Water Quality Framework:

Extracted From:

Martha’s Vineyard Coastal Pond Water Quality Survey-Summer 2004

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The term “eutrophication” carries a wide range of meaning. It is generally associated with an increase in productivity (the cycling of carbon into living matter) and high concentrations of nutrients (Wetzel, 1983). The term was devised to indicate the extreme end of a range of conditions in lakes from clear and unproductive to excessively productive on the eutrophic end. Eutrophication in marine waters is characterized by a number of conditions that are undesirable from the human use perspective. These include excess phytoplankton, sometimes abundant aquatic plants, low oxygen levels in the water sometimes to the point of causing a die off of animals, a reduction in the number of species living in the system with a shift from filter feeders (scallops and clams) to detritus feeders like snails and, under extreme conditions, burrowing worms. The eutrophic state can develop under natural conditions where nutrients released from the surrounding uplands enter the pond in quantities that are not flushed out quickly enough and stimulate excessive productivity. The process is hastened by man made nutrients that are released in concentrations far in excess of the natural processes. These nutrients are released from development in the watershed by runoff of stormwater, erosion of soil from farmland, disposal of sewage by septic systems or by treatment facilities and by fertilizers applied to farmland and landscaping. The nutrients are also added from outside the watershed by acid rain that is contaminated through the stack emissions of power plants, manufacturing processes and auto exhaust.

One nutrient that all of these activities release and which is required for plant growth is nitrogen. The other major nutrients required for growth of phytoplankton and algae include phosphorus, carbon, hydrogen and oxygen. Generally, the last three are sufficiently available in coastal waters so that they do not hinder growth of these aquatic plants. In phytoplankton, nitrogen and phosphorus are required in the approximate ratio of 16 to 1 (Redfield, 1963). While other less important nutrients may also affect growth rates, these two are of primary importance and, by their availability alone, usually determine the amount of growth of biomass in the system. In ocean waters, it is generally agreed that nitrogen is the deficient nutrient and phosphorus is usually present in sufficient quantities for growth of phytoplankton (Valiela, 1995). For this reason, marine waters are often described as being nitrogen limited. This means if nitrogen is added to the water, phytoplankton can reproduce to take advantage of the supply and the amount of organisms in the water column can increase until once again limited by availability of nitrogen or another necessary nutrient.

While some increase in the phytoplankton population is not necessarily a problem, with enough nutrients the population can explode. High populations of phytoplankton (often called an algae bloom) cloud the water reducing light transmission. In large numbers, overnight oxygen uptake by these living organisms or the die off and decay of phytoplankton can reduce oxygen levels to the point where other organisms are stressed or killed. This may have occurred in Edgartown Great Pond in 1993, when the oyster population died out following a late summer bloom.

Reduced light limits the vigor of eelgrass that requires sunlight, as does any green plant. Eelgrass is an important component of the ecosystem providing cover for bait fish, scallops, tautog, blue crabs and eels as well as food and a substrate for the growth of a myriad of aquatic plants and animals. It also acts as a sediment stabilizer through its dense root system.

While the available light level limits the potential success of eelgrass, both phytoplankton and large macro-algae (wrack algae) are typically limited by the availability of nutrients rather than light (Valiela, 1995). In more marine waters, common wrack algae include *Ulva*, *Enteromorpha* and *Cladophora*. The differing growth limitations set up a situation where, as nutrients are added to the system, phytoplankton and wrack algae increase, reduce the light penetrating to the bottom and cause a decline of eelgrass which may eventually be replaced entirely by macro-algae. The wrack algae however do not fill the role that eelgrass plays as a key component of the shallow, marine habitats. The macro-algae also tend to break loose late in the season or after a storm and gather into large mats which may smother desirable, filter feeding shellfish such as clams, scallops and oysters, encourage detritus (debris) feeders such as snails and, in severe cases, cause anoxia (lack of dissolved oxygen), aquatic animal die off and odors.

Nutrient stimulation of phytoplankton blooms also reduces available light to the eelgrass beds at the bottom particularly where the water depth is 2 or more meters. Nutrients also increase the growth of single cell and chain algae (e. g. diatoms) that grow on the surface of the eelgrass blades further blocking the sun light. Reduced light may stress the eelgrass making it more susceptible to wasting disease or may just reduce its vigor and lead to thinning of the eelgrass and eventual loss of entire beds over time.

