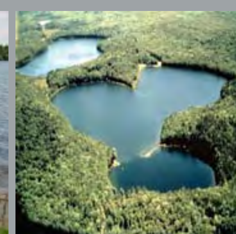
Prepared for:
SePRO Corporation
Carmel, Indiana







Use of the Aquatic Herbicide Triclopyr Renovate® in the State of New York

Supplemental Environmental Impact Statement

ENSR Corporation
March 2007
Document No.: 10746-001-310

ENSR | AECOM

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1.0 Introduction

1.1 Purpose of the Supplemental Environmental Impact Statement

It is the purpose of the Supplemental Environmental Impact Statement (SEIS) to objectively evaluate the scientifically documented evidence regarding all aspects of the use of Renovate for the control of nuisance aquatic weeds in waters of the State of New York. This document is intended to present a general description of the potential positive and negative impacts from the use of this product within waters of the State of New York. The SEIS is being submitted to the New York State Department of Environmental Conservation (NYSDEC) by ENSR Corporation (ENSR) on behalf of SePRO Corporation (SePRO), the distributor of Renovate® 3 and its granular formulation Renovate® OTF. [Note: OTF is an alternate brand name of Renovate® Granular marketed by SePRO Corporation]. The rights of the trademarked product Renovate® 3 and OTF were purchased by SePRO Corporation of Carmel, Indiana from Dow AgroSciences, LLC of Indianapolis, Indiana.

The Supplemental Environmental Impact Statement (SEIS) has been prepared by SePRO specifically for the evaluation of potential use of Renovate® 3 and Renovate® OTF (these two products are collectively termed “Renovate®“) in New York State and is applicable only to that trademarked product formulation. The information and technical data contained in this SEIS pertaining to the active ingredient, triclopyr triethylamine salt (TEA), is provided to allow full evaluation of the Renovate products , support selection of appropriate application setback distances and comparisons to other aquatic herbicides or alternative treatment options. The impact evaluation contained herein is not intended nor should it be used as a surrogate SEIS for other triclopyr-containing products. While sharing a common active ingredient, these products may differ widely in other formulaic components, resulting in physical and chemical properties that may significantly affect exposure and toxicity factors, thus invalidating the application and setback conditions contained in the Renovate® 3 NYSDEC-approved Supplemental 24C label (and the pending Renovate® OTF Supplemental 24C label). Accordingly, NYSDEC should be contacted regarding establishing environmental safe conditions for application of alternative triclopyr-containing products in riparian and aquatic settings.

1.2 Objective of the SEIS

The development of the SEIS for Renovate® is intended to provide potential users of this product with a general understanding of the various results that might be associated with the use of Renovate in the waters of the State of New York. Renovate® is an aquatic herbicide containing the active ingredient triclopyr triethylamine salt (TEA). By developing the SEIS, SePRO has provided the information necessary for individual potential applicators to easily develop the necessary permit applications. However, the approach taken through the development of the SEIS is not intended to prevent any applicant from preparing a site specific supplement to the Final Programmatic Environmental Impact Statement on Aquatic Vegetation Control (NYSDEC, 1981a) in the development of a permit for the use of Renovate® in surface waters of New York State. The preparation of this SEIS is intended to provide potential users and interested parties with information specific for Renovate® and its positive and negative impacts on surface water resources of New York State. In addition, Supplemental Labeling (i.e., Chapter 24(c) Special Local Need Registration) has been developed for use of Renovate® 3 in New York and is presented in Appendix E.

1.3 Regulatory Framework

The SEIS was prepared in accordance with 6 NYCRR Part 617, the New York State Environmental Quality Review Act (SEQR). The purpose of SEQR is to incorporate the consideration of environmental factors into the existing planning, review and decision-making processes of State, regional and local government agencies at the earliest possible time. An action is subject to review by the NYSDEC under SEQR if any state or local agency has the authority to issue a permit or other type of approval over that action.

Section 617.15 (a)(4) allows for the development of a SEIS to assess the potential environmental effects of an entire program or plan having wide application. The regulations concerning the use of pesticides in NYS are defined in 6 NYCRR Part 325 through 327. The regulations addressing the use of pesticides in wetlands are defined in 6 NYCRR Part 663 and within the Adirondack Park, 9 NYCRR Part 578.

This registration represents a major change in labeling for the active ingredient triclopyr triethylamine salt (TEA). Currently, the Dow AgroSciences LLC triclopyr product Garlon® 3A (USEPA registration number 62719-37) is registered for use in New York to control woody plants and broadleaf weeds in selected terrestrial areas (i.e., rights-of-way, industrial sites, non-cropland areas, non-irrigation ditch banks, forests and wildlife openings). The United States Environmental Protection Agency (USEPA) approved label for Garlon® 3A (dated December 3, 2002) also included directions for aquatic applications to control emersed, submersed, and floating aquatic plants.

SePRO and Dow AgroSciences have entered into an agreement to allow the former to distribute the aquatic use portion of the Garlon® 3A label as Renovate® 3. SePRO applied to the Pesticide Product Registration Section of the NYSDEC Bureau of Pesticides Management (all aquatic herbicides are considered pesticides) for registration of Renovate® 3 as a new pesticide production and it was accepted for registration on July 19, 2006). In addition, a “Supplemental Labeling” 24C label was approved by NYSDEC on October 23, 2006. The USEPA approved labels and Material Safety Data Sheets (MSDS) for Renovate® 3 and Renovate Granular/OTF are presented in Appendix A. The NYSDEC-accepted 24 C Supplemental Labeling is provided in Appendix E.

1.4 Identification and Jurisdiction of the Involved and Interested Agencies

The following agencies were identified as involved agencies for the development of this SEIS:

- New York State Department of Environmental Conservation (NYSDEC) - Responsible for implementation of the laws and regulations pertaining to the management of environmental resources for the State of New York.
- New York State Department of Health (NYSDOH) - Responsible for potential public health issues associated with the use of the products.
- New York State Office of General Services (NYSOGS) - Responsible for the management of property owned by the State of New York. As pertaining to this project, they are responsible for the management of the lakes and/or lake bottoms owned by the State of New York.
- Adirondack Park Agency (APA) - responsible for implementation of the Adirondack Park Land Use and Development Plan (as described by the Adirondack Park Agency Act).
- New York State Department of State (NYSDOS) - Responsible for the administration of the Coastal Zone Program.

