

3.0 Environmental Setting

This section describes the environmental setting in which the proposed action, the use of the aquatic herbicide Renovate®, is projected to occur. While this section presents the available data in as detailed an extent as is required, the information is fairly generic for the State of New York. Further site-specific information may be required for application in particular waterbodies, as well as for wetland areas, which are specifically permitted under Article 24.

3.1 General Descriptions of New York State Aquatic Ecosystems

The aquatic ecosystems of New York State generally fall into four basic categories. These include standing freshwater systems (lakes, ponds, and reservoirs), flowing freshwater systems (rivers and streams), brackish systems (tidal estuaries), and saline coastal systems. Since the use of Renovate® 3 is aimed principally at macrophyte control in freshwater lentic (standing) systems, the focus will be on this category of aquatic ecosystem, but given the potential for application to macrophytes in littoral or riparian zones, some information is also given regarding wetlands.

It is calculated that New York State has over 3.5 million acres covered by some type of surface water system (NYSDEC, 1967). That includes over 7,500 lakes (NYSDEC, 1987), of which over 1,500 are found in the Adirondack Mountains (NYSDEC, 1967). The Adirondack Mountains also contain over 16,700 miles of significant fishing streams. The state's largest lakes are Lake George, Chautauqua Lake, Oneida Lake, and the major Finger Lakes; Canandaigua, Keuka, Seneca, Cayuga, and Skaneateles (NYSDEC, 1967).

The specific characteristics of each aquatic system are partially determined by its physiographic setting within the state. Changes in the characteristics of each aquatic system will lead to changes in the endemic biota associated with that waterbody. Generally, waterbodies within New York State can be defined geographically by region and drainage basin location. Aquatic ecosystems in the eastern region, which includes the St. Lawrence/Lake Champlain/Black River basin, the Hudson-Mohawk basin, the Delaware basin, and Long Island are defined by either the Adirondack/Catskill mountain areas to the north or the New York Bight tidal estuarine area to the south. Aquatic ecosystems in the central region, which includes the Oswego-Ontario basin and the Susquehanna, are defined by areas of low relief with large areas of marshes to the north and broad, steeply sided valleys with limited natural storage capacity in the south. Aquatic ecosystems in the western region, which includes the Lake Ontario basin, the Erie-Niagara basin, the Genesee basin, and the Allegheny basin, are defined by the glaciated geology of that region (NYSDEC, 1967).

In addition to the watershed drainage basin, it is also possible to classify lakes and ponds according to their respective ecoregions. Ecoregions are geographical map units that depict areas which share common geology, morphology, soils, climate, and other characteristics (Omernick, 1987). Accordingly, due to these similarities in watershed characteristics, water chemistry within an ecoregion tends to be similar and often is distinctive from other ecoregions (unless impacted by human activities). For example, the USEPA has issued Ambient Water Quality Criteria Recommendations (or "reference conditions") for nutrients for lakes in the 14 national ecoregions. For New York, USEPA has established numeric nutrient criteria recommendations for lakes in the following Level III Non-Aggregate Nutrient Ecoregions:

- Ecoregion VII – Mostly Glaciated Dairy Region – this is the ecoregion for the majority of New York including western and central portions, as well as major river and lake plains;
- Ecoregion VIII – Nutrient Poor, Mostly Glaciated Upper Midwest and Northeast – found primary in the Adirondack and Catskill mountain regions;
- Ecoregion XI – Central and Eastern Forested Uplands – a small portion of the lower Hudson Valley is located in this ecoregion;

- Ecoregion XIV – Eastern Coastal Plain – metropolitan New York City region and Long Island are included.

USEPA has also issued waterbody-specific technical guidance, in the form of the Nutrient Criteria Technical Guidance Manual for Lakes and Reservoirs (USEPA, 2000.)

As noted above, water chemistry in each of these basins is influenced by the composition of the geological formations found within the region. For example, waters in the Adirondack Mountains and the Catskill Mountains can be influenced by geologic formations with little buffering capacity. In some lakes, this geological setting, coupled with anthropogenic inputs, has resulted in waters with pH values of less than 5 standard units (S.U.) (NYSDEC, 1981b). Surface water systems in the Erie-Niagara basin in western New York State are characterized by high levels of dissolved solids (140 to 240 ppm) and hard water (108 to 200 ppm, expressed as CaCO₃) (NYSDEC, 1968). Surface water in the Delaware River basin is characterized by low total dissolved solid levels (averaging 37 ppm) and an average hardness of approximately 37 ppm. The dominant ions are silica, calcium, bicarbonate and sulfate (Archer and Shaughnessy, 1963). The dissolved solid concentrations in surface waters in the Champlain-Upper Hudson basin rarely exceed 500 ppm (Giese and Hobba, 1970). In surface waters of the Western Oswego River basin, dissolved solid concentrations range from 50 to 300 ppm (Crain, 1975).

Wetlands, both freshwater and coastal, are transitional areas where land and water interact. The State of New York is highly variable in its environment relative to terrain, climate, and other environmental factors, and the state's wetlands are similarly varied. Wetlands in New York are highly diverse and range from Long Island tidal marshes dominated by cordgrasses, emergent and shrub marshes along the clay flats of the Finger Lakes region and the Hudson River valley floodplain, forested wetlands common to the Adirondacks, as well as fringe wetlands along lake shores and riparian wetlands along streams and rivers throughout the state.

The typical wetland environments where application of an aquatic herbicide may be considered vary widely. This variation includes the nature of soil saturation among habitat types such as seasonally flooded freshwater marshes, wetlands located above the mean tide line of estuarine marshes, and marsh and shrub wetlands that exhibit perennially saturated surface soils but may never receive full inundation. Some of these wetlands occur in isolated pockets, characteristic of the "perched" wetlands found upon clay plains, but more often they are found on the periphery of a larger wetland/waterbody complex. Many lakes and ponds, particularly those formed in the glacially-affected landscape of New York, often have shallow aquatic marshes at their boundary with adjacent uplands. Such ecosystems that form in perennial shallow standing water are particularly susceptible to colonization by riparian invasives such as purple loosestrife, which exerts a strong competitive advantage due to its ability to tolerate very wet but variable water levels. Purple loosestrife, which is a potential target species, is described further in Section 3.4.2.

3.1.1 Lake Basin Characteristics

The lakes in New York were created in two principal ways. Many lakes resulted from glacial activity approximately 12,000 years ago. Others were created by damming streams or by enhancing a small lake by damming its outflow. Most damming occurred during the early industrial age of the country when water power was a critical resource. Through natural processes, most lakes become shallower and more eutrophic (nutrient-rich) and eventually fill in with sediment until they become wet meadows. The aging process is not identical for all lakes, however, and not all start out in the same condition. Many lakes that were formed by the glaciers no longer exist while others have changed little in 12,000 years. Yet lake aging is reversible. The rate of aging is determined by many factors including the depth of the lake, the nutrient richness of the surrounding watershed, the size of the watershed relative to the size of the lake, erosion rates, and human induced inputs of nutrients and other contaminants.

Existing lakes can be subdivided into four categories. Nutrient-poor lakes are termed oligotrophic, nutrient-rich lakes are eutrophic, and those in between are mesotrophic. A fourth category includes lakes following a

different path; these typically result in peat bogs and are termed dystrophic lakes. They are often strongly tea colored. Lakes in one part of the New York State may share many characteristics (depth, hydrology, fertility of surrounding soils) that cause them to be generally more nutrient-rich while another region may generally have nutrient-poor lakes.

Lakes that are created by man-made impoundments and damming streams often follow a different course of aging than natural lakes. At first, they may be eutrophic as nutrients in the previous stream's floodplain are released to the water column. Over a period of decades, that source of productivity tends to decline until the impoundment takes on conditions governed more by the entire watershed, just as for natural lakes. Impoundments in New York are commonly shallower than natural lakes, have larger watersheds (relative to lake area), and the pre-existing nutrient-rich bottom sediments may provide nutrients for abundant aquatic plant growth early in the life of the lake. However, most impoundments in New York are smaller, shallower systems with high watershed to lake area ratios.

Human activity can accelerate the process of lake aging or, in the case of introduced species or substances, force an unnatural response. Examples of unnatural response include the elimination of most aquatic species as a result of acid deposition, noxious algal blooms resulting from excessive nutrient enrichment, or the development of a dense monoculture of a non-indigenous aquatic plant and elimination of native aquatic plants. However, it would be unrealistic to assume that managing cultural impacts on lakes can convert them all into oligotrophic basins of clear water and/or clean bottoms, and this would not be an appropriate goal for many lakes. Understanding the causes of individual lake characteristics (i.e., understanding the lake ecosystem) is a fundamental part of determining appropriate management strategies.

3.1.2 Hydraulic Residence

Hydraulic residence time is a function of the volume of water entering or leaving the lake relative to the volume of the lake (i.e., the water budget). The larger the lake volume is, and the smaller the inputs or outputs, the longer will be the residence time.

Lake residence time may vary from a few hours or days to many years. Lake Superior, for example, has a residence time of 184 years (Horne and Goldman, 1994). However, New York lakes typically have residence times of days to months. Very short residence times will mean that algae cannot grow fast enough to take advantage of nutrients before the algae and nutrients are washed out of the lake. Long residence times mean that algae can utilize the nutrients and that they will probably settle to the lake bottom rather than be washed out. Those nutrients may become available again to the rooted plants or may be moved by biotic and abiotic internal recycling mechanisms back into the water column for additional algal growth.

Water may flow into a lake directly as rainfall, from streams and from groundwater. Water may leave a lake as evaporation, via an outlet, or as groundwater. Lakes that have no inlets or outlets are called seepage lakes while lakes with outlets are called drainage lakes. Seepage lakes are basically a hole in the ground exposed to the groundwater. Precipitation and evaporation may also be influential in such lakes, and will increase the concentration of minerals to some degree. Few particulates will be brought into the lake or leave it. Drainage lakes, on the other hand, may receive significant quantities of particulates and dissolved material from inlet streams. Because lakes slow the flow of water, many particulates will be deposited on the lake bottom. Precipitation, evaporation, and groundwater flow may have some influence, but drainage lakes are normally dominated by storm water flows.

3.1.3 Mixing

The thermal structure of lakes also determines productivity and nutrient cycling (Wetzel, 2001; Kalff, 2002). For many shallow New York lakes, the mixed layer may extend to the lake bottom. Deeper lakes may form a three-layered structure that throughout the summer consists of an upper warm layer (the epilimnion), a middle

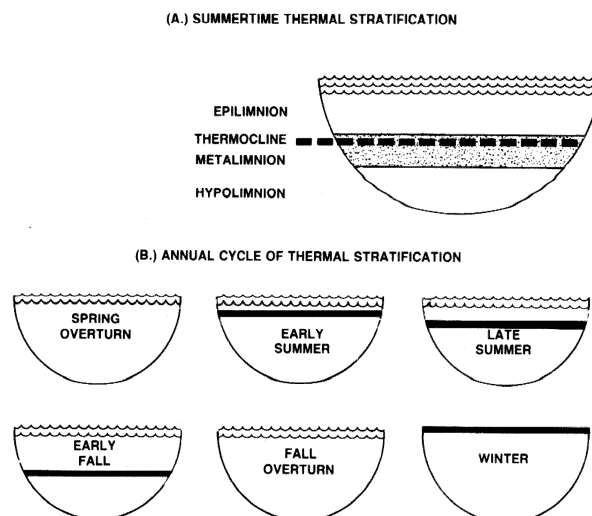
transition layer (the metalimnion, with the point of greatest thermal change called the thermocline), and a colder bottom layer (the hypolimnion).

A lake's thermal structure is not constant throughout the year (Figure 3-1). Beginning at ice out in early spring, all the lake's water, top to bottom, is close to the same temperature; the density difference is slight and water is easily mixed by spring winds. With warmer days, the difference between the surface and bottom waters increases until a layer (the metalimnion) is created where the incoming solar heat and wind-mixing effects are balanced. More heat and more wind moves the layer lower in the water column over the summer. Eventually, solar heating declines and the upper layer begins to cool. But the metalimnion does not retreat to the surface; it continues to move downward as wind mixes the remaining heat in the epilimnion ever deeper. Finally, in fall, the metalimnion arrives at the bottom and the lake is completely mixed again (turnover), but the upper layer is much cooler than during summer. In the early months of winter, the whole lake cools until it reaches 4°C. Further cooling which occurs only at the surface causes the surface water to be less dense. Ice forms at the surface and a new, inverse stratification (cold over cool water) is created and persists until spring.

This rather curious phenomenon affects many lake processes. During summer stratification, if incoming tributary water is relatively warm, it will float across the top of the cooler hypolimnion. Thus, during stratification, the effective residence time for incoming water and nutrients may be substantially less than when the lake is unstratified. If incoming water is especially cool, it may sink, often running along the thermocline as a sustained layer.

The cooler waters of the hypolimnion provide a refuge for so-called coldwater fish (e.g., salmonids) that are intolerant of warmer waters. The metalimnion provides a one-way barrier for many materials. Photosynthetic organisms may grow in the epilimnion, but when they die they will settle by gravity into the hypolimnion. As they settle, they carry nutrients with them to the bottom where they may be incorporated into the sediments or may be recycled by bacteria that will convert the nutrients into an inorganic form. Thermal characteristics of a lake and its tributaries are therefore important to lake ecology and management.

Figure 3-1 Seasonal Patterns in the Thermal Stratification of North Temperature Lakes (Olem and Flock, 1990)

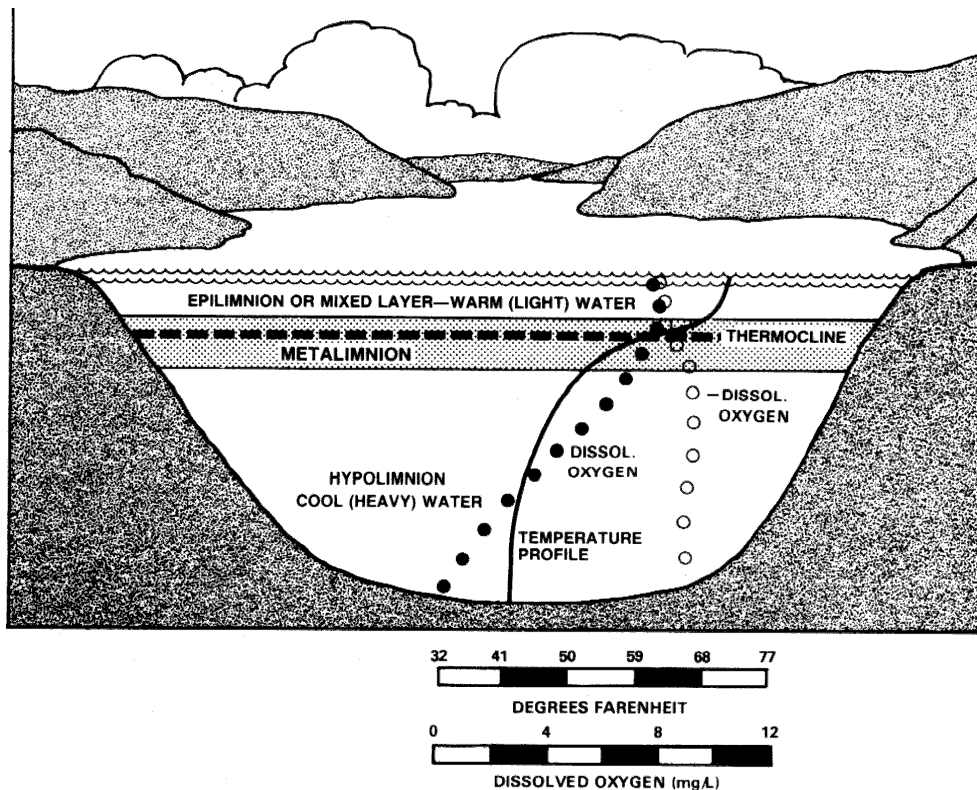


When the metalimnion is established, the hypolimnion no longer has a significant source of oxygen, either from exchange at the surface or as a result of photosynthesis. But animals and bacteria live in these lower waters and consume oxygen. If enough organic matter rains down to the hypolimnion, bacterial decay may consume all the oxygen and kill any fish and other aerobes which may require cooler waters (Figure 3-2).

Lakes can have oxygen problems for other reasons. During winter when the lake is ice-covered, there is little plant photosynthesis and reduced animal and bacterial respiration. When there is heavy snow on the ice cutting off most light, plant photosynthesis is especially low. If the lake has substantial organic material in the water column or surface sediments, bacterial decay can, by late winter, deplete the oxygen and kill oxygen-dependent organisms such as fish. Ice-out may reveal a fishkill.

Figure 3-2 A Cross-sectional View of a Thermally Stratified Lake in Mid-summer. (From Olem and Flock, 1990).

Solid circles represent the dissolved oxygen profile in eutrophic lakes; open circles represent oligotrophic lakes.



Similarly, low oxygen levels may occur in areas of dense vegetation within highly enriched lakes as plants respire during darkness, particularly if the days have been very cloudy and photosynthesis has been lower than normal. A fish kill may occur in early morning after a night of heavy respiratory oxygen consumption. These are somewhat rare conditions, but all stratified lakes and some unstratified lakes reveal their trophic state by the degree of loss of oxygen. The greater the amount of primary productivity in the epilimnion, than typically the greater the potential oxygen loss in the hypolimnion. If hypolimnetic oxygen progressively declines from year to year, these simple data provide an excellent record of increasing productivity. Conversely, increasing levels of dissolved hypolimnetic or winter oxygen under the ice is clear evidence of improvement.

3.2 General Characterization of Aquatic Plant Communities in New York Waterbodies

The characteristics of plant communities in aquatic settings are determined by the type of waterbody in which the community is located. Aquatic plants are often the dominant biotic factors in pond settings and are important ecological features of larger waterbodies such as lakes and reservoirs. New York State, with over 7,500 lakes, contains an extensive array of freshwater systems. This diversity is further increased by the inclusion of streams, rivers, and other bodies of flowing water. Waterbodies vary in terms of color, pH, temperature, silt loading, bottom substrate, depth, rate of flow if it is a moving body, and watershed area. Each of these characteristics will affect, to some extent, the type and distribution of the plant communities in that waterbody.

3.2.1 Types of Freshwater Ecosystems

Freshwater ecosystems include lentic ecosystems, represented by standing waterbodies such as lakes and ponds; lotic ecosystems, which are represented by running water habitats (rivers and streams); and wetland habitats where water is present at or near the surface and flow may range greatly over the seasons. These habitats are discussed briefly below.

3.2.1.1 Ponds and Lakes

Lentic systems (ponds and lakes) can be further subdivided in littoral, limnetic, profundal, and benthic zones. The littoral zone is that portion of the waterbody in which the sunlight reaches to the bottom. This area is occupied by vascular, rooted plant communities. Beyond the littoral zone is the open water area, or limnetic zone, which extends to the depth of light penetration or compensation depth. This is the depth where approximately 1% of the light incident on the water surface still remains. As a result of this decreased light, photosynthesis does not balance respiration in plants. Therefore, the light is not sufficient to support plant life. The water stratum below the compensation depth is called the profundal zone. The bottom of the waterbody, which is common to both the littoral zone and the profundal zone, is the benthic zone (Wetzel, 2001; Kalff, 2002).

Kishbaugh et al., (1990) notes that the bottom morphology (shape) of a lake is a key factor in determining the type and extent of plant communities that are present. The chemical quality of the water is another factor that influences the distribution of plant species. Soft water lakes (total alkalinity of up to 40 ppm and a pH of between 6.8 and 7.4) will often have sparse amounts of vegetation. Hard water lakes (total alkalinity from 40 ppm to 200 ppm and a pH between 8.0 and 8.8) will have dense growths of emergent species that can extend into deeper water (Fairbrothers and Moul, 1965). Sculthorpe (1967) noted that the distribution of species within a waterbody is determined by the bottom substrate, light intensity (function of depth and water clarity), and turbulence (currents or wave action). For additional information on lentic systems typical of New York lakes, see Diet For a Small Lake (Kishbaugh et al., 1990).

3.2.1.2 Lotic Systems

Lotic systems include rivers and streams. In lotic systems the distribution of plant communities is dictated by the velocity of the water flow and the nature of the bottom substrate. In fast moving waters, the system is usually divided into riffle and pool habitats. Riffles, which are areas of fast water, are centers of high biological productivity. However, the speed at which the water flows in these areas usually will not allow for rooted macrophytes to become established. Rooted vascular plants are more characteristic of pool habitats, which are interspersed with the riffle zones. In pool habitats, the softer bottom substrate and the slower current velocities allow for the establishment of rooted plants. This is also the case for slower moving streams and rivers. In larger rivers, as with lakes, ponds, and reservoirs, depth becomes a determining factor for the distribution of plant communities (Wetzel, 2001; Kalff, 2002).

3.2.1.3 Wetlands

Wetlands constitute a great range of habitat types which demonstrate different floristic, soil, and hydrologic characteristics, but most all share certain important characteristics. These include the ability to attenuate floodwaters, to cleanse surface water and recharge groundwater supplies, and to prevent soil erosion. Within wetlands ecosystems, sediment and associated pollutants from road runoff and other sources are deposited as water velocity slows and moves through the sinuous channels of natural swamps and marshes. Microbes intrinsic to wetland environments are capable of breaking down and using nutrients and contaminants that may otherwise be harmful to the environment. Similarly, chemical processes in saturated soils characteristic of most wetland types further preserve water quality through the uptake and immobilization of heavy metals, salts, and other contaminants.

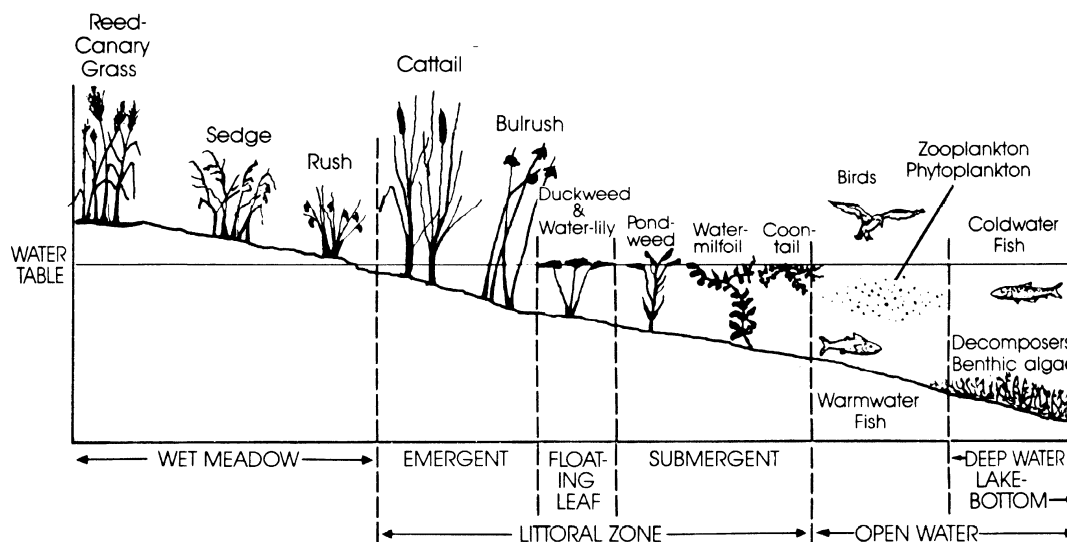
In addition to these important biogeochemical attributes, such natural systems are also valued for their recreational and aesthetic characteristics and for provision of valuable habitat for fish and wildlife, particularly those emergent wetland dominated by cattail, rushes or sedges. Large expanses of wetlands not only serve the purpose of protecting surface and ground water quality, but they are also often used for hiking and other outdoor recreational pursuits, waterfowl hunting, and fishing. Estuarine wetlands, and particularly tidal wetlands, are very important breeding and spawning grounds for a myriad of species of birds, fish, shellfish, and aquatic invertebrates. Not least importantly, wetlands are also valued and protected for their scenic beauty.

3.2.2 Growth Forms of Aquatic Macrophytes

One useful way of classifying aquatic macrophytes conceptually is based on their habitat and location relative to the waterbody surface. There are four growth forms of aquatic plants that are commonly recognized (Figure 3-3): floating unattached, floating attached, submersed and emergent (Riemer, 1984; Kishbaugh et al., 1990). Some plants consist of both submerged and floating leaves, and some have different growth forms under different abiotic conditions (submersed and emergent forms), so the groupings are not quite so distinct.

There are many taxonomic groups but the above categories are often the most useful for understanding the causes of a macrophyte problem and determining an appropriate management strategy. In fact, within each category, many species may look very similar as their growth habit responds to common lake conditions. Although many macrophyte species appear similar, their propensity to cause problems in lakes varies. Effective management of macrophytes usually requires species identification (e.g., Fassett, 1966; Crow and Hellquist, 2000). For example, a drawdown may reduce densities of *Cabomba caroliniana* but may increase densities of *Najas flexilis* based on their overwintering strategies (vegetative vs. seeds).

Figure 3-3 Typical Aquatic Plant Zones in Lakes and Ponds (from Kishbaugh et al., 1990)



Rooted aquatic plants typically grow from a root system embedded in the bottom sediment. Unlike algae, they derive most of their nutrients from the sediments just like terrestrial plants, but they may be able to absorb nutrients from the water column as well. Because they need light to grow, they cannot exist where the lake bottom is not exposed to sufficient light. The part of a lake where light reaches the bottom is called the photic zone. For many such plants, nutrients in the sediments may be in excess and growth is limited by light, particularly during early growth when the plant is small and close to the bottom. Emergent plants solve the light problem by growing out of the water, but that limits them to fairly shallow depths. Free-floating plants also are not limited by light except in cases of self-shading when growths are dense, but cannot use the sediments as a source of nutrients. Finally, floating-leaf plants have attempted to achieve the best of all worlds by having their roots in the sediment and leaves at the surface. Although less limited by water depth, they still have depth limits.

Submerged plants are generally relegated to the littoral zone and include such genera as *Potamogeton* and *Myriophyllum*. Many of these macrophytes are rooted plants which complete the majority of their life cycle below the water surface, with only the reproductive structures extending above the water surface. Exceptions to this include plants in the genera *Ceratophyllum* and *Utricularia*. These plants do not have true roots, but are considered to be submerged plants found in the littoral zone (Kishbaugh et al., 1990). *Lemna* and other free-floating species are generally found over the littoral zone and deeper water.

Aquatic plant communities are commonly arranged by species along depth contours. These communities are comprised of either heterogeneous mixtures of species, or as is sometimes the case, they are comprised of monotypic stands of a single opportunistic macrophyte. The species diversity or richness of a plant community depends on sediment type, disturbance, and vegetation management efforts. The characteristics of the communities will change with increasing depth as more shade tolerant species become dominant. Mosses, charophytes, several vascular species, and blue-green algae (cyanobacteria) are the common constituents of the near-profundal zone. Open architecture species such as members of the genera *Potamogeton* are found in shallower, better lighted zones. Emergent species will typically dominate the shallowest water, but are usually accompanied by other vascular species.

3.2.3 Functional Attributes of Macrophyte Communities

Functionally, aquatic plants play important roles in the aquatic ecosystem. Aquatic macrophytes provide food and shelter for both vertebrate and invertebrate organisms and as spawning habitat for fish ((Nichols, 1991; Keast, 1984; Gotceitas and Colgan, 1987; Schramm and Jirka, 1989; Hacker and Steneck, 1990; and Kershner and Lodge, 1990). The ability of the macrophyte community to fill these functions, its value per se, is often a function of the species, density, and distribution of the members of that plant community.

Aquatic vegetation performs four basic functions in waterbodies (Fairbrothers and Moul, 1965). These functions include:

- modification of the dissolved gas content of the surrounding water;
- provision of nutrient material suitable for food and the introduction of inorganic nutrients into the food cycle;
- modification of the physical environment; and
- the protection and provision of habitat for other organisms. In general, aquatic plants fulfill the preceding functions in the aquatic ecosystem.

However, the extent to which those functions are fulfilled will depend on the location of the plant community (i.e., emergent community versus a deepwater community).

Daubenmire (1968) notes that plants in the genera *Potamogeton* and *Scirpus* are a favored food source for North American waterfowl, whereas muskrats (*Ondatra zibethica*) favor plants in the genera *Carex*, *Sagittaria*, and *Typha*. Brown et al. (1988) reported that vertically heterogeneous stands of aquatic macrophytes tended to contain more invertebrates than a community dominated by a single taxon. Therefore, opportunistic, rapid-growing species such as Eurasian watermilfoil, purple loosestrife, phragmites, and cattails, which develop dense monotypic stands in mature communities, would not be expected to offer the quality or diversity of habitat in such circumstances as more diverse communities would.

Dionne and Folt (1991) note that high plant densities can interfere with the foraging ability and efficiency of piscivorous and insectivorous fish. Dense plant stands can directly or indirectly disrupt the utilization of macrophyte beds by fish and macroinvertebrates by affecting light penetration, temperature regimes, and water chemistry (Lillie and Budd, 1992).

In ponded waters, generally a greater variety of plant genera is available to fulfill the necessary functions provided by the plant communities (Daubenmire, 1968). This occurs because of the small size of the ponds, which results in a reduction in the influence of wave action. Plant communities in large lakes can be influenced by wind driven waves which will restrict the distribution of plants in exposed areas. The functions described by Daubenmire include habitat for fish and invertebrates, food for waterfowl, and nesting or hiding areas for fish and other vertebrates, such as amphibians. Plants in the genera *Ceratophyllum*, *Chara*, *Elodea*, *Najas*, and *Potamogeton* are the most common native species to fulfill these functions. These macrophyte species are generally the first macrophytes to advance over the bottom and will usually dominate the plant community which occupies that portion of the littoral zone at the pond margin to a depth of 7 meters.

Aquatic plants serve as food sources for a variety of organisms, including fish, waterfowl, turtles (snapping, *Chelydra serpentina* and painted, *Chrysemys picta*), and moose (*Alces alces*). Herbivores will consume fruits, tubers, leaves, winter buds and occasionally, the whole plant. Many species in the genera *Potamogeton* and *Najas* are considered to be valuable sources of food items. Plants in the genera *Myriophyllum*, *Nymphaea*, and *Ceratophyllum* are considered to be poor sources of food items (Fairbrothers and Moul, 1965). Nichols and Shaw (1986) note that Eurasian watermilfoil (*M. spicatum*) is a poor source of food for waterfowl.

Submerged plants play an important role in supporting fish populations (Kilgore et al., 1989; Smith et al., 1991). Submerged plants provide food and shelter for fish and their young. Submerged plants serve as the substrate for the invertebrates that support fish populations. Smith et al. (1991) stated that the production of forage fish and invertebrates generally increases in proportion to the submerged plant biomass. However, they conclude that populations of piscivorous fish tend to peak in water with intermediate levels of plant biomass. This is a function of the ability of the piscivorous fish, such as largemouth bass (*Micropterus salmoides*) to see their prey.

Submerged macrophyte stems and leaves may act as a substrate for a variety of microscopic organisms, called aufwuchs. Aufwuchs include bacteria, fungi, diatoms, protozoans, thread worms, rotifers and small invertebrates. The architecture of a particular plant species will also determine its suitability as a place for egg deposition for fish and amphibians. Additionally, the young of many fish species and some tadpoles will seek shelter in plant structures to evade predators.

Pullman (1992) notes that the architectural attributes of a particular plant species are a critical feature in the ability of that plant to function in support of fish populations. Those vertical plants with open architecture (some *Potamogetons*, *Elodea*, *Cabomba*, and a native species of *Myriophyllum*) provide more suitable habitat for fish than those plant species that form dense vertical mats or mats at the surface such as are formed by (*M. spicatum*), and some *Potamogeton* species (including *Potamogeton crispus*). Matted Eurasian watermilfoil plants have few leaves along their stems. The leaves are shaded and replaced by a dense leaf cover at the water's surface. The collection of vertical stems has limited habitat value. Madsen et al. (1991a) supports this by noting that most native species are recumbent or have short stems and do not approach the water surface and therefore tend to support greater fish populations than mat forming macrophyte species. Variable height and leaf architecture will yield more diverse habitats.

3.3 Description of Nuisance and Aquatic Invasive Species

Nuisance species is a generic term given to organisms (both fauna and flora) that are generally known to interfere with human activities including agriculture, aquaculture, or recreation. Nuisance aquatic plant species can be aesthetically unpleasing, may interfere with effective and proper harvest of fishery resources, may interfere with other recreational activities such as swimming or boating, or cause impairment to other designated water uses. Some species may act as nuisance species in some environmental settings but not in others, influenced by, among other factors, their proximity to human activities.

Invasive species are species that display a marked ability, upon being introduced into a new environment, to colonize or exploit that particular environment at the expense of the existing ecological community, resulting in their quantitative or biomass predominance in the resulting community structure. Their replacement of the existing community members is considered to be fundamentally detrimental to the colonized ecosystem in terms of reducing biodiversity, or in more specific ways, such as loss of habitat structure or reduced wildlife function. By virtue of their dominance of the colonized community, an invasive species can become a nuisance species in that they interfere with or are detrimental to human activities.

The ability of an aquatic plant to behave invasively, i.e., spread rapidly and grow to potentially nuisance biomass levels, is dependent on the interactions of many factors, among them reproductive and dispersal mechanisms, growth rate, competitive abilities for light and nutrients, presence of natural biological controls, resistance to and presence of pathogens and favorable abiotic conditions. Favorable abiotic conditions for a particular plant can include nutrient abundance, preferred water depth and sediment type, hardness of water and pH. Occasionally a cycle of expansion and decline is observed in aquatic plants, attributable to the presence of pathogens (Shearer, 1994), the presence of herbivorous insects (Sheldon, 1994), competition between plant species (Titus, 1994, Madsen et al., 1991), or a change in abiotic conditions (Barko et al., 1994; Shearer, 1994).

One of the most striking characteristics of nuisance species is that a large number of them are not native to the geographic area in which they are problematic, i.e., they are invasive. In some cases these invasive, non-indigenous species have expanded their historic range through natural means, but in the large majority of such cases, it is through human activities, either intended or inadvertent (e.g., aquarium and horticulture trades). Once established in a lake, waterfowl and boats may facilitate their spread to other locations due to the invasive species' growth strategy that emphasizes efficient dispersal of propagules, rapid spread and growth rate, and sometimes high rates of biomass production emphasized by high productivity and rapid growth. In many situations where a non-indigenous invasive species has been introduced, a near monoculture of that species develops, reducing recreational utility and habitat value. These plants are able to occupy a wide diversity of habitats (Wetzel, 2001; Kalff, 2002).

The native plant communities in the ecosystem have evolved under long-term conditions and relationships including inter-specific and intra-specific competition for nutrients, space and sunlight; presence of natural enemies like insects, waterfowl and fish; and a range of environmental conditions such as temperature, pH and mineral content. These relationships tend to keep any one native species from dominating and encourage a diverse plant community. Introduced species are often able to out-compete native vegetation because of the absence of natural enemies and competitive pressures. Suter (1993) maintains that many of the severe anthropogenic effects brought upon natural biotic systems are caused by the introduction of non-indigenous species. Accordingly, there is a great need for control of rooted exotic or non-indigenous plants.

Non-indigenous species, unlike the native biota, may experience few or no predators, parasites or pathogens when introduced into a new habitat. Invasive, non-indigenous species can therefore potentially totally dominate and eliminate native populations. Nichols and Shaw (1986) and Wade (1990) note that an invasive aquatic macrophyte has the potential to infest a waterbody, and then spread to the maximum extent of the available habitat. Following the initial invasion period, the production of the invasive species can attain a degree of stability and habitat equilibrium. Subsequently, the population of the invasive will fluctuate in response to the temporal and spatial dynamics of the aquatic environment (Nichols and Shaw, 1986; Wade, 1990). Usually, the equilibrium condition for the production of invasive species such as Eurasian watermilfoil (*Myriophyllum spicatum*) and curlyleaf pondweed (*Potamogeton crispus*) is considered to be deleterious for most recreational and utilitarian uses as well as a disruptive influence on native plants and animals.

There are many examples of non-indigenous invasive species which have successfully colonized aquatic ecosystems in New York and Northeastern North America. Introductions of Eurasian milfoil (*M. spicatum*) in Lake Champlain (Vermont/New York), Lake George (New York), Okanagan Lake (British Columbia) and many other lakes in New York and Massachusetts and other states threaten otherwise healthy lakes (Mattson et al. 2004). Within just a few years, a small patch of this species can grow to fill the lake, top to bottom, within the photic zone. Another nuisance species, fanwort (*Cabomba caroliniana*), is a popular aquarium plant. Many believe it was introduced from freshwater aquariums (Les, 2002). Purple loosestrife, a non-indigenous wetland plant, completely crowds out native species and creates stands so dense that wildlife habitat is degraded. It was introduced by horticulturists and gardeners desiring the beauty of the plant for their area (Les, 2002). There are many other non-indigenous aquatic species of concern, but not all are as successful as these examples.

It is important to distinguish between nuisance conditions caused by non-indigenous (i.e., non-native) invasive species and those caused by locally dense populations of indigenous plants. In the case of the former, any infestation of non-indigenous invasive species should be considered a *de facto* biological impairment and a threat to the natural aquatic ecosystem which should be dealt with quickly and completely. In the case of the latter, a much greater burden of proof would be required to show a causative impairment due to simple overabundance.

Invasive species are also a concern for wetland habitats. The introduction and spread of non-indigenous invasive plant species represents a potentially significant threat to the structure, function, and associated habitat values provided by New York's freshwater and tidal wetlands. Such species most commonly observed

in non-submergent freshwater and coastal wetlands include purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*), though others such as the woody species buckthorn (*Rhamnus* spp.) and multiflora rose (*Rosa multiflora*) may be locally problematic.

3.4 Distribution and Ecology of Primary Aquatic Macrophyte Target Species

Several non-indigenous species are potential target species of Renovate® 3 (see Table 2-1). Eurasian watermilfoil is the primary target species and is discussed in most detail for this SEIS. However, other non-indigenous species which have substantial populations in New York State (e.g., purple loosestrife, waterchestnut (*Trapa natans*), fanwort (*Cabomba carolinia*)) may be additional target species. The following describes the general distribution and ecology of the primary target macrophytes for Renovate® 3 with particular focus on Eurasian watermilfoil (Section 3.4.1) and purple loosestrife (Section 3.4.2).

3.4.1 Eurasian Watermilfoil

The genus *Myriophyllum*, water-milfoil, is almost cosmopolitan in nature. Approximately 60 species occur world-wide from three main geographic centers. According to Orchard (1981), the three geographic centers are Australia, North America, and India/Indo-China. To date, species in the genus *Myriophyllum* are found on every continent, except Antarctica. For nearly all introduced species, introductions are the result of the aquaria and aquatic gardening industries. Marketing of *Myriophyllum* species is wide-spread in these markets due to their feather-like appearance and hearty nature.

Eurasian watermilfoil, *M. spicatum*, is a submersed perennial herb that attaches to the substrate with fibrous roots. The stems of Eurasian watermilfoil are slender, reddish-brown, and can reach 6 meters in length, typically branching near the surface of the water. The leaves are green, less than 5 centimeters in length, and contain at least 12 segments. When removed from the water, the leaves of Eurasian watermilfoil tend to collapse around the stem. Mature leaves are typically arranged in whorls of 4 around the stem, ranging from 3 to 6 on rare occasions. Flowers of Eurasian watermilfoil are located on a spike protruding from the water. Flowers are reddish to pink in color, each containing four petals, and are most often observed in August and September. The fruit of Eurasian watermilfoil is four-lobed and splits into four separate one-seeded nutlets. Pigment or DNA analysis is sometimes needed for species identification as a consequence of morphological variability and possible hybridization. Other milfoils share some of these characteristics. Reproductive parts are the most definitive character. In the absence of flowers and/or seeds, the most distinctive characteristics are the normally reddish stem tips, the 12 or more filaments on each side of the central axis of each leaf, and the truncated leaf tips. This latter feature gives leaf ends the appearance of having been trimmed with scissors. Eurasian watermilfoil is sometimes confused with other species of milfoils, most notably the native northern watermilfoil (*M. sibiricum*).

3.4.1.1 Geographic Range and History of Invasion

Eurasian watermilfoil is native to Europe, Asia and northern Africa. First believed to have been introduced to the Chesapeake Bay area in the 1880's (Aiken et al., 1979), the first known sample of Eurasian watermilfoil was collected in a Washington, DC, waterbody in 1942 (Couch and Nelson, 1985). Eurasian watermilfoil has great potential for expansion due to an adaptive life history strategy, rapid vegetative growth, and carbohydrate storage in the root crowns, allowing for overwintering in cold climates (Giesy and Tessier, 1979; Adams and Prentki, 1982; Madsen, 1994, 1998; Madsen and Welling, 2002). Plant fragments are easily transported to new waterbodies by boats, trailers, fishing gear, wind, animals and currents (Aiken et al., 1979). In one study, Minnesota authorities found aquatic plants on 23% of all boats inspected (Bratager et al., 1996). Plant fragments transported to new waterbodies can become rooted and form new shoots.

As of 1992, COLAM (1992) reported that Eurasian watermilfoil had been identified in lakes in 35 of New York State's 62 counties. In its 1993 Annual Report on the Aquatic Plant Identification Program, the Rensselaer Fresh Water Institute noted that 38 counties had documented populations of Eurasian watermilfoil in 1993

(Eichler and Bombard, 1994). By 2006, Eurasian watermilfoil had expanded its geographical extent further, with verified populations in 50 counties and reports of occurrence in 3 of the remaining 12 counties (Eichler, 2006).

By 2002, Eurasian watermilfoil had been reported in 45 of the 50 U.S. States and in the southern portions of Canada from Quebec to British Columbia (Madsen and Welling, 2002). Currently, *M. spicatum* is listed as regulated, prohibited, invasive or noxious in at least 15 different states. In addition, Eurasian watermilfoil is on lists of government agencies or pest plant councils in at least 21 different states.

3.4.1.2 Ecology of Eurasian Watermilfoil

Eurasian watermilfoil is a tolerant species that has been shown to grow well in a variety of aquatic habitats. Couch and Nelson (1985) note that the plant will thrive in all types of nutrient conditions (oligotrophic to eutrophic), both hard and soft water and under both brackish and freshwater conditions. The plant appears to grow best in fine, nutrient-rich sediments that do not contain more than 20% organic matter and requires a minimum light intensity of 1% to 2% of the available light (Smith and Barko, 1990). Kimbel (1982) reports that the colonization success of Eurasian watermilfoil is best in late summer months; particularly within shallow water and on rich organic sediments. Eurasian watermilfoil's maximum growth rate occurs at temperatures ranging from 30 to 35°C (Smith and Barko, 1990). The plant utilizes both sediments and the surrounding surface water as sources of nitrogen and phosphorus (Smith and Barko, 1990). Barko and Smart (1980; 1981) indicate that uptake by the roots is the primary means of obtaining phosphorus.

Eurasian watermilfoil grows in waters at depths of 0 to 10 meters (typically between 1 to 5 meters in depth). Eurasian watermilfoil will commonly grow as an emergent in circumstances where the water level of the lake slowly recedes (Aiken et al., 1979). Smith and Barko (1990) suggest that light intensity determines much of the distribution and morphology of Eurasian watermilfoil. While it grows in waterbodies with wide ranges in water clarity, in turbid waters growth is generally concentrated in the shallow areas (Titus and Adams, 1979). In relatively clear waters, Eurasian watermilfoil grows at much deeper depths and may not reach the water surface.

Pearsall (1920) considers Eurasian watermilfoil to be a deep water plant species, which he defines as a plant growing at a depth where light intensity is less than 15% of full sunlight. The common growth pattern for Eurasian watermilfoil is for the plant to initially colonize deeper waters, where it will generate a large quantity of biomass which extends to the surface (Coffey and McNabb, 1974). As the Eurasian watermilfoil reaches toward the surface, the lower leaves of the plant will be shaded out and will slough off. This creates a dense organic bed beneath dense beds of Eurasian watermilfoil and is part of the process that recycles nutrients back into the water column. The leaves and stems of Eurasian watermilfoil will concentrate at the surface of the waterbody, forming a thick canopy or mat which extends into shallower waters when the plant reaches sufficient densities.

Madsen et al. (1991a), in work done in Lake George, New York, noted that growth characteristics are facilitated by a high photosynthetic rate and a high light compensation point. Because of its high photosynthetic rate and correspondingly increased metabolic activity and productivity, the plant is able to grow at a significantly higher rate than that exhibited by native species such as *Potamogeton* spp. and *Elodea canadensis*. Additionally, with its high light tolerance, Eurasian watermilfoil will tend to grow closer to the water surface than the native species that occur in low to medium light intensity regions of the littoral zone. This pattern allows for successful replacement or disruption of native vegetative communities. Madsen et al. (1991b) reported that dense growth of Eurasian watermilfoil in a bay in Lake George had significantly reduced the number of native species present.

Eurasian watermilfoil will overwinter with much of its green biomass intact. Because of its adaptation to grow at lower temperatures than many native aquatic species, Eurasian watermilfoil is capable of tremendous growth at the very beginning of the growing season. The early timing of growth, in conjunction with its great ability to

produce large quantities of biomass, further gives Eurasian watermilfoil a competitive advantage over most native aquatic macrophytes (Pullman, 1992). Smith and Barko (1990) report that the characteristic annual pattern of growth is for the spring shoots to begin growing rapidly as soon as the water temperature approaches 15°C. Pullman (1993) notes that this growth generally occurs before most native aquatic macrophytes become active. However, Boylen and Sheldon (1976) state that some native aquatic macrophytes, including *Potamogeton robbinsii* and *P. amplifolius*, will remain metabolically active at temperatures as low as 2°C.

As the shoots grow, the lower leaves slough off as a result of shading. As the shoots approach the surface, they branch extensively and form the characteristic canopy (mat). Biomass peaks at flowering in early July, and then declines. If the population flowers early, a second biomass peak and subsequent flowering may be attained. It is common for Eurasian watermilfoil to adopt a stoloniferous habit in the autumn, growing prostrate over the surface of the lake sediment. This may also assist Eurasian watermilfoil in the displacement of competing native species through the acquisition of space when most native species are dormant. Variations in this growth pattern can occur as a result of differences in climate, water clarity and rooting depth.

Dispersal of Eurasian watermilfoil is primarily through the spread of vegetative fragments. Seed production has been reported, but is considered a minor contributor to the plant spread (Hartleb et al., 1993). Pullman (1993) notes that there is much circumstantial evidence indicating that Eurasian watermilfoil does not form a viable seed bank in infested lakes. Eurasian watermilfoil has a tremendous capacity for the formation of vegetative fragments. A viable plant can regenerate from a single node carried on a fragment released in the water. Fragmentation can occur from boating or skiing impacts, as well as from mechanical harvesting operations. Additionally, Madsen et al. (1988a) and Madsen and Smith (1997) reports that autofragmentation (self-fragmentation) is common after peak seasonal biomass is attained. Often fragments released through autofragmentation bear adventitious roots. Madsen et al. (1988a) also noted that fragments are very durable, and resistant to extensive environmental stress.

3.4.1.3 Ecological Impacts of Eurasian Watermilfoil

Eurasian watermilfoil is an opportunistic species, which is commonly found growing in areas that are not highly disturbed (Pullman, 1992). However, Pullman goes on to report that Eurasian watermilfoil appears to significantly increase in numbers and in biomass in areas of disturbance. This is reflective of the high productivity rate of the species and its resulting ability to outgrow native plant species.

Lillie and Budd (1992) provide a definitive evaluation of the quality of habitat offered by Eurasian watermilfoil. In their study, conducted on a lake in Wisconsin, Lillie and Budd utilized an index of plant habitat quality and quantity to describe the following:

- horizontal visibility within macrophyte beds;
- the amount of shading afforded by the surface canopy;
- the amount of available habitat for macroinvertebrate attachment;
- the relative amount of protection afforded fish by the plants; and
- the degree of crowding or compaction among plants.

The results of their study indicated that the edges of Eurasian watermilfoil beds potentially provide more available habitat for macroinvertebrates and fish than interior portions. This conclusion was based on their observation that habitat space was more optimal at the edges, than in the center of the beds where stem crowding and self-defoliation resulted in a lack of vertical architecture due to the formation of surface mats. They noted that as Eurasian watermilfoil densities increase from sparse to dense, habitat value for prey species increased. However, as the vegetative density increased in Eurasian watermilfoil stands, a reduction in habitat for macroinvertebrates reduced the habitat quality for small fish. Habitat value for predator fish

species initially increased as Eurasian milfoil first colonized areas, but, then decreased as plant crowding impacted the ability of the predators to access their prey.

Pullman (1993) concluded that Eurasian watermilfoil is supportive of fish populations during its initial expansion stages in a waterbody. However, he goes on to note that once Eurasian watermilfoil begins to dominate the plant community and form its characteristic dense mats, the lack of plant species diversity and associated water quality impacts will reduce the quality of the habitat for fish. Nichols and Shaw (1986) and Engel (1995) reported that Eurasian watermilfoil provides beneficial cover for fish, unless the cover is so dense that stunting of fish growth from overcrowding results.

Eurasian watermilfoil significantly modified the habitat available to fish and macroinvertebrates (Keast, 1984; Pardue and Webb, 1985). In work conducted in a lake in Ontario, Canada, Keast (1984) noted that since the advent of Eurasian watermilfoil in his study area, significantly fewer bluegill (*Lepomis macrochirus*) were observed, but greater numbers of black crappie (*Pomoxis nigromaculatus*) and golden shiner (*Notemigonus crysoleucus*) were seen. He reported 3 to 4 times as many fish feeding in native plant beds as in the Eurasian watermilfoil beds.

The most critical impact Keast (1984) noted was to prey organisms. Keast reported that significantly fewer macroinvertebrates were seen in the watermilfoil beds than in a native plant community composed of *Potamogeton* and *Vallisneria*. He found 3 to 7 times greater abundance of 5 invertebrate taxa in the native plant communities and noted that foliage of the native plants supported twice as many invertebrates per square meter. Keast observed twice as many insect emergences in the native plant community as in the Eurasian watermilfoil beds.

Other studies have documented the impacts to the aquatic environment by the invasion of Eurasian watermilfoil. Madsen et al. (1991a) noted a sharp decline in the number of native macrophyte species per square meter in a bay in Lake George, New York. The decline was due to the suppression of native macrophyte species by Eurasian watermilfoil. The decline was from 5.5 species per square meter to 2.2 species per square meter over a 2-year period.

Honnell et al. (1992) noted that in ponds containing Eurasian watermilfoil, dissolved oxygen levels were significantly lower than dissolved oxygen levels in ponds dominated by native plants. Additionally, they note that pH levels were higher in Eurasian watermilfoil than in native plant dominated ponds. Nichols and Shaw (1986) noted that Eurasian watermilfoil is poor food for muskrats and moose and fair food for ducks, which will eat its fruit.

Once it has formed dense stands, Eurasian watermilfoil interferes with, or prevents, recreational activities in a lake. Pullman (1993) notes that mats may constitute a safety hazard because they are not penetrable by boats and may hide submerged objects that could be struck by moving boats. He also notes that people can be placed at risk if they swim in dense areas of Eurasian watermilfoil due to the potential for entanglement.

3.4.2 Purple Loosestrife

Another important invasive aquatic species that Renovate® 3 is well suited to control is Purple Loosestrife (*L. salicaria*). There is considerable information on this species due to extensive geographic range and nuisance plant status. The following description is adapted and summarized from life history and ecological information obtained from several federal and state agencies and cooperative extension websites (e.g., USGS, Washington State, Cornell University). The respective websites are listed in the references.

Lythrum is the type genus of the loosestrife family (Lythraceae). About 22 genera and 500 species occur worldwide. Although *L. salicaria* has more than 10 common names in America, the most widespread and best established usage is "purple loosestrife." Purple loosestrife is a perennial, emergent aquatic plant (Thompson, et al. 1987; Malecki et al., 1994). As many as 30 - 50 herbaceous, erect, annual stems rise to about 9 feet tall,

from a persistent perennial tap root and spreading rootstock. Short, slender branches spread out to form a crown five feet wide on established plants (Thompson, et al. 1987). The somewhat squarish stems are four to six sided, with nodes evenly spaced. Main leaves are 3 to 10 cm long and can be arranged opposite or alternate along the squared stem and are either glabrous or pubescent. Inflorescence is a spike of clusters of reddish-purple petals (10 to 15 mm in length). Flowers are tri-morphic with short, medium, and long petals and stamens (USDA, 2002). Stems submerged under water develop aerenchyma tissue characteristic of aquatic plants. Loosestrife is most easily identified by the characteristic reddish-purple floral masses present during its long season of bloom (late June to early September in most areas).

3.4.2.1 Geographic Range and History of Invasion

Purple loosestrife was reportedly introduced as a garden perennial from Europe during the 1800's. It is still promoted by some horticulturists for its beauty as a landscape plant, and by beekeepers for its nectar-producing capability. Many of the early records of *L. salicaria*'s spread into the estuaries and canals of northeastern North America indicate it may be traced to incidental transport in ship ballast or in imported wool. It has since extended its range to include most temperate parts of the United States and Canada. The plant's reproductive success across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America. Currently, about 24 states have laws prohibiting its importation or distribution because of its aggressively invasive characteristics.

Purple loosestrife has been present in New York State since the 1800's but seemed to achieve problem status during the 1950s. By this time *L. salicaria* was so widely distributed in the uplands of the lower Hudson district that McKeon (1959) reported "a large percentage of marshes in the district have an almost pure stand of purple loosestrife which provides little food but does give some cover." McKeon chose a 4.9-ha (12-acre) marsh constructed in 1952 as the site of *L. salicaria* control studies. By 1955, the central portion of this marsh had become "almost completely dominated by purple loosestrife with a few sedges interspersed." Water level manipulation, burning (in winter), and cutting at surface and subsurface were attempted in sequence, with no success.

3.4.2.2 Ecology of Purple Loosestrife

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many of our wetlands, lakes, and rivers.

Vegetative disturbances such as water drawdown or exposed soil accelerate the process by providing ideal conditions for seed germination. Invasion usually begins with a few pioneering plants that build up a large seed bank in the soil for several years. When the right disturbance occurs, loosestrife can spread rapidly, eventually taking over the entire wetland. The plant can also make morphological adjustments to accommodate changes in the immediate environment; for example, a decrease in light level will trigger a change in leaf morphology. The plant's ability to adjust to a wide range of environmental conditions gives it a competitive advantage; coupled with its reproductive strategy, purple loosestrife tends to create monotypic stands that reduce biotic diversity.

The remarkable success of purple loosestrife as a worldwide pioneer is reflected in a combination of attributes that enable it to spread and thrive in disturbed temperate-climate habitats. In addition to an elaborate means of sexual reproduction and prolific seed production, *L. salicaria* has a wide scope of dispersal mechanisms. Some of these modes are adapted to long-range jumps in distribution (i.e., seeds in plumage of migratory

birds); others are well suited to vegetative spread during local perturbations (adventitious shoots and roots from clipped, trampled, or buried stems). Moreover, *L. salicaria*'s abundant propagules can establish themselves under a wide range of soil conditions, which enables the weed to colonize new surfaces caused by natural- or human-caused perturbations. Lastly, *L. salicaria*'s ability to make morphological adjustments to changes in its immediate environment (development of aerenchyma on submerged stems; change in leaf morphology with decrease in light level) enables it to adjust to a wide range of seasonal or semi-permanent changes in water levels and gives it a competitive advantage against other plants growing under these conditions.

Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70%, resulting in an extensive seed bank. Mature plants with up to 50 shoots grow over 2 meters high and produce more than two million seeds a year. Germination is restricted to open, wet soils and requires high temperatures, but seeds remain viable in the soil for many years. Even seeds submerged in water can live for approximately 20 months. Most of the seeds fall near the parent plant, but water, animals, boats, and humans can transport the seeds long distances. Vegetative spread through local perturbation is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. Plants may be quite large and several years old before they begin flowering. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

3.4.2.3 Ecological Impacts of Purple Loosestrife

Purple loosestrife displaces native wetland vegetation (e.g., cattail (*Typha latifolia*)) and degrades wildlife habitat. As native vegetation is displaced, rare plants are often the first species to disappear. Eventually, purple loosestrife can overrun wetlands thousands of acres in size, and almost entirely eliminate the open water habitat, thus reducing fish habitat. It can exclude desirable waterfowl food plants and reduces the effectiveness of the wetland for brooding and nursery waterfowl by reducing availability of secure routes to water and allows greater predator concealment. There is evidence to suggest that replacement of cattail by purple loosestrife will reduce the carrying capacity of the habitat for muskrat. The domination of the sites by tall dense monocultures causes both physical and trophic changes of the habitat and may reduce the quality of bog turtle habitat (Kiviat, 1978). The plant can also be detrimental to recreational water use by choking waterways. Due to its impact to waterfowl and furbearers, there are indirect effects to hunting and trapping

Potential control treatments for purple loosestrife include physical (handpulling, mowing, burning, water level manipulation), biological control (introduction of European herbivorous weevils and beetles), and chemical (herbicides such as glyphosate and triclopyr).

3.5 Distribution and Ecology of Other Potential Aquatic Macrophyte Target Species

In addition to the primary potential aquatic macrophyte target species discussed in Section 3.4, Renovate® 3 is intended for use to potentially control other aquatic macrophyte species. While not the typical species of concern, under certain conditions, additional species may also reach a nuisance level. These include both introduced and native species. Table 3-1 presents the submerged, floating-leaved and floating macrophyte species that are potential targets for control by Renovate® 3. The sources of information for Table 3-1 include Kishbaugh et al (1990), These species are found throughout New York State, although the actual presence and distribution in a waterbody are dependent on the physical characteristics of that waterbody.

Table 3-1 Distribution and Ecology of Potential Submerged, Floating-Leaves and Floating Target Macrophyte Species

| |
|--|
| American frogbit (<i>Limnobium spongia</i>) Native floating or rooted aquatic plant; may form dense mats; found from Lake Ontario to the southern United States |
| American Lotus (<i>Nelumbo lutea</i>) Found in ponds and quiet streams; is at the northern edge of its geographic distribution in NYS |
| Parrotfeather (<i>Myriophyllum aquaticum</i>) Grows in shallow ponds, lakes and sluggish streams; currently limited to Long Island; poor food source; good shelter for invertebrates and fish |
| Pennywort (<i>Hydrocotyle ranunculoides</i>) Found in marshes and ponds; endangered in NYS; |
| Pickerelweed (<i>Pontederia cordata</i>) Native species found along waters edge throughout NYS; leaves and rhizomes eaten by muskrats |
| Spatterdock (<i>Nuphar luteum</i>) Found in sluggish streams, ponds, small lakes and swamps throughout NYS; low wildlife food value |
| Waterhyacinth (<i>Eichornia crassipes</i>) Rare and introduced in NYS; found in ponds, lakes and sluggish streams |
| Waterlily (<i>Nymphaea</i> spp.) Found in shallow ponds, lakes and swamps throughout NYS; seed and rootstocks are eaten by ducks and marshbirds; beaver and moose eat the foliage; invertebrates utilize the undersides of leaves as shelter |
| Watermilfoil (<i>Myriophyllum</i> spp.) Native watermilfoil species are found in ponds, lakes and sluggish streams throughout NYS; is considered a low-grade duck food; is considered to be good habitat and shelter for fish and macroinvertebrates |
| Waterprimrose (<i>Ludwigia</i> spp., including waterpurslane (<i>Ludwigia palustris</i>)) Found in streams and springy areas throughout NYS; serves as a food source for birds and grazing mammals |

3.6 Role of Potential Aquatic Macrophyte Target Species in Plant Communities within New York State Waterbodies

As discussed in Section 3.2.2, aquatic macrophytes fulfill valuable functions in the aquatic environment. They assist in oxygenation of the water, recycling of nutrients, and provide nesting and shelter areas for fish, amphibians, birds and mammals. Aquatic macrophytes serve in the stabilization of banks along watercourses and are a food source for a variety of organisms, including both invertebrates and vertebrates. The ability of a particular macrophyte to perform these functions and the quality of that function often depends on the characteristics of the entire aquatic community.

Heterogeneous stands of plant species generally offer more of these functions than a monotypic stand (dominated by a single species). Heterogeneous stands have a greater vertical distribution of niches, which aquatic organisms that are dependent on the vegetation may fill. Additionally, the horizontal distribution of the aquatic plant communities will affect the functions and values that the individual species may offer.

Patchy communities, with a variety of vegetative species spread over the available substrate, tend to offer a greater variety in habitats than a community dominated by a single species that completely covers the substrate. However, if that single species community is localized and is the only available habitat in a large aquatic setting, then at least some of the functions generally offered by aquatic vegetation would be offered. This circumstance may be evaluated in a lake management plan that would determine the goals and objectives of the vegetation management needs for that waterbody. Restoration of a mixed community of desirable plant species is likely to require initial removal of a monotypic plant stand.

3.7 General Characterization of Aquatic Vegetation Management Objectives for the Use of Renovate® 3

Aquatic macrophyte management is required when the overabundance of vegetation impairs the use of the waterbody. As mentioned in Section 2.0, the proposed action is the use of the aquatic herbicide Renovate® 3 for the control of nuisance aquatic vegetation located in the State of New York.

3.7.1 Control of Invasive Aquatic Macrophyte Species

The primary management objective for Renovate® 3 is the management and control of overabundant submerged and emergent weeds, particularly invasive aquatic species such as Eurasian watermilfoil and purple loosestrife. Secondary objectives that are also relevant are the reduction in impairment of designated water uses, early response eradication of water milfoil during primary infestation period, and being a potential method or technique as part of an Integrated Plant Management (IPM) plan.

Triclopyr presents several advantages over other registered aquatic herbicides commonly used to treat Eurasian watermilfoil (e.g., 2,4-D, fluridone) in New York State (see Section 7.7.4). It is highly selective and effective against Eurasian watermilfoil and many other (but not all) dicotyledonous plants (dicots). Triclopyr can also be used for control of the invasive emergent macrophyte purple loosestrife. Previous application of triclopyr has revealed little or no effect for a large number of the more common monocotyledonous (monocots) naiads and pondweeds, which often constitute the more valued native species in the aquatic plant community. [Note: there are potential impacts to some monocot species, so identification of the lake-specific macrophyte community assemblage is critical to proper treatment design and application.] For additional information see also Table 4-2.

Triclopyr works rapidly (uptake within 6 –12 hours) so that dosage concentrations do not have to be held in the lake for extended periods. Triclopyr rapidly degrades in the environment and is not considered bioaccumulative.

Triclopyr can be applied to waters used as potable water supply, through use of a setback distance from any functioning intake that is determined by dose and size of the area treated. For smaller sized water supply lakes, this may significantly limit the practical applicability of triclopyr due to proximity of intakes. There are no federal label restrictions for recreational use of treated waters or for use in livestock watering. Crop irrigation use is prohibited for 120 days or until the triclopyr concentration is undetectable by immunoassay testing. There is no restriction on use for irrigating established grass (i.e., lawns).

Triclopyr has also been proven effective in the control of emergent species such as purple loosestrife and common reed in wetland areas. Due to the varying nature of freshwater and coastal wetland habitats where invasive species may be found, prescription of one or more specific control techniques is challenging. Unlike the majority of invasive plant species occurring in submergent habitats, the control of emergent species such as loosestrife and common reed generally require multiple treatments over a multi-year period, and a single or incomplete application of an herbicide to these species may actually worsen their infestation by harming native plant communities and providing the invasive species with a competitive advantage.

Application rates and techniques for herbicides vary among ecosystems, and an herbicide such as Renovate® 3 would be used differently within a lakeshore emergent wetland dominated by purple loosestrife and exhibiting standing water year-round versus a relatively “dry” clay plain shrub wetland with localized patches of purple loosestrife. In many instances, as part of an integrated aquatic vegetation management plan, a combination approach of mechanical harvesting or burning in conjunction with herbicide application may be much more effective than herbicide application alone. To this end, invasive species eradication and control plans may need to be individually prescribed to such systems to ensure proper, safe, and effective use of herbicides. These programs may be described in a lake-specific aquatic vegetation management plan or as part of the information and conditions associated with relevant permits (e.g., Article 24 Wetland permits).

3.7.2 Reduction in Impairment of Designated Uses

As part of an Integrated Plant Management plan, Renovate® 3 can help reduce the level of impairment to designated uses caused by overabundant macrophyte vegetation, particularly by Eurasian watermilfoil. As with any aquatic macrophyte species that produces a high amount of biomass in the water column that is subject to fragmentation and eventual senescence and decay, removal of excess vegetation can lead to improvements in aquatic support (fishery, native macrophytes), recreational uses (contact and non-contact recreation), drinking water (removal of taste and reduction in potential disinfection by-product (DBP) precursors)), and aesthetics. Applications of Renovate® 3 should reduce the level of designated use impairment caused by susceptible macrophytes.

3.7.3 Rapid Response Action

In most cases, introduced species demand special attention and this is particularly the case of Eurasian watermilfoil. While an overabundance of native species and diminution of desired uses can be managed over time, introduced species generally require quick action if eradication is to be achieved. The environmental cost of delay is usually higher than the risk of immediate use of most control options. The quicker the response, the smaller the degree of intervention needed to protect the environment. It may be difficult to impossible to actually eradicate an invasive species, but the probability of achieving and maintaining control is maximized through early detection and rapid response. The use of Renovate® 3 as part of a rapid response action management plan for Eurasian watermilfoil is one of the secondary plant management objectives.

3.7.4 Integrated Plant Management

The use of herbicides to get a major plant nuisance under control is a valid element of long-term integrated pest or plant management when other means of keeping plant growths under control are then applied (Nichols and Shaw, 1983; Gangstad, 1986; Wade, 1990; Mattson et al., 2004; Wagner et al., 2004; NYSDEC, 2005). However, failure to apply alternative techniques on a smaller scale, once the nuisance has been abated, places further herbicide treatments in the cosmetic maintenance category; such techniques tend to have poor cost-benefit ratios over the long-term. Therefore, it is critical that an integrated aquatic vegetation management plan (IAVMP) be developed to support selection of an appropriate and cost-effective suite of control treatments to provide immediate and long-term control (i.e., > 5 years) of plants. The elements of an IAVMP are provided in detail in Section 7.2. One of the secondary aquatic plant management objectives of Renovate® 3 is to provide a useful addition to the methods to be considered when developing such a plan.