Numerous studies of coastal ponds by researchers have concluded that nitrogen loading from shoreline development may have adverse impacts on these waters. Waquoit Bay, Cape Cod, has been thoroughly studied over 30 years (Valiela et al 1990). It is a coastal pond with a fixed inlet through a barrier beach. As residential land use increased in the recharge area, the pond has steadily lost formerly extensive eelgrass beds. The loss was attributed to nutrient loading from septic systems in the watershed (Kennish, 1996).

It seems clear that addition of nitrogen to our coastal ponds will lead to undesirable consequences if it exceeds a threshold known as the loading limit. Interim loading limits have been determined by the MV Commission but establishing final limits is the goal of the Massachusetts Estuaries Project. We should be very concerned at what the future nitrogen loading of the recharge area may do to our ponds. Once the recharge area is built out, it will take about 20 years for the system to reach equilibrium and for the full effect of the nitrogen loading to appear in the pond to which the recharge area contributes groundwater. If the "effect" on the pond is undesirable, changes made to reduce nitrogen loading further back in the recharge area will take another 20 years to reach the pond and reverse the negative impacts. For this reason we need to make every effort to anticipate possible impacts with a conservative limit on nitrogen loading within the recharge area.

Water Column Parameters:

There are key chemical and physical measures that are indicators of the condition of a water body under study. When collected over time, these measures can identify the trophic state of the system. The trophic state of a coastal pond is a descriptive term that indicates the amount of biomass production in the system. The most familiar trophic state is the eutrophic condition that indicates excessive biomass production.

The measures discussed here include **chlorophyll pigment(s)** that are an indicator of the microscopic algae population in the water column. The depth at which the Secchi disk can no longer be seen is the **extinction depth** and indicates the amount of light penetration through the water column. The amount of **dissolved oxygen** is a fundamental necessity for the animals living in a pond. It is affected by the algae population but also by the amount of organic matter that is decaying in the pond. The amount of **nitrogen** in the water column in all forms indicates whether a system is over- productive and if the nitrogen input from the watershed is excessive.

Although there are many other approaches to characterizing the condition of a pond including population studies of the benthic organisms, distribution and amount of aquatic plants and fish population, these parameters have not yet been evaluated. In examining the data presented for each pond, the rating system devised by the Buzzard's Bay Program (Costa et al, 1996) is helpful. The ratings are summarized in Table 1.

The lab analyses data is included in spreadsheet form in Appendix A.

Table 1: Buzzard's Bay Eutrophication Index (Costa et al 1996)

Parameter	Zero Score	Perfect Score
Oxygen Saturation (lowest 1/3 observed)	40% saturation or less	90% saturation or more
Transparency (Secchi disk)	0.6 meters or less	3 meters or more
Phytoplankton **pigments**	10 parts per billion or more	3 ppb or less
Dissolved inorganic nitrogen (DIN)	10 micromolar (0.14 ppm) or more	1 micromolar or less
Total organic nitrogen (TON)	0.6 ppm or more	0.28 ppm or less

In reviewing the charts, we suggest that you apply a *desirable* goal for these water bodies as follows:

- maintain ratings that are above 60% of the perfect score value for DO saturation and Secchi depth and
- less than 60% of the zero score value for pigments, DIN and TON for the growing season.

Average Buzzard's Bay eutrophication rating scores are reported for a subset of the stations in each pond. These scores are calculated from the average of the values for each parameter over the course of the sampling season.

The application of any rating system to such a diverse group of ponds is prone to misinterpretation. The caveat to the text that follows is that these ratings will change as the amount of specific information we have increases. The ratings may also change from year to year depending on weather, the temperature of the offshore water and other factors not known at this time. The rating system will be refined specifically for each pond during the Massachusetts Estuaries Project study of these systems.

Sengekontacket Pond Physical Character:

Sengekontacket Pond is a shallow, 700-acre coastal salt pond and is connected by a culvert to Trapp's Pond a 44-acre tidal water body. Sengekontacket is vigorously circulated by the tides that average 2 feet in range and produce a flushing rate of about 2.33 days for removal of 95% of the old pond water to the Sound.

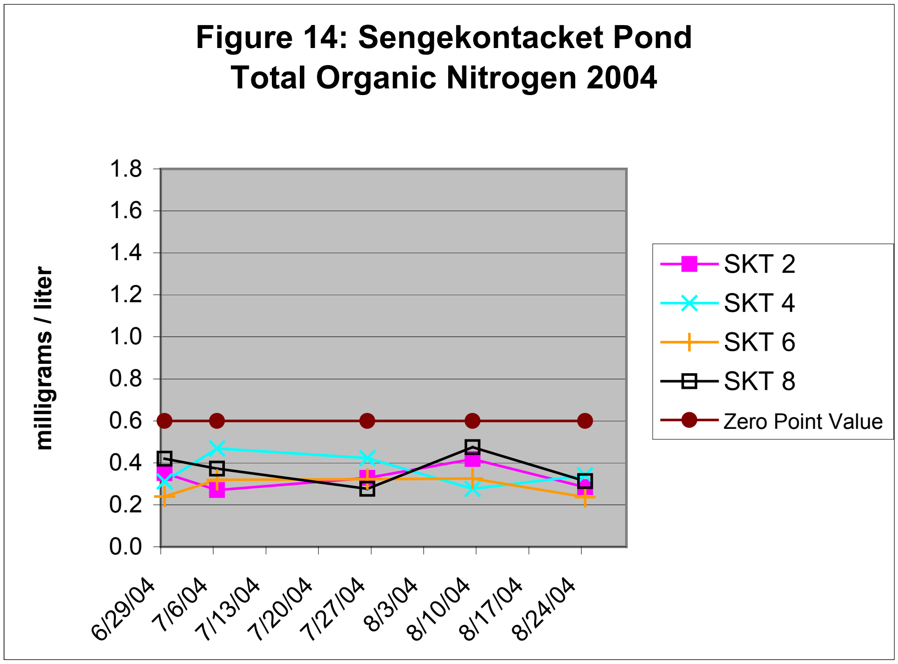
The Pond is marked by an extensive system of relict flood tidal deltas that form a large shoal area that runs from the southern inlet to the north past the mouth of Major's Cove causing the average depth of the Pond to be 0.9 meters or 3 feet (Gaines, 1995). While this area is an important source of soft-shelled clams and quahogs, it is also an obstruction to tidal flow with uncertain consequences. At the southern inlet, the flood tidal delta is bisected by the channel forming Sarson's Island to the north and a subsurface shoal area to the south that was largely dredged and used to nourish the beach in the 1990's. The west side of the Pond is marked by deeper water basins including Major's Cove and three more continuing to the south from there.

The Pond is flushed through two armored inlets. The southern inlet drains about 2/3 of the Pond, drawing water from the area to the south and north up to Major's Cove. The northern inlet is a smaller, armored inlet that is prone to sand deposition reducing the effective flow. Gaines (1995) identified possible "conveyor belt" type water transport into and out of Major's Cove. A shoal area near the mouth of the Cove was identified as a possible obstruction to exchange.

Trapp's Pond drains into the southern end of Sengekontacket by an undersized corrugated metal pipe. From tidal elevation data collected in 2001 (Wilcox, 2002) it is apparent that the culvert beneath Beach Road is inadequate to pass the tidal prism that is available at the Sengekontacket Pond gauge through to the Trapp's Pond side. On the Sengekontacket side, the tide range averages nearly 4 times that on the Trapp's Pond side. Increased tidal exchange should be available by increasing the size of the culvert to permit passage of a larger volume of water during the 6 to 7 hours of each tide. Greater flushing will remove nutrients entering Trapp's Pond more rapidly which should reduce the impacts associated with nutrient excess such as epiphytic slime growth on eelgrass and decline of eelgrass health. The eastern pond has a large watershed containing some significant wastewater flows that have been recently sewered (Dripps & Wilcox, 1999). The eelgrass in this shallow pond is very heavily coated with epiphytes but apparently survives because the water is shallow and the sunlight can penetrate to the eelgrass blades.

Nearly all eelgrass was lost from Sengekontacket Pond in the late 1980's from an unknown cause. Hempy and Wilcox (1998) speculated that the pattern of the remaining eelgrass, restricted to Trapp's Pond and parts of Major's Cove, implied that wasting disease may have been the cause. The Pond is important habitat for the bay scallop, quahog, soft-shell clam, blue claw crab and eel as well as a nursery for food chain fish important to the sport fishery.

As Sengekontacket is a vigorously circulated tidal Pond, salinity concentrations of about 30 parts per thousand are typically uniform through the system and are not plotted. Total organic nitrogen concentrations are plotted in Figure 14.



The concentrations found are all better than the threshold for the poor water quality rating. They cluster just below 0.4 ppm near the desirable target of less than 0.38 ppm. The lowest average values found are at stations SKT5, 6 and 7 that were clustered near the main inlet to the Pond or in the area where the circulation from that inlet is most vigorous. The highest values were found at SKT4 in Major's Cove and station SKT8 off the Boulevard mooring field where circulation is less vigorous. The ratings by the Buzzard's Bay Eutrophication Index system for the stations ranged from a low of 71.9 at station SKT8 to a high of 96.9 at station SKT6.

The sum of pigments found in the water indicates the amount of growth at the base of the food chain. The values measured in 2004 were very good. The Buzzard's Bay rating scores ranged from a low of 72.9 at SKT8, to 80 at SKT4 and a high score of 100 at SKT6. From observation of the system, it appears that much of the growth driven by the supply of nitrogen in Sengekontacket is focused on large drift algae that grow and accumulate at the bottom in the vicinity of stations SKT2, 3, 6, 7 and 8. This material can cause problems by drifting into eelgrass and smothering the plants and by removing oxygen from the water column overnight.

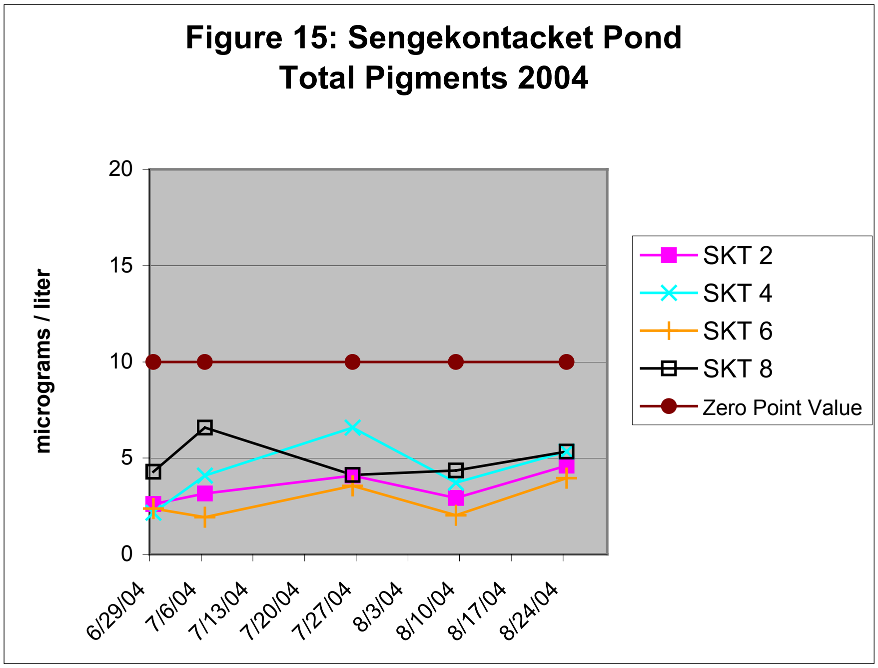


Figure 15: Sengekontacket Pond
Total Pigments 2004

Dissolved inorganic nitrogen is low throughout the Pond. Values are higher at SKT2 at the north end of the Pond and SKT8 off the Boulevard mooring field.

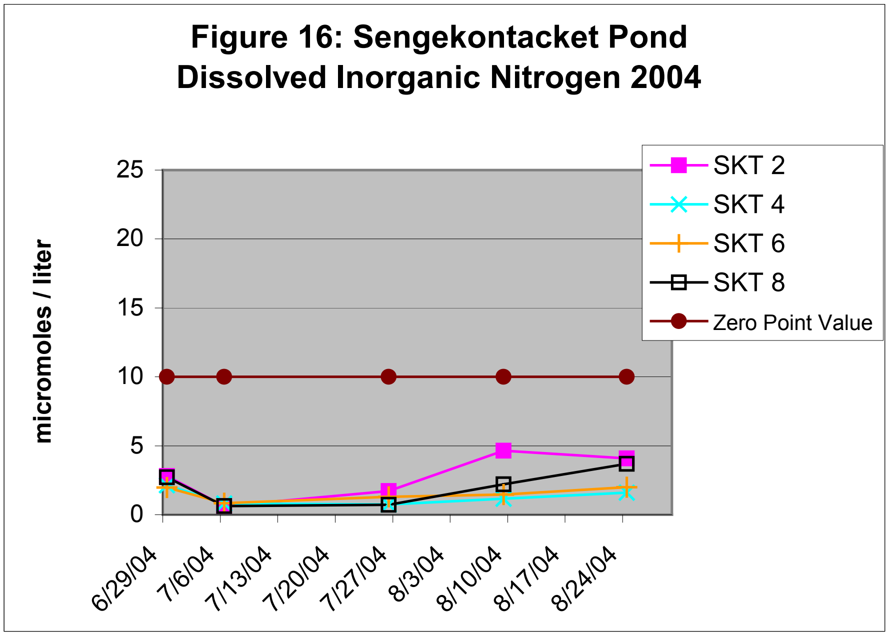
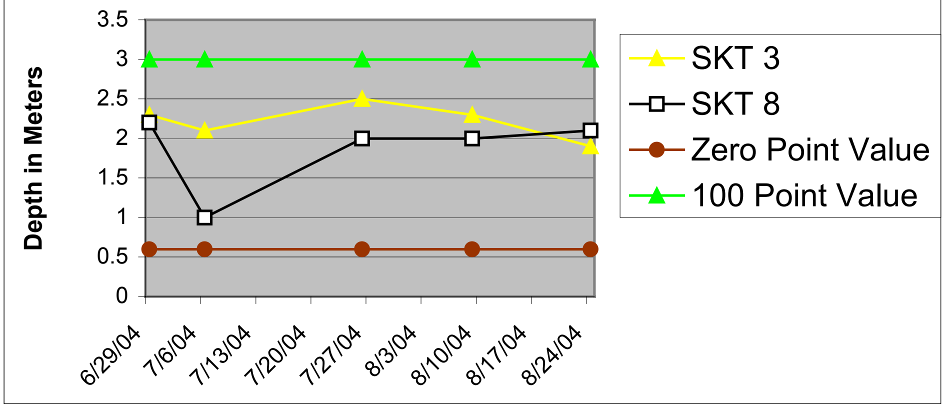


Figure 16: Sengekontacket Pond
Dissolved Inorganic Nitrogen 2004

Eutrophication scores ranged from 80 at SKT 2, to 94 at SKT 6 and 97 at SKT4.

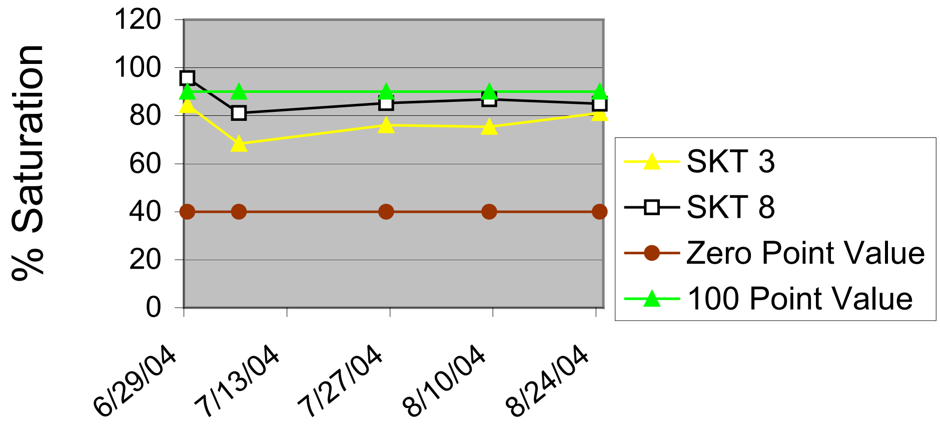
The Secchi depths plotted in Figure 17 are **minimum values** because the disk could be seen on the bottom throughout the sampling period. These are good values and correlate with the low levels of chlorophyll described in the previous discussion. At station SKT 4 an Eutrophication Index score of 66.7 could be calculated from 2 August measurements.

Figure 17: Sengekontacket Pond: Secchi Minimum Depth (visible on bottom)



Dissolved oxygen in the deeper water remained above the 60% saturation minimum acceptable value. Buzzard's Bay Eutrophication Index ratings varied from a low of 81.6 at SKT4 to a score of 100 at SKT6.

Figure 18: Sengekontacket Pond: Dissolved Oxygen Sarturation at 1.5 to 2 meters, 2004



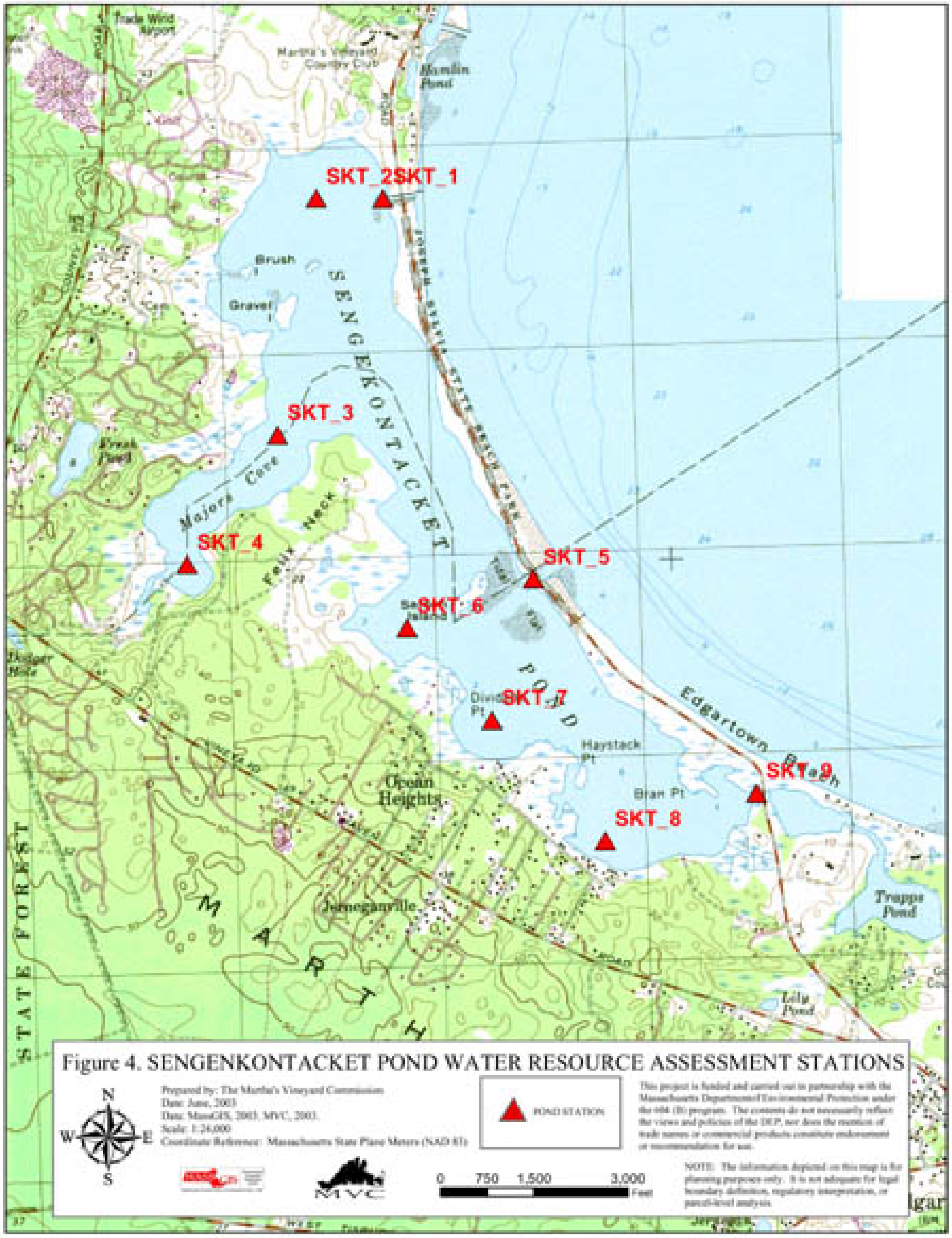


Figure 4. SENGENKONTACKET POND WATER RESOURCE ASSESSMENT STATIONS

Prepared by: The Martha's Vineyard Commission
Date: June, 2003
Data: MassGIS, 2003; MVC, 2003.
Scale: 1:24,000
Coordinate Reference: Massachusetts State Plane Meters (NAD 83)

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NOTE: The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analysis.