By agreement of the involved agencies, NYSDEC was designated as the lead agency for the SEIS.

1.5 Content and Organization of the SEIS Document

An initial scoping meeting for purposes of identifying the necessary components of the SEIS for Renovate® 3 was held at the offices of the NYSDEC in Albany, NY on April 26, 2005. Present at the meeting were representatives of NYSDEC (Betty Ann Hughes, Anthony Lamanno, Samuel Jackling, Scott Kishbaugh, Timothy Sinott), SePRO (Steve Cockreham), and their consultant ENSR (David Mitchell).

At this meeting, the registration and SEQR process were reviewed and discussed. A proposed outline of the SEIS was reviewed, discussed, and commented on by the agencies with regard to its content and completeness. This SEIS outline was revised and submitted to NYSDEC in early May 2005. This outline was approved by NYSDEC and other agencies in June 2005 (e-mail from A. Lamanno, dated June 9, 2005). During a second meeting with NYSDEC held in December 2006 to discuss their comments on the draft SEIS, it was proposed and NYSDEC accepted that information on the granular formulation, Renovate® OTF, could be included in the SEIS.

The SEIS document is organized in the following fashion;

- Section 1.0 **Introduction** – provides general overview of the product registration and SEQR process and associated regulations;
- Section 2.0 **Description of the Proposed Action – Use of Renovate®** - provides information on the aquatic herbicide, the general locale of its proposed application, its use in support of maintaining designated uses, and intended macrophyte target species;
- Section 3.0 **Environmental Setting** – places the application of Renovate® in the context of the New York lake environment. The general characteristics of New York lakes are described, along with the macrophyte communities – their ecology and functional roles. The overall objectives of aquatic macrophyte management control by Renovate® are identified;
- Section 4.0 **General Description of Renovate® and its Active Ingredient Triclopyr** – provides a full description of Renovate® and its chemical formulations. This description includes proposed use, mode of action, application factors, solubility, surfactant properties, fate and transport properties and residues;
- Section 5.0 **Significant Environmental Impacts Associated with Renovate®** - this section reviews direct and indirect impacts to non-target species, potential bioaccumulation and residence time in water column, and the potential for recolonization of macrophytes following application;
- Section 6.0 **Potential Public Health Impacts of Renovate®** - evaluates the potential for concerns or issues associated with human exposure to the product;
- Section 7.0 **Alternatives to Renovate®** - describes and briefly reviews the advantages and disadvantages of alternative aquatic macrophyte control methods and technologies including physical, chemical and biological-based alternatives. The use of a combination of these techniques (Integrated Plant Management) or none (no-action alternative) are described. An alternatives analysis is also conducted;
- Section 8.0 **Mitigation Measures to Minimize Environmental and Health Impacts of Renovate®** - reviews the approved use instructions and label information to mitigate and/or minimize any potential impacts to humans and the environment and discusses potential permit requirements;
- Section 9.0 **Unavoidable Environmental Impacts if Use of Renovate® is Implemented** – considers impacts to habitat, non-target species, and potential for reinfestation; and
- Section 10.0 **References** – contains the citations and sources of the information presented in the SEIS.

2.0 Description of the Proposed Action – Use of Renovate®

The proposed action is the use of the aquatic herbicide Renovate® for the control of nuisance aquatic vegetation in waterbodies located in the State of New York.

2.1 General Description of the Aquatic Herbicide Triclopyr (Renovate®)

Renovate® 3 is classified in New York State as a restricted use herbicide product labeled for control of floating, submerged or emergent aquatic plants in and around aquatic settings such as ponds, lakes, reservoirs, non-irrigation canals, ditches, marshes and wetlands.

Renovate® 3 is composed of 44.4% active ingredient, triclopyr (3,5,6-trichloro-2-pyridinyloxyaceticacid) triethylamine (TEA) salt, and 55.6% “inert” ingredients. “Inert” ingredients listed on the herbicide material safety data sheet (MSDS) (see Appendix A) include ethanol and triethylamine Water also composes a portion of the “inert” ingredients. Renovate® 3 is currently packaged as a liquid, but a flake formulation will be introduced in the future (see discussion below regarding Renovate OTF- formulation).

2.1.1 Purpose of the Product

Renovate® is a relatively fast-acting, systemic, selective herbicide proposed for the control of certain submersed, floating, and emergent aquatic plant species, including woody plants, in ponds, lakes, and reservoirs. Additional treatment sites include adjacent banks, shores, canal banks and on non-irrigation canals which have little or no continuous outflow, marshes and wetlands.

Triclopyr is a systematic herbicide with selective control of woody and broadleaf species. While the parent molecule of triclopyr is an acid, it is formulated in Renovate® as an amine/salt derivative. Generally, salts, esters or amines are formulated to enhance absorption by the plant leaf or increase herbicide solubility. The parent acid portion of the formulation is the active portion, binding to the herbicide target site within the plant leading to plant death (Antunes-Kenyon and Kennedy, 2004).

When applied, triclopyr rapidly enters through a plant’s leaves and stems, then translocates down into the roots, disrupting the plant’s metabolism. Foliar applications are most effective when applied when plants are actively growing from spring to early summer. Triclopyr is very useful for controlling dicots like Eurasian watermilfoil and purple loosestrife. Native grasses and sedges (monocots) are generally unaffected by triclopyr, increasing the selectivity of the herbicide.

2.1.2 Need for the Product

The use of Renovate® 3 or OTF can be an important component of a comprehensive and integrated plant management approach to limit the spread of certain aquatic macrophytes. These macrophytes can be undesirable in certain circumstances. They may be introduced non-indigenous (i.e., exotic) species, which because of the lack of natural controlling ecological factors reach a nuisance stage in terms of extreme numbers or biomass. Such exponential growth can significantly reduce the recreational use of a waterbody by interfering with swimming, boating, or fishing. They may also clog intake screens and turbines, impart an unpleasant taste to the water, and reduce the presence of native aquatic species (Madsen et al., 1991a). Vermont Department of Environmental Conservation notes that nuisance vegetation may modify the aquatic habitat for indigenous organisms (VDEC, 1993).

Because of its capability of forming beds of high biomass reaching into the water column, excessive growth of the invasive exotic species Eurasian watermilfoil (i.e., *Myriophyllum spicatum*; a primary target species for Renovate®) may also present a safety hazard to the recreational use of a waterbody. These dense beds reaching to the surface may obscure or cover rocks, logs, and other obstructions that could damage moving boats or injure water skiers. Additionally, the beds may entangle swimmers, potentially resulting in injury or death. Drownings as a result of entanglement in Eurasian watermilfoil mats have been documented in New York (Long et al., 1987) and Michigan (COLAM, 1992).

New York has abundant lakes and ponds located throughout the Empire State and they represent a significant ecological, cultural and recreational resource. For example, NYSDEC (1987) reports that over 7,500 lakes, ponds, and reservoirs can be found in New York. A large number of New York lakes are currently impacted with aquatic weeds as documented on NYS Priority Waterbody List (NYSDEC, 2005). Many of these lakes suffer impairment due to the presence of exotic invasive species. Eurasian watermilfoil is considered the most invasive submergent aquatic plant throughout New York (NYSDEC, 2005).

Triclopyr is particularly valuable as an active ingredient because the primary competing active ingredients for use in controlling submersed, emersed and floating invasive plants can not be used over the range of encountered conditions. It also has some advantages over other NYS-registered aquatic herbicides commonly used to control Eurasian watermilfoil. Fluridone requires an extended contact time with elevated water concentrations of weeks to months, while effective triclopyr exposures can be less than a few days and allow for localize management of Eurasian watermilfoil. Endothall is a contact herbicide and is not selective for Eurasian watermilfoil (i.e., impacts native pondweed species). Similar to diquat, in New York State 2,4-D cannot be applied beyond 200 feet from shore or in water depths greater than six feet (whichever provides the greater distance from shore). Although glyphosate is an effective floating and emergent product, it does not provide the selective properties required for many invasive weed management programs in aquatic sites (i.e., to control purple loosestrife, *Phragmites*). Additional information is provided in Section 7.7.4.

2.1.3 Benefits of the Product

Renovate® provides an alternative means for management and/or control of common invasive exotic species, particularly Eurasian watermilfoil and purple loosestrife (*Lythrum salicaria*), with little or no impact to native aquatic plants, such as cattails, rushes, reeds, grasses, and submerged monocots (Petty et al., 2003). Therefore, Renovate® can be used selectively to restore wetlands and for aquatic ecosystem management. Specific target macrophyte species are presented in Section 2.4 and in Table 2-1.

The recent registration of Renovate® 3 (and pending registration for Renovate® OTF) will provide an additional macrophyte control treatment to the existing arsenal of tools and techniques already used to manage lakes with excessive macrophyte biomass (see Section 7.0 for discussion of alternatives).

2.1.4 History of the Product Use

Triclopyr was first registered by USEPA in 1979 and has been used since the 1970s for control of broadleaf weeds and wood plants on rights-of-way (ROWs), rangeland, industrial sites, and other non-crop areas (Antunes-Kenyon and Kennedy, 2004). Most applications for these purposes have used the pesticide product Garlon® 3 or 3A as manufactured by Dow AgroSciences, LLC. The triclopyr TEA formulation in Garlon® 3A has been approved by NYSDEC for these types of applications in terrestrial settings.

Between 1984 and 2002, the active ingredient triclopyr was used under an Experimental Use Permit (EUP) as an aquatic herbicide for small test plots around the country. In 2002, the USEPA master Federal label (approved on December 2, 2002 for Garlon® 3) listed additional use directions for applications at aquatic sites. Accordingly, a dedicated product for aquatic settings, designated Renovate® 3 was approved in December 2002 [note: Renovate is a registered trademark of Dow AgroSciences LLC]. The USEPA registration number for Renovate® 3 is 62719-37-67690. Renovate® 3 is the first aquatic herbicide to be federally registered since 1988.

Renovate® 3 is registered for use without restrictions beyond those on the Federal label in all states bordering New York. The State of Massachusetts recently approved (November 2004) the use of this aquatic herbicide (see review for Massachusetts application in Antunes-Kenyon and Kennedy, 2004), While Renovate® 3 is not presently registered in Canada, triclopyr was recently re-evaluated by Health Canada Pest Management Regulatory Agency (PMRA) who determined that the chemical was acceptable for potential registration providing that proposed mitigative measures were adopted (PMRA, 2004).

On October 23, 2006, SePRO received Renovate® Granular registration from USEPA and this document in contained in Appendix A. SePRO is currently pursuing state registrations (including a Supplemental 24C label for New York) for the alternate brand, Renovate® OTF. Renovate OTF is composed of 10% acid equivalent, triclopyr TEA salt, and 86.0% "inert" ingredients (see Appendix A for MSDS sheet and Section 4.0 for chemical properties). Renovate OTF is a dry flake formulation and is labeled for control of emersed, submersed and floating aquatic plants in the following aquatic sites: ponds; lakes; reservoirs; marshes; wetlands; impounded rivers, streams and other bodies of water that are quiescent; non-irrigation canals, seasonal irrigation waters and ditches which have little or no continuous outflow. The use of a dry flake carrier for triclopyr will improve control and cost-effectiveness of Eurasian watermilfoil and other susceptible weeds in shoreline treatments, spot treatments and in deeper water areas that are more susceptible to dilution.

2.2 General Location of the Proposed Action

For the purposes of this portion of the SEIS, the general location for the proposed action is in the surface waters of the State of New York. The proposed action is the use of the aquatic herbicide Renovate® 3 for the control of certain nuisance aquatic macrophytes. Renovate® 3 is currently seeking registration in New York for use in freshwater ponds, lakes, reservoirs, non-irrigation canals and ditches with little or no continuous outflow, marshes and wetlands. Under Article 24 of the Environmental Conservation Law, some ponded water may be described as wetlands. A specific description of the actual body of water in which Renovate® 3 is intended for use would be included in the individual permit applications. This would also include any applications in New York State-designated wetland areas. Further descriptions of New York lakes and wetlands and their characteristics are given in Section 3.0.

2.3 Support of Designated Uses

All New York State surface waters are classified under 6 NYCRR Part 701.2 – 701.9, which delineates the protected or so-called designated uses inherent to such classifications. These designated uses for fresh waters include: source of water supply for drinking; culinary or food processing purposes; primary and secondary contact recreation; and fishing. In addition, the waters shall be suitable for fish propagation and survival.

To protect these uses, New York has promulgated water quality standards (6 NYCRR Part 703) to support the best uses of the waters. These standards include several types including those pertaining to human health (water source and fish consumption), aquatic life (survival and propagation), wildlife (protection of piscivores) and aesthetic qualities. The latter is defined in a narrative water quality standard (6 NYCRR Part 703.2) that provides a general condition for all taste, color, and toxic and other deleterious substances shall not be in amounts "that will adversely affect the taste, color or odor thereof, or impair the waters for their best usages."

Presently there are no chemical-specific New York State water quality standards for triclopyr or its salts (e.g., Renovate®) in effect. However, for purposes of the SEIS, information will be provided to show how proper use of the aquatic herbicide Renovate® 3 or OTF for the control of nuisance aquatic vegetation will not adversely affect any of the protected or best uses of the treated waterbody. In addition, there can be secondary economic benefits by control of nuisance aquatic vegetation (Mongin, 2005).

Protection of human health concerns (drinking water, fish consumption, primary and secondary recreation) are considered in Section 6.0; considerations for potential ecological impacts (aquatic life support function, wildlife) are considered in Sections 5.0 and 9.0; and aesthetics in Section 7.0.

2.4 Potential Aquatic Macrophyte Target Species

Based on the registered label for Renovate® 3, the aquatic macrophyte species listed in Table 2-1 are considered to be potential target species for this product. However, not all of the aquatic macrophyte species described on the product label are typically found in the State of New York. Table 2-1 indicates which species are listed on the federally registered Renovate® 3 label, but do not occur in New York State. The detailed discussions of the primary target species below refer to species common to much of New York State.

2.4.1 Eurasian Watermilfoil

A primary target species for Renovate® in New York State is Eurasian watermilfoil (*M. spicatum* L.). Eurasian watermilfoil is considered the most invasive submergent aquatic plant throughout New York State NYSDEC, 2005). Eurasian watermilfoil is an aquatic plant found in the taxonomic family Haloragaceae. It is a rooted, vascular submergent macrophyte with long stems and feathery perennial leaves. Plants form no specialized overwintering vegetative structures such as turions. Eurasian watermilfoil is an invasive, opportunistic exotic plant that is native to Europe, Asia, and North Africa (Reed, 1977; Pullman, 1993; and Long et al., 1987). Hotchkiss (1972) reports that Eurasian watermilfoil is distributed across the northern tier of the United States, from California to Vermont. Additional information regarding the distribution, life history, and ecology of this species is given in Section 3.4.1.

2.4.2 Purple Loosestrife

Another primary target species for Renovate® in New York State is purple loosestrife (*L. salicaria*). Purple loosestrife is an herbaceous, wetland perennial of European origin. 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). Additional information regarding the distribution, life history, and ecology of this species is given in Section 3.4.2.

2.4.3 Other Potential Aquatic Macrophyte Target Species

The following species are listed on the federal label for Renovate® 3 as potential species targeted for control. Only those potential target species actually occurring in New York State are discussed in this section.

- American frogbit (*Limnobium spongia*) – American frogbit is a native aquatic monocot found in marshes or slow flowing waters. Although it is a native plant, it may produce extensive floating mats and create nuisance situations (Madsen, et al., 1998).
- American lotus (*Nelumbo lutea*) - The American lotus or yellow lotus is found in the taxonomic family Nymphaeaceae. The lotus is characterized by grayish-green leaves which are as much as 2 feet across and float or stand above the water.
- Parrotfeather (*Myriophyllum aquaticum*) – Parrotfeather is an easily recognized member of the milfoil family because its stiff, bright green leaves rise above the water like a forest of tiny fir trees. These emergent leaves have a feather-like shape and are arranged in whorls around the stiff stem. Introduced from South America, parrotfeather has become a nuisance in many parts of the world, often creating dense mats on the surface of shallow water or on wet soil (Hamel and Parsons, 2001).
- Pennywort (*Hydrocotyle ranunculoides*) – Pennywort is a perennial, aquatic plant, with floating and emergent leaves and is protected in New York State. The most visible feature of water pennywort is the dark green, deeply-lobed, round leaves rising above the water surface. The plants are smooth and

somewhat fleshy, with long creeping stems that often float near the waters surface. The small clusters of flowers occur on stalks attached to the horizontal stems. Water pennywort can form a dense mat of leaves along the edges of lakes and ponds and often remains green in winter (Hamel and Parsons, 2001).

- Pickerelweed (*Pontederia cordata*) – Pickerelweed is a very common emergent plant that can be a very prolific grower and may cover large areas. Pickerelweed is found most commonly in shallow, quiet, streams, lakes, and rivers.
- Spatterdock (*Nuphar spp*.) - Spatterdock (Family Nymphaeaceae) is found in inland and coastal fresh water marshes, ponds, lakes, pools, and the borders of slowly moving streams. Leaves vary greatly in size, but are generally large and lance-like in shape. In the form of the species indigenous to the northeastern United States, the leaves generally float on the surface of the water (Hotchkiss, 1972).
- Water hyacinth (*Eichhornia crassipes*) – Water hyacinth is an erect, free-floating, stoloniferous, perennial herb. The buoyant leaves vary in size and morphology. The short, bulbous leaf petioles produced in uncrowded conditions provide a stable platform for vertical growth. Water hyacinth grows best in neutral pH, water high in macronutrients, warm temperatures (28° to 30°C), and high light intensities (USDA, 2002)
- Waterlily (*Nymphaea spp.*) - Waterlilies (Family Nymphaeaceae) are aquatic herbs with thick cylindric, horizontal rootstocks. The leaves are generally large and cordate. Flowers are showy (Britton and Brown, 1970). Waterlilies are found in slow, standing water in ponds, lakes or slowly moving streams. The three species of waterlily commonly found in New York State include *Nymphaea odorata, N. tuberosa*, and *N. alba*.
- Watermilfoil (*Myriophyllum spp.*) - Native species of Myriophyllum (Family Haloragaceae) are submersed, stout-stemmed perennials (Fairbrothers and Moul, 1965). There are generally 5 to 13 pairs of leaflets per leaf with each leaf approximately 4 cm long. Flowers are small and inconspicuous and occur in the axils of the upper leaves Watermilfoil is found in ponds, lakes, sluggish streams, and shorelines. Three species of watermilfoil (*M. alterniflorum, M. farwellii, M. pinnatum*) are listed as protected plants in New York State (Young, 2004).
- Water primose (*Ludwigia spp.*) – Water primroses are found in the evening-primose family (Onagraceae). Plants in the genus *Ludwigia* are perennial or annual herbs, with alternate, usually entire leaves. They are generally found in freshwater marshes (Britton and Brown, 1970). *Ludwigia* (*Ludwigia sphaerocaqa*) is listed as a rare plant species in NYS.

Table 2-1 Aquatic Macrophytes Controlled by Renovate® as indicated by Federal labeling.

alligatorweed [2]	milfoil species	purple loosestrife
American lotus	spatterdock	water hyacinth
American frogbit	parrotfeather [1]	waterlily
aquatic soda apple [2]	pickerelweed	waterprimose
Eurasian watermilfoil	pennywort	

1 -- Retreatment may be needed to achieve desired level of control.

2 – Species not found in the State of New York

List of aquatic weeds obtained from Renovate® 3 label presented in Appendix A.

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, Lake Chautauqua, 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 possibly 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 $CaCO_3$,) (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

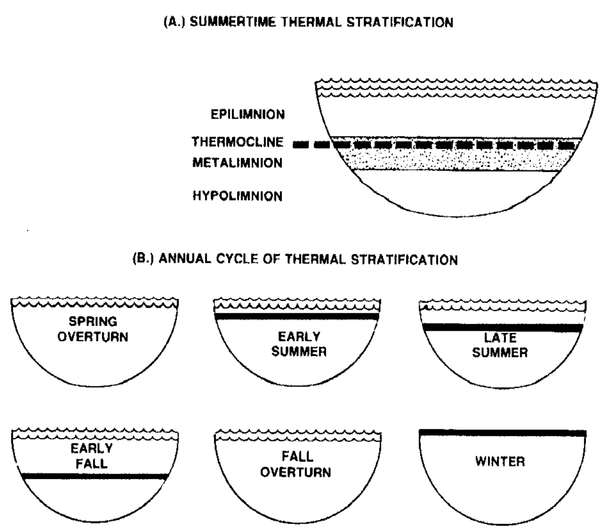
The thermal structure of lakes also determines productivity and nutrient cycling (Wetzel, 2001; Kalff, 2002). For many shallow New York lakes, the mixed layer may extend to the lake bottom. Deeper lakes may form a three-layered structure that throughout the summer consists of an upper warm layer (the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

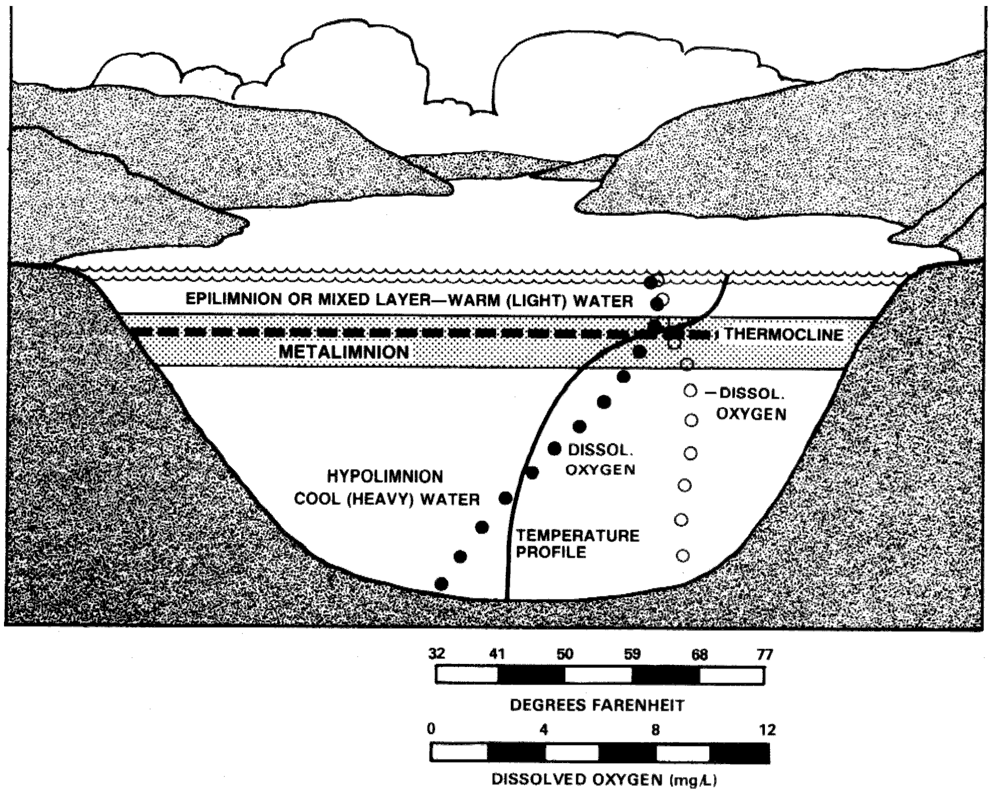


When the metalimnion is established, the hypolimnion no longer has a significant source of oxygen, either from exchange at the surface or as a result of photosynthesis. But animals and bacteria live in these lower waters and consume oxygen. If enough organic matter rains down to the hypolimnion, bacterial 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 is 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.

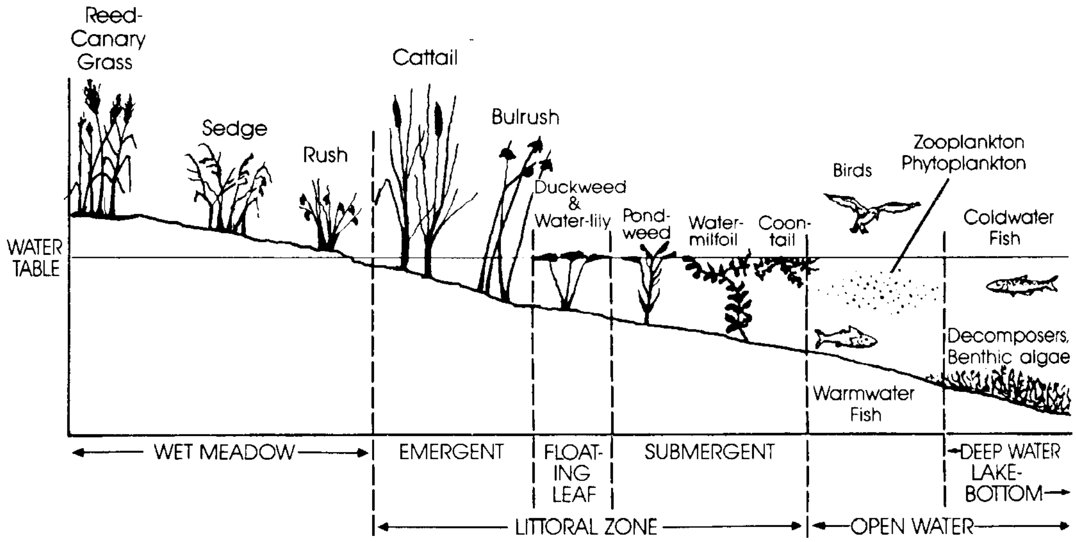
In addition to these important biogeochemical attributes, such natural systems are also valued for their recreational and aesthetic characteristics and for provision of valuable habitat for fish and wildlife, particularly those emergent wetland dominated by cattail, rushes or sedges. Large expanses of 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 *Ceratophvllum* and *Utriculari*a. 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 submersed 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 cause 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 crates 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 waters 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.

Honnel 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 (*Limnobium spongia*) Native floating or rooted aquatic plant; may form dense mats; found from Lake Ontario to the southern United States
American Lotus *(Nelumbo lutea)* Found in ponds and quiet streams; is at the northern edge of its geographic distribution in NYS
Parrotfeather *(Myriophyllum aquaticum)* Grows in shallow ponds, lakes and sluggish streams; currently limited to Long Island; poor food source; good shelter for invertebrates and fish
Pennywort (*Hydrocotyle ranunculoides*) Found in marshes and ponds; endangered in NYS;
Pickerelweed (*Pontederia cordata*) Native species found along waters edge throughout NYS; leaves and rhizomes eaten by muskrats
Spatterdock *(Nuphar luteum)* Found in sluggish streams, ponds, small lakes and swamps throughout NYS; low wildlife food value
Waterhyacinth *(Eichornia crassipes)* Rare and introduced in NYS; found in ponds, lakes and sluggish streams
Waterlily (*Nymphaea* 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 *(Myriophyllum* 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 *(Ludwigia* spp., including waterpurslane (*Ludwigia palustri*s)) 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 plant, 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.

4.0 General Description of Renovate® and its Active Ingredient Triclopyr

4.1 General Description of Renovate® and its Formulations

Renovate® 3 is an aquatic herbicide labeled for control of floating, immersed, or submersed aquatic plants in and around aquatic sites such as ponds, lakes, reservoirs, non-irrigation canals, ditches, marshes and wetlands. Renovate® 3 is composed of 44.4% active ingredient, triclopyr (3,5,6-trichloro-2-pyridinyloxyaceticacid triethylamine salt), and 55.6% "inert" ingredients. "Inert" ingredients include ethanol, triethylamine. Triclopyr is a synthetic plant growth hormone (auxin) that interferes with plant metabolism and allows selective control of woody and broadleaf species (Swadener, 1993). In aquatic ecosystems, this differential response gives triclopyr the ability to remove milfoil and allow non-invasive native monocots and tolerant dicots to proliferate (Antunes-Kenyon and Kennedy, 2004).

Renovate® 3 has been accepted for registration in the State of New York as of October 2006 (see Appendix A). This registration represents a major change in labeling for the active ingredient triclopyr triethylamine salt from terrestrial uses under the Garlon 3A® label, to aquatic uses under the Renovate® 3 label. The Renovate® 3 formulation is sold to SePRO for distribution by the Garlon 3A® manufacturer Dow AgroSciences. As noted above, SePRO is also seeking registration in New York state for the USEPA label-approved Renovate® OTF formulation (see Appendix A).

4.2 Description of Use

Renovate® 3 is labeled for use in lakes, ponds, reservoirs, non-irrigation canals or ditches, marshes, wetlands, and transitional areas adjacent to aquatic sites. Renovate® 3 can be applied to aquatic macrophytes through surface applications from a backpack sprayer, boat, helicopter, spray boom, handgun or other suitable equipment or through sub-surface applications from a boat-mounted distribution system. Applications to terrestrial sites near wetlands can be accomplished via surface applications from a backpack sprayer or vehicle, or directly to individual woody plants through injections or cuts through the bark. The use of mistblowers is not recommended nor may applications be made via chemigation.

4.2.1 Typical Application Methods

Application of Renovate® 3 for the control of a submerged weed like Eurasian milfoil in a pond or lake could consist of either a surface or sub-surface application. For treatment of emergent and floating-leaved species, foliar applications are also conducted. Finally, pending registration with New York, application of Renovate® OTF flakes to deliver the herbicide more effectively to plants growing at depth will also be possible. The application rate would be selected based on the rate chart presented on the product label (see Appendices A and E). Additional details are provided in Section 4.4.3.

4.2.2 Rapid Response

Renovate® 3 has the potential to kill nuisance weeds with only one or two foliar applications. Bending and twisting of leaves and stems is evident almost immediately after application. Delayed symptom development includes root formation on dicot stems, misshapen leaves, stems, and flowers, and abnormal roots. Symptoms are evident on new growth first. Pigment loss (yellow or white), stoppage of growth, and distorted new growth are typical symptoms. Most injury appears in the period of several days to weeks (USEPA, 1998; Purdue, 1996). Following application to Eurasian watermilfoil, chlorotic apices were noted in three days, defoliation and sinking to the sediment surface within 14 days, and necrosis occurring over the next two weeks (Poovey et al., 2004).

4.3 Mode of Action/Efficacy

The mode of action is the overall manner in which an herbicide affects a plant at the tissue or cellular level. Herbicides with the same mode of action will have the same translocation (movement) pattern and produce similar injury symptoms (Purdue, 1996). Triclopyr, along with other herbicides such as clopyralid, fluroxypyr, and picloram, is classified as a picolinic acid (Purdue, 1996). This type of herbicide kills the target weed by mimicking the plant growth hormone auxin (indole acetic acid), and when administered at effective doses, causes uncontrolled and disorganized plant growth that leads to plant death (Tu, et al., 2001). The symptoms typical of auxin mimic herbicides include bending and twisting of stems and petioles, stem swelling (particularly at nodes) and elongation, and leaf cupping and curling.

As a systemic herbicide, killing the entire plant including the roots, triclopyr will generally provide longer efficacy than contact aquatic herbicides, such as endothall, which leave roots alive to regrow (Antunes-Kenyon and Kennedy, 2004).Triclopyr's auxin-type herbicidal activity generally controls woody and broadleaf species while most grasses and other monocots are tolerant (WSSA, 2002; Table 4-1). In contrast, broad-spectrum herbicides kill most, if not all plants, if the dosage is appropriate. Broadleaf herbicides generally kill dicot plants with broad leaves but there are exceptions; some broadleaf herbicides can kill monocots with broad leaf morphology and certain “narrowleaf” (i.e., dissected leaf) dicots are not harmed at concentrations that typically kill broadleaf plants. In aquatic ecosystems, triclopyr treatments exhibit a differential response between monocots and dicots, which generally allows non-susceptible native monocots and tolerant dicots to proliferate while effectively removing susceptible dicots, including Eurasian watermilfoil. However, there are exceptions to this generalization and it is considered in detail below.

Field evaluations with Renovate® 3 have confirmed monocots such as *Phragmites* and American frogsbit, can be controlled with foliar treatments (at labeled rates) where as cattails and grasses are not controlled (Table 4-2). In terms of submerged species, field evaluations have documented “narrowleaf” dicots such as coontail (*Ceratophyllum*), fanwort (*Cabomba*), bladderwort (*Utricularia* spp.) and white watercrow-foot are not controlled with labeled rates of Renovate® 3.

Various studies have shown triclopyr to be an effective herbicide for emersed, submersed and floating macrophyte control. It is highly selective and effective against susceptible submerged species (i.e., watermilfoil spp.) and floating and emersed plant species at a dose range of 0.75 to 2.5 mg/L and 2 -8 quarts per acre respectively. The actual recommended dose will vary based on target species, timing of application and site conditions (i.e., treatment plot size, dilution potential, flow).

Experimental treatments of aquatic environments (Netherland and Getsinger, 1993, Poovey et al., 2003) revealed little or no effect on many monocot naiads and pondweeds, which are among the most valued native species. In addition to these experimental field evaluations, information on the selectivity of Renovate® 3 between monocots and dicots has been confirmed and expanded in recent and ongoing operational lake treatment and aquatic vegetation control programs in the Midwest and Vermont. Results were compiled from several reports from the Indiana Department of Natural Resources (INDNR) Lake and River Enhancement (LARE) Program (available on-line at http://www.in.gov/dnr/fishwild/lare/),as well as from Lake Hortonia and Burr Pond in Vermont (Eichler, 2006). Species sensitivity results from a recent review (Antunes-Kenyon and Kennedy, 2004) are included in Table 4-2, which also indicates species’ monocot or dicot status.

Table 4-2 indicates that for most listed dicots, relative susceptibility to triclopyr is rated at “medium” or “high”, with the exceptions of the following submersed dissected leaf species (*Certaphyllum*, *Cabomba* and *Utricularia*). For the monocots, the relative susceptibility is rated “low” with the following exceptions: *Phragmites*, arrowhead (*Sagittaria spp.*), water hyacinth (*Eichhornia crassipes*), American frogsbit (*Limnobium spongia*), and water stargrass (*Heteranthera dubia*). Moncot species exhibiting “low” susceptibility include some of the more common native species to New York lakes including common waterweed (*Elodea canadensis*), naiad species (*Najas* spp.), ten native pondweeds (*Potamogeton* spp.), and freshwater eelgrass (*Vallisneria americanum*) (a.k.a. wild celery or tapegrass) (Table 4-2).

A laboratory study that measured the efficacy of triclopyr on Eurasian watermilfoil showed that effectiveness increased as both concentration and exposure time increased (Netherland and Getsinger, 1992). Control (defined as 85% reduction in biomass) was achieved in laboratory growth chambers with the following combinations of concentration (active ingredient) and exposure times: 0.25 ppm for 72 hours, 0.5 ppm for 48 hours, 1.0 ppm for 36 hours, 1.5 ppm for 24 hours and 2.0 and 2.5 ppm for 18 hours. Treatment at these concentrations for less than the indicated exposure times will provide less reduction in biomass. Ineffective control resulted when the following combinations of concentration and exposure times were applied; 2.5 ppm for 2 hours, 1.0 ppm for 6 hours and 0.25 and 0.5 ppm for 12 hours. Still, the exposure times at which control was achieved are far less than that necessary with fluridone, the preferred herbicide for most Eursasian watermilfoil control efforts

Application of the maximum recommended label rate (2.5 ppm ae) in 10-15 acre plots located in areas of quiescent waters which promoted extended exposure times led to excellent control of Eurasian watermilfoil for up to two growing seasons (Getsinger and Westerdahl, 1984; Getsinger et al 1997; Petty et al, 1998). Application of lower dosage rates (i.e., 0.5, 1.0, 1.5 ppm ae) in smaller plots (2.5 ac) with relatively short half-lives (2.9-4.2 hours) led to decreased but proportional reduction in Eurasian watermilfoil; with 27% reduction in frequency between pre- and post-application noted in the 0.5 ppm application, 33% reduction in the 1.0 ppm application, and 43% reduction in plots receiving the 1.5 ppm treatment (Poovey et al., 2004). Extrapolation from laboratory studies indicate that in waterbodies where effective concentrations of triclopyr of 0.5 to 1.5 ppm can be maintained for 24 hours, the amount of Eurasian watermilfoil reduction may exceed 85% (Poovey et al., 2004).

SePRO Corporation has conducted pond scale evaluations of foliar and submerged applications of triclopyr (Renovate® 3 and Renovate® OTF) targeting waterchestnut. Initial findings suggest Renovate® 3 may be an effective tool to control or growth regulate waterchestnut. Future evaluations are needed to better understand the dose rate and ability of Renovate® 3 to effectively damage waterchestnut tissue and impact the plants ability to produce viable seeds. Accordingly, SePRO has elected not to provide a recommendation for applying Renovate® 3 to control waterchestnut on the USEPA or NY Supplemental labels at this time.

4.4 Application Considerations that Maximize the Selectivity of Triclopyr

No specific conditions for triclopyr applications are described in 6 NYCRR Part 326 (Registration and Classification of Pesticides). However, any relevant general registration and classification conditions do apply. The Renovate® 3 label does recommend setback distances if the product is applied to lakes, reservoirs or ponds that contain a functioning potable water intake for human consumption (distance varies from 1,300 to over 11,500 feet and depends on application rate, number of acres treated, and type of weeds being treated; see Appendix E). The factors discussed in the following sub-sections should be considered in the application of Renovate® to ensure maximum selectivity of the product.

4.4.1 Method of Application

The method of application of Renovate® 3 should be chosen based on the target macrophyte to be controlled and the overall management objectives of the control program. As described in Section 4.2, Renovate® 3 can be applied to aquatic macrophytes through surface applications or sub-surface applications of the liquid formulation. Renovate® 3 should be applied as evenly as possible over nuisance plant zones. However, certain lake morphometrics may require application uniformly over the entire lake. This should be done to enhance the selectivity of the Renovate® 3 application. The other form of application for Renovate® 3 is through foliar application through spray treatments.

In the future (pending its New York registration), the Renovate® OTF triclopyr flake formulation may aid in achieving multi-year plant control in hydraulically challenging treatment sites (i.e., deep water, high dilution potential) for spot-management. By utilizing a dry flake carrier, triclopyr can be carried onto the target and spatially localized where plants are growing on the substrate.

4.4.2 Time of Application

It is recommended that Renovate® be applied when plants are actively growing, early spring into fall depending on target species. Eurasian watermilfoil initiates productivity and metabolic activity at an earlier time than native plants (Smith and Barko, 1990). They 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.

Utilizing an early growing season application would allow for the treatment of Eurasian watermilfoil prior to dense biomass establishment and while the remaining plant community is still dormant. Additionally, such applications would occur while the water is sufficiently cold so that recreational activities (i.e., swimming, fishing) are limited. However, due to the selective nature of Renovate® treatments can be effective in targeting susceptible species such as Eurasian milfoil throughout the growing season while protecting less susceptible monocots that would be established during a mid to late season treatment program.

4.4.3 Rate of Application

The federally registered application rates are described on the Renovate® 3 and Renovate® OTF labels included in Appendix A. Information on in-water and foliar applications are provided below. (see also NYS 24 C Supplemental Labeling in Appendix E).

<u>In-water application</u>
It is expected that this will be the more common application type and applicable to both Renovate® 3 and Renovate® OTF. The target triclopyr concentration for in-water application ranges from 0.75 to 2.5 ppm ae for Renovate® 3. The target concentration for Renovate® OTF is similar to Renovate® 3 in water 4 feet deep or less. However, in water with an average depth greater than 4 feet deep, do not exceed 270 pounds of formulated Renovate® OTF per acre.

Application rates for individual treatments may be adjusted to reflect site-specific conditions such as the potential for water exchange within the treated area and for the susceptibility of the target macrophytes. Within that range, higher concentrations may be required where applications are made to smaller portions of a waterbody (i.e., shorelines, semi-protected and exposed cove or bay treatments), where a higher level of macrophyte control is desired, and where water movement will cause dilution with untreated water, based on the characteristics of an individual site. Repeat application may be necessary to control subsequent macrophyte regrowth in these areas, but it should not exceed 2.5 ppm triclopyr in a treatment area per annual growing season.

As with any aquatic herbicide treatment, selection of the application rate is subