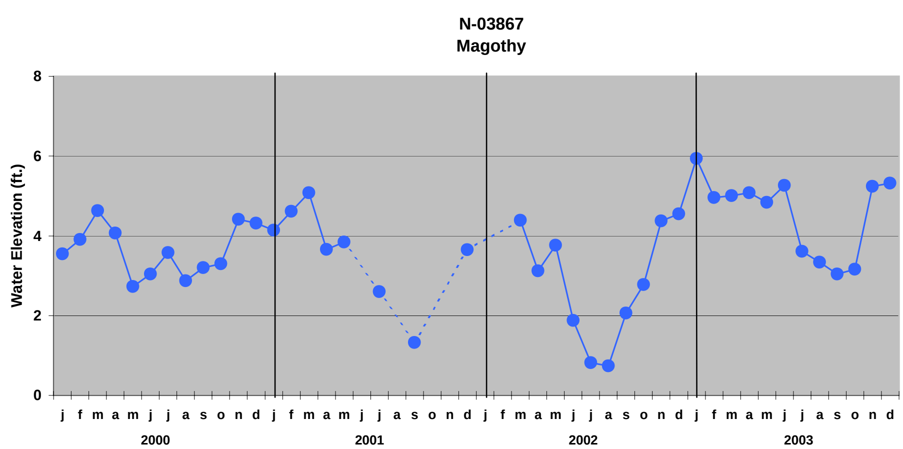
Southwest Nassau Monitoring Well Network

HYDROGRAPHS FOR SOUTHWEST NASSAU INDICATOR WELLS

(elevations in feet above mean sea level)







● Measured water elevation data point
- - - - Inferred elevation between data points

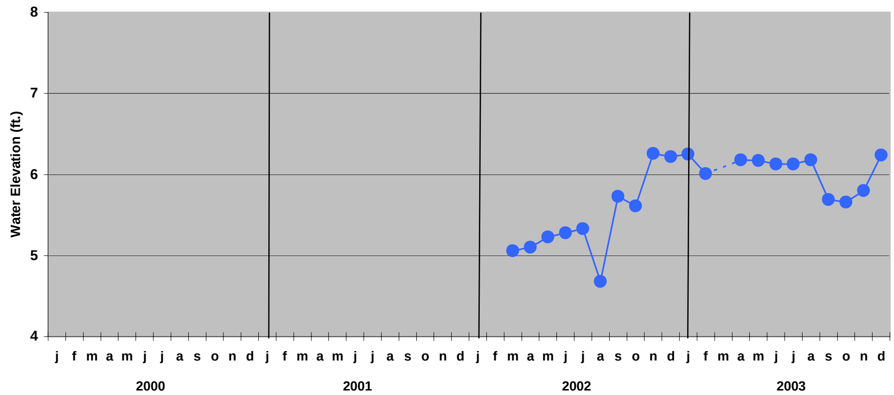
FIGURE 5-5

Southwest Nassau Monitoring Well Network

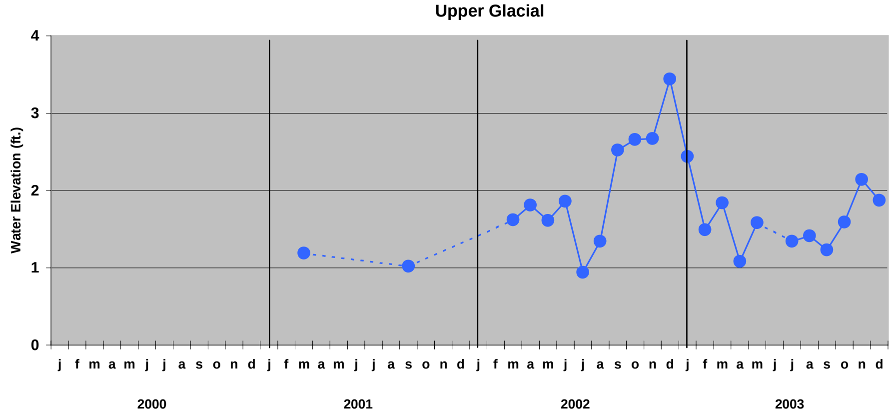
HYDROGRAPHS FOR SOUTHWEST NASSAU INDICATOR WELLS

(elevations in feet above mean sea level)

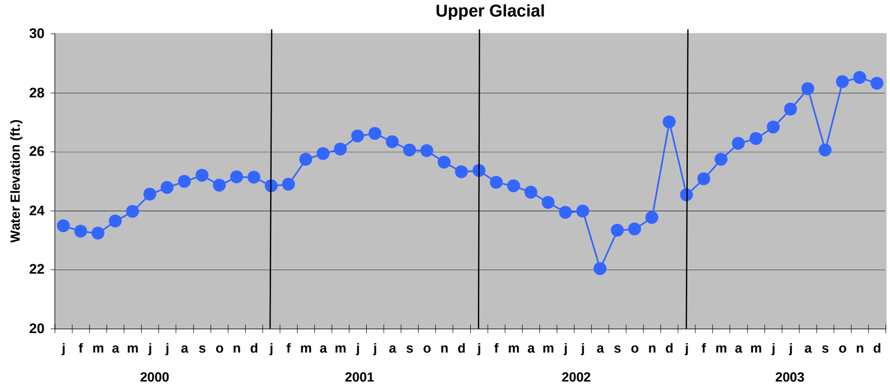
N-08636
Upper Glacial



N-09359
Upper Glacial



N-09979
Upper Glacial



● Measured water elevation data point
- - - - Inferred elevation between data points

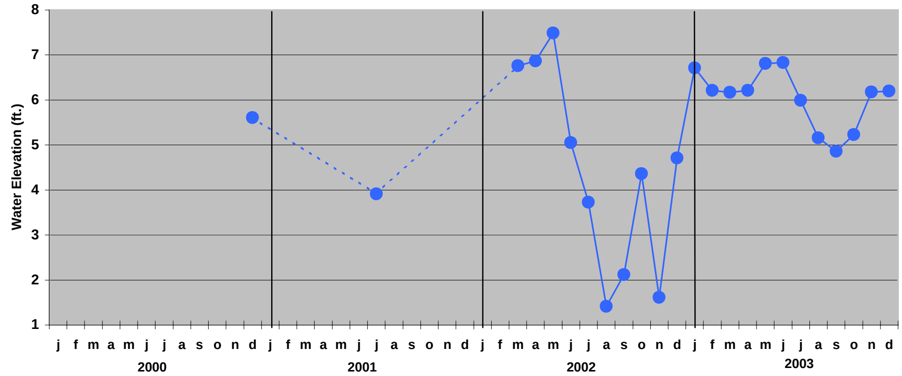
FIGURE 5-5

Southwest Nassau Monitoring Well Network

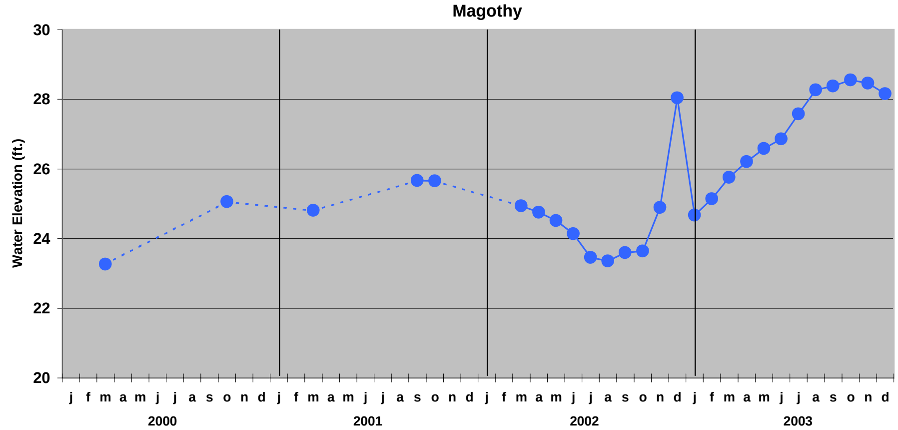
HYDROGRAPHS FOR SOUTHWEST NASSAU INDICATOR WELLS

(elevations in feet above mean sea level)

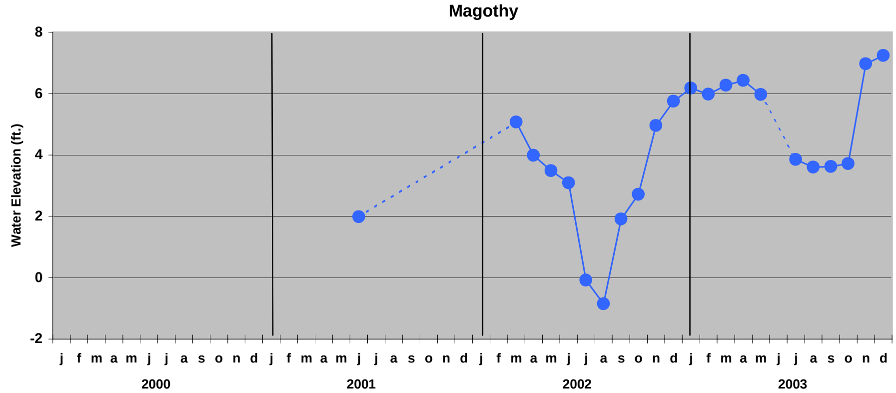
N-10620
Lloyd



N-10731
Magothy



N-10978
Magothy



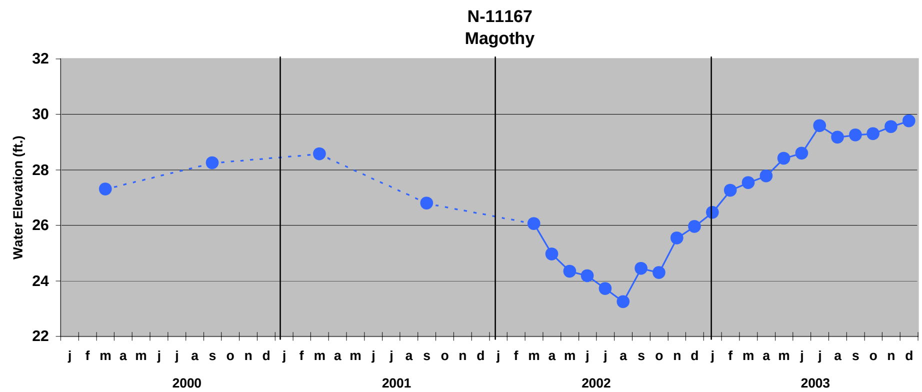
● Measured water elevation data point
- - - - Inferred elevation between data points

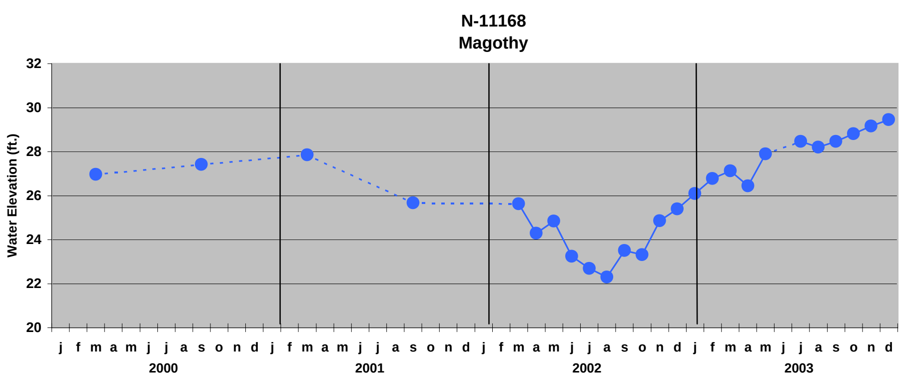
FIGURE 5-5

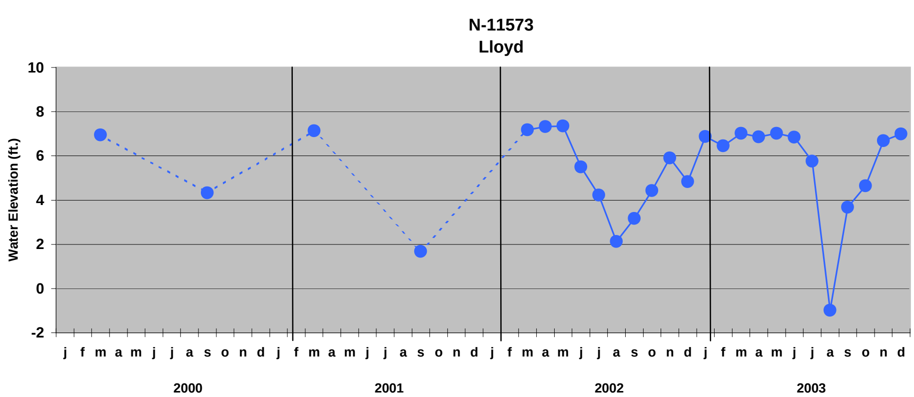
Southwest Nassau Monitoring Well Network

HYDROGRAPHS FOR SOUTHWEST NASSAU INDICATOR WELLS

(elevations in feet above mean sea level)







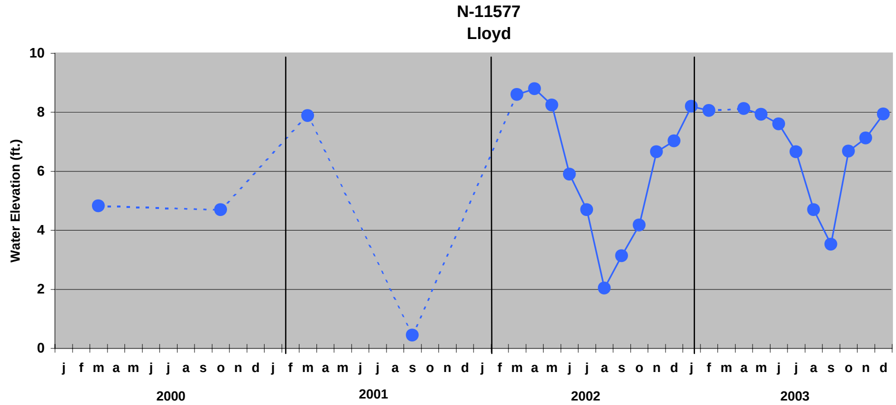
● Measured water elevation data point
- - - - Inferred elevation between data points

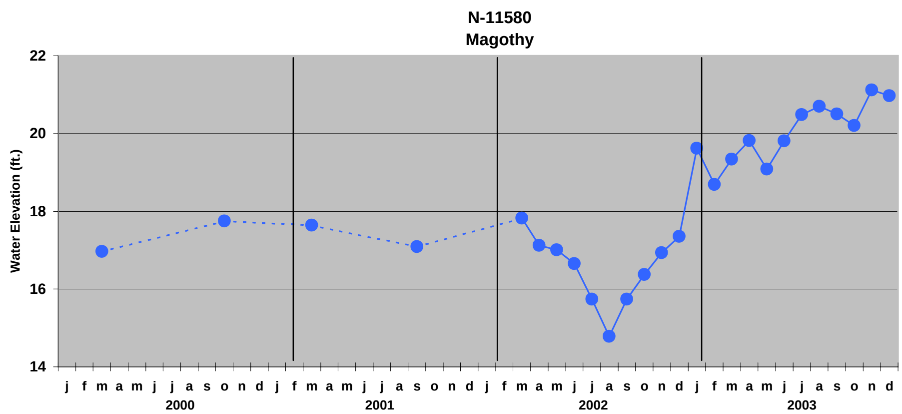
FIGURE 5-5

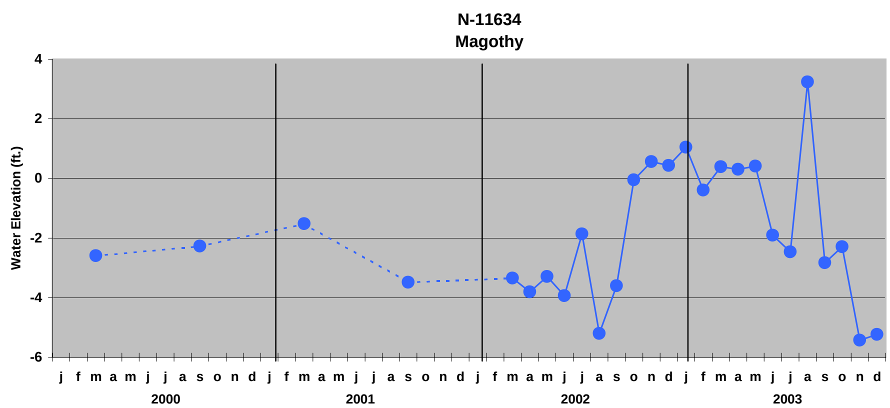
Southwest Nassau Monitoring Well Network

HYDROGRAPHS FOR SOUTHWEST NASSAU INDICATOR WELLS

(elevations in feet above mean sea level)







Measured water elevation data point

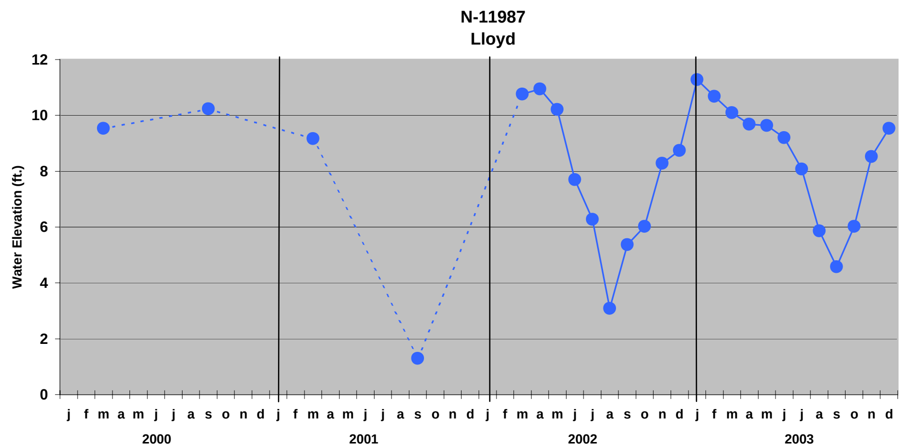
Inferred elevation between data points

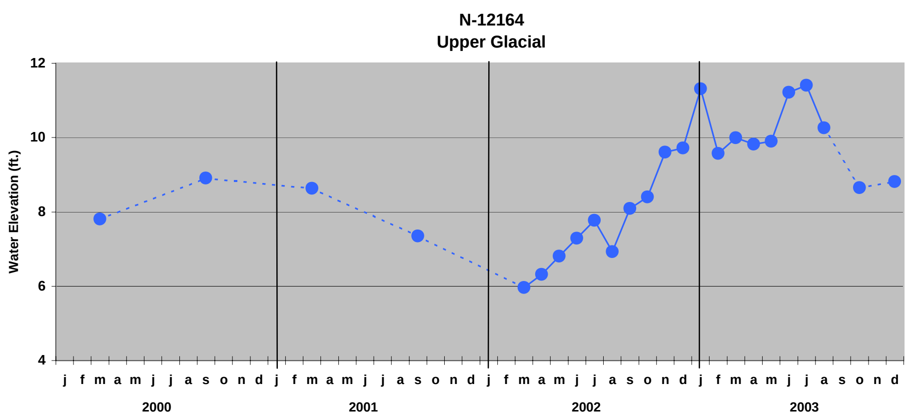
FIGURE 5-5

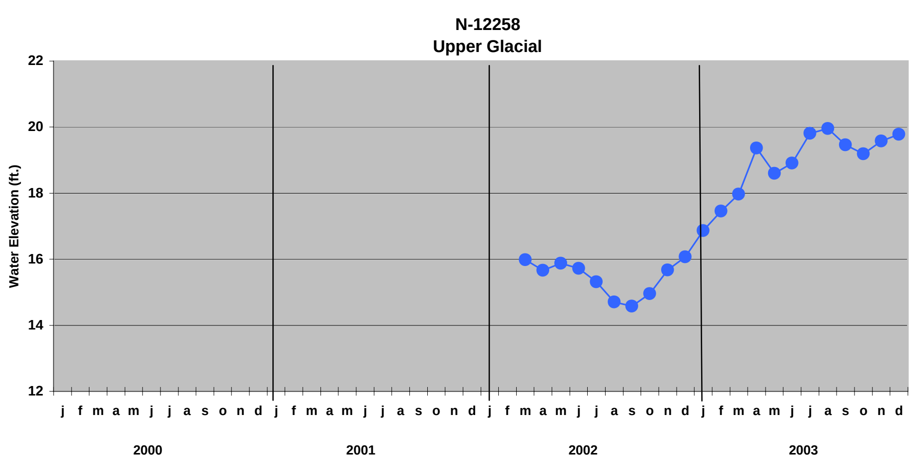
Southwest Nassau Monitoring Well Network

HYDROGRAPHS FOR SOUTHWEST NASSAU INDICATOR WELLS

(elevations in feet above mean sea level)







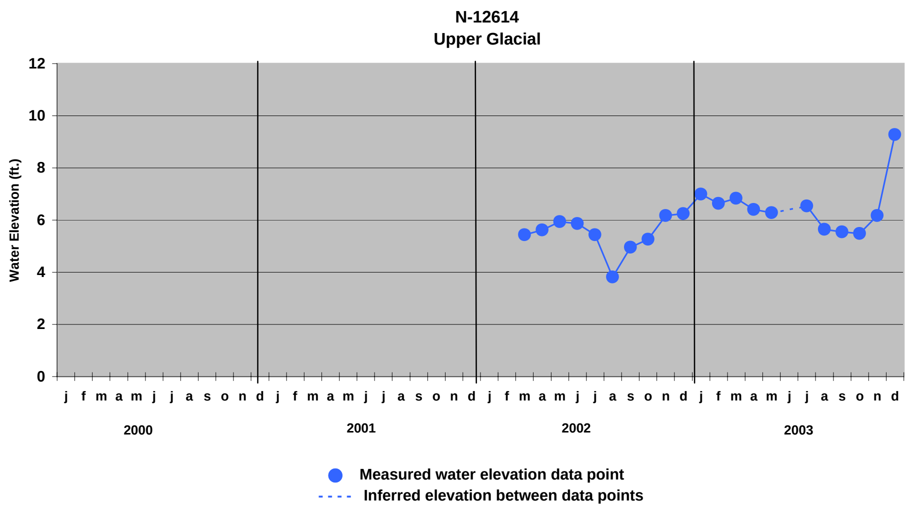
Measured water elevation data point

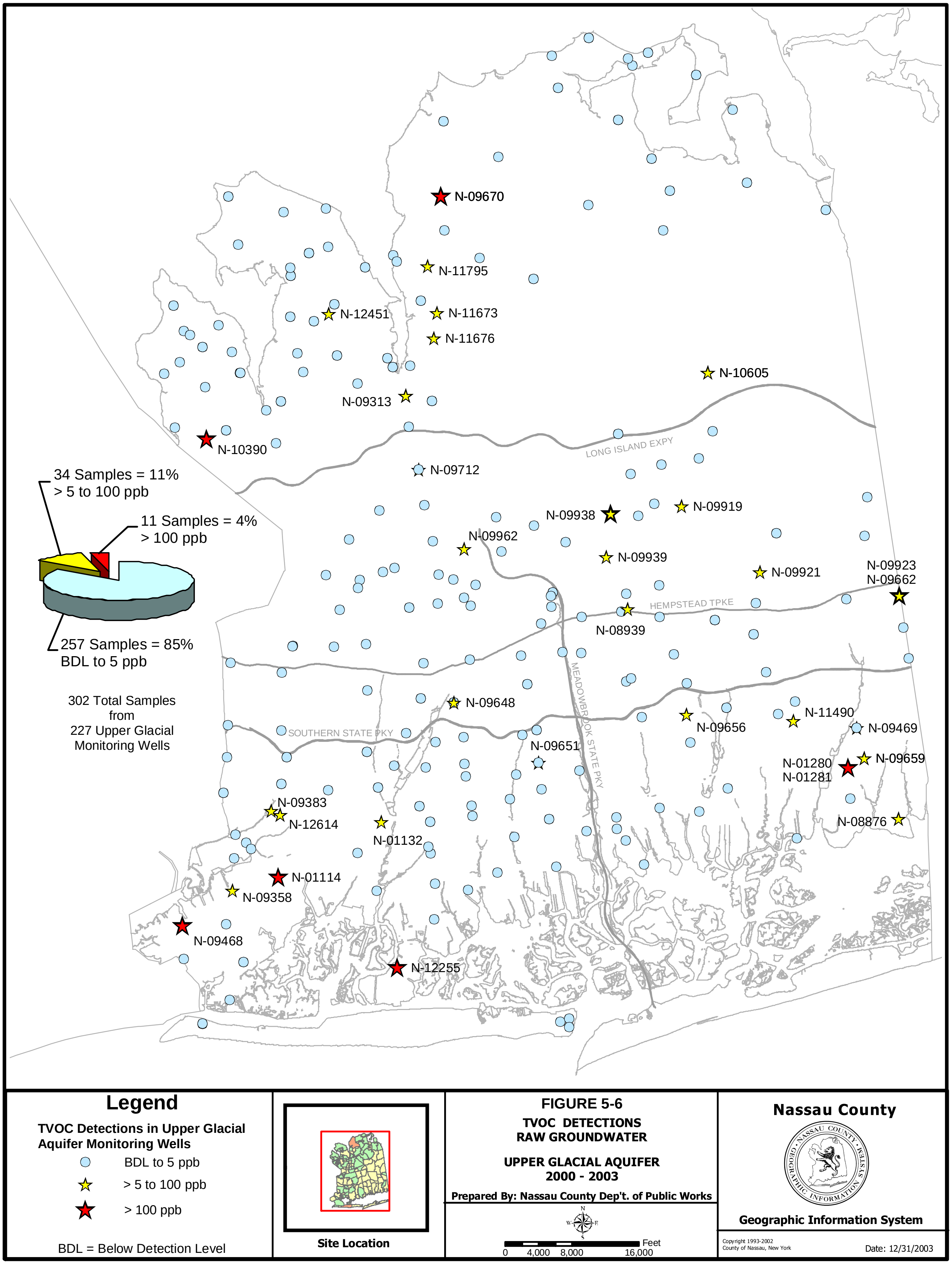
Inferred elevation between data points

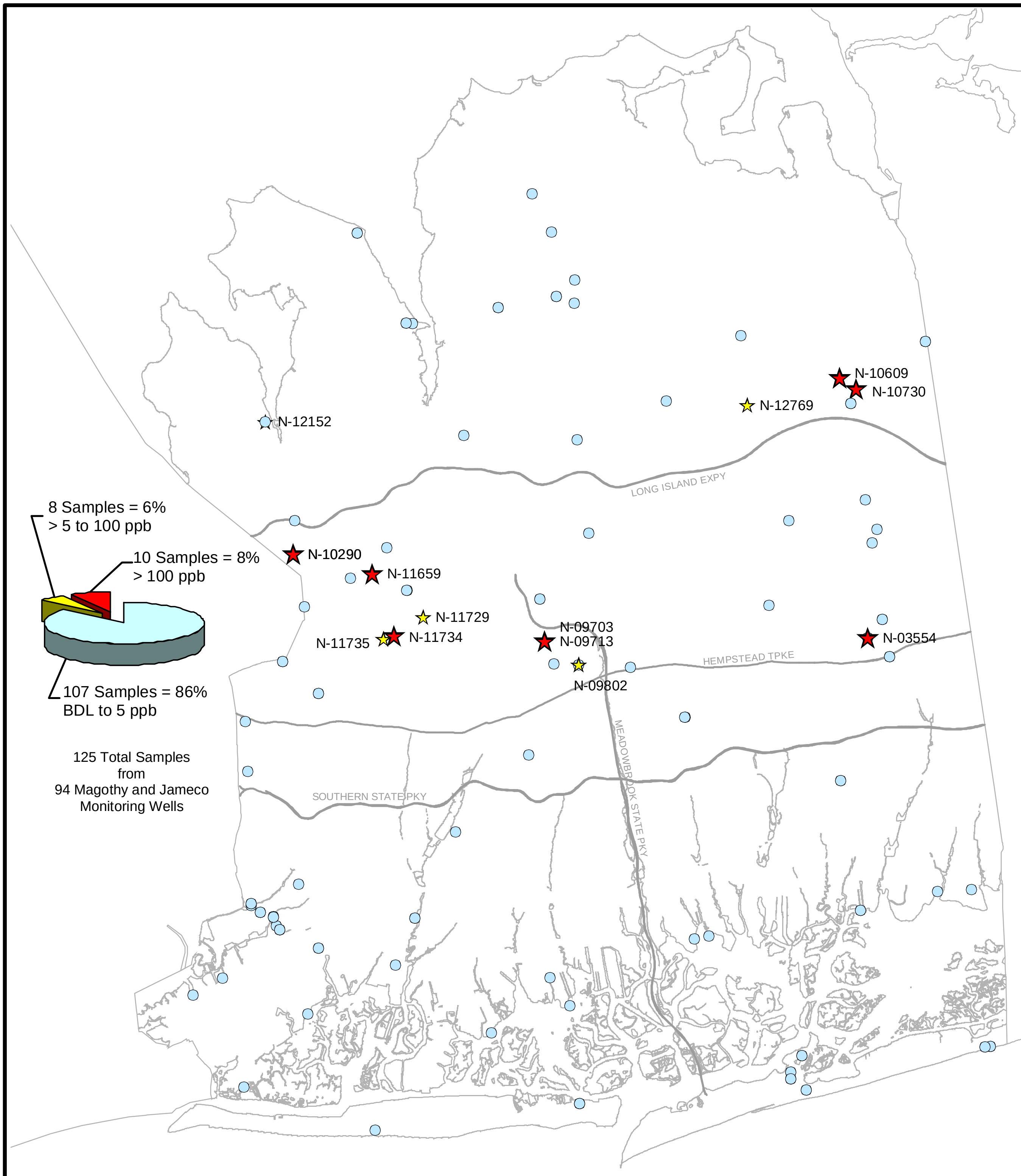
FIGURE 5-5

Southwest Nassau Monitoring Well Network

HYDROGRAPHS FOR SOUTHWEST NASSAU INDICATOR WELLS
(elevations in feet above mean sea level)




N-09670
N-11795
N-12451
N-11673
N-11676
N-10605
N-09313
N-10390
LONG ISLAND EXPY
N-09712
34 Samples = 11%
> 5 to 100 ppb
11 Samples = 4%
> 100 ppb
257 Samples = 85%
BDL to 5 ppb
302 Total Samples
from
227 Upper Glacial
Monitoring Wells
N-09938
N-09919
N-09962
N-09939
N-09921
N-09923
N-09662
HEMPSTEAD TPKE
N-08939
MEADOWBROOK STATE PKY
N-09648
SOUTHERN STATE PKY
N-09656
N-11490
N-09469
N-09651
N-01280
N-01281
N-09659
N-09383
N-12614
N-01132
N-08876
N-01114
N-09358
N-09468
N-12255
Legend
TVOC Detections in Upper Glacial
Aquifer Monitoring Wells
BDL to 5 ppb
> 5 to 100 ppb
> 100 ppb
BDL = Below Detection Level
Site Location
FIGURE 5-6
TVOC DETECTIONS
RAW GROUNDWATER
UPPER GLACIAL AQUIFER
2000 - 2003
Prepared By: Nassau County Dep't. of Public Works
Feet
0 4,000 8,000 16,000
Nassau County
Geographic Information System
Copyright 1993-2002
County of Nassau, New York
Date: 12/31/2003



Legend

TVOC Detections in Magothy and Jameco Aquifer Monitoring Wells

- BDL to 5 ppb
- > 5 to 100 ppb
- > 100 ppb

BDL = Below Detection Level

Site Location

FIGURE 5-7

TVOC DETECTIONS
RAW GROUNDWATER

MAGOTHY AND JAMECO AQUIFERS
2000 - 2003

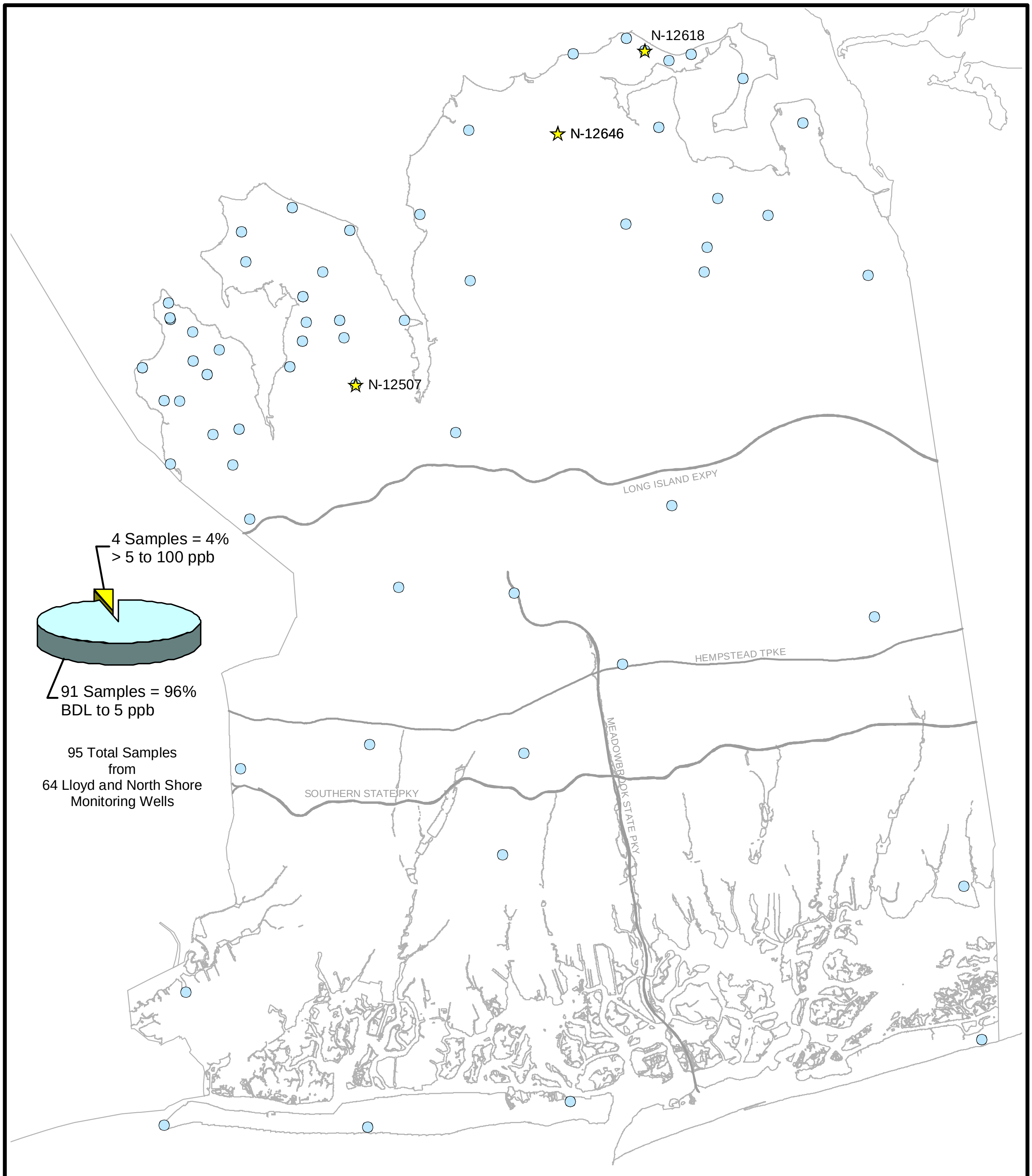
Prepared By: Nassau County Dept. of Public Works

Feet
0 4,000 8,000 16,000

Nassau County

Geographic Information System

Date: 12/31/2003

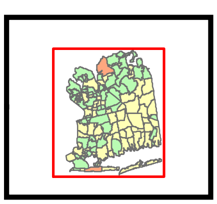


Legend

TVOC Detections in Lloyd and North Shore Aquifers

- ○ BDL to 5 ppb
- ☆ > 5 to 100 ppb

BDL = Below Detection Level



Site Location

FIGURE 5-8

TVOC DETECTIONS
RAW GROUNDWATER

LLOYD AND NORTH SHORE AQUIFERS
2000 - 2003

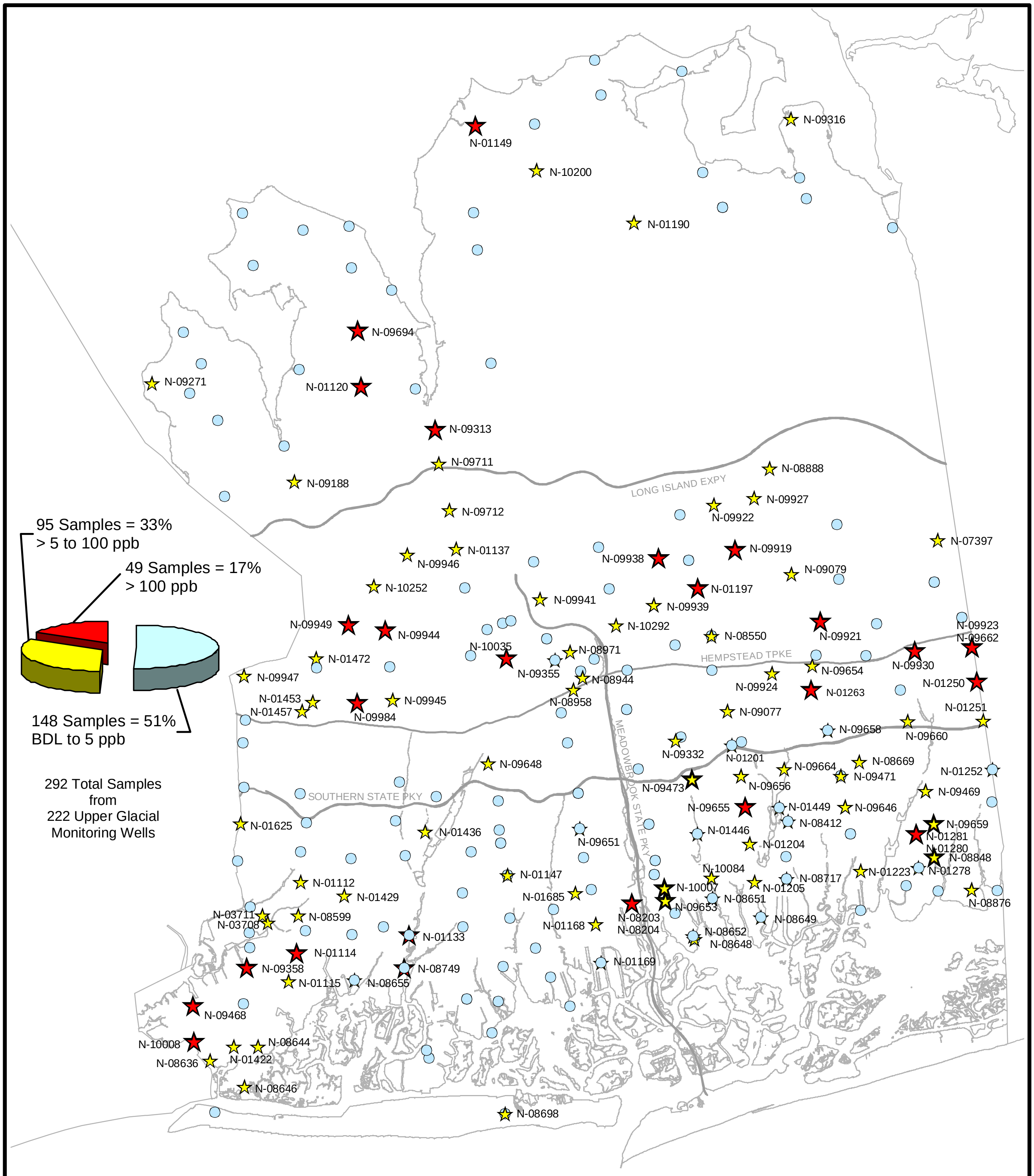
Prepared By: Nassau County Dep't. of Public Works

Feet
0 4,000 8,000 16,000

Nassau County

Geographic Information System

Date: 12/31/2003

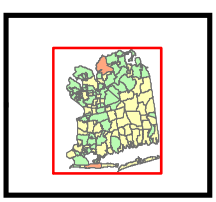


Legend

TVOC Detections in Upper Glacial Aquifer Monitoring Wells

- (circle) BDL to 5 ppb
- (yellow star) > 5 to 100 ppb
- (red star) > 100 ppb

BDL = Below Detection Level



Site Location

FIGURE 5-9

TVOC DETECTIONS RAW GROUNDWATER

UPPER GLACIAL AQUIFER 1985 - 1987

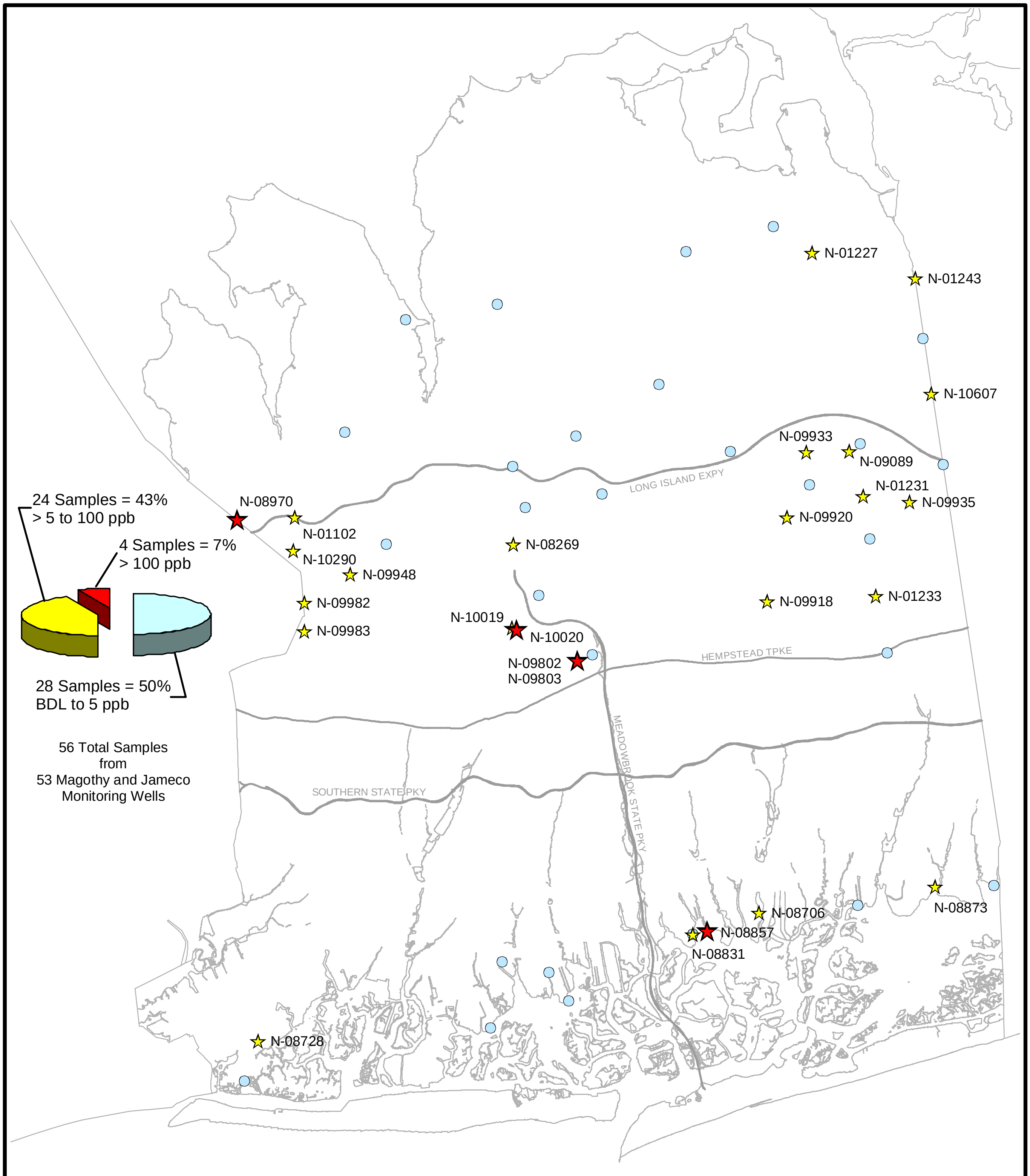
Prepared By: Nassau County Dep't. of Public Works

Feet 0 4,000 8,000 16,000

Nassau County

Geographic Information System

Date: 12/31/2003

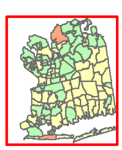


Legend

TVOC Detections in Magothy and Jameco Aquifer Monitoring Wells

- BDL to 5 ppb
- > 5 to 100 ppb
- > 100 ppb

BDL = Below Detection Level



Site Location

FIGURE 5-10

TVOC DETECTIONS RAW GROUNDWATER

MAGOTHY AND JAMECO AQUIFERS 1985-1987

Prepared By: Nassau County Dep't. of Public Works

N W E S

Feet
0 4,000 8,000 16,000

Nassau County

Geographic Information System

Date: 12/31/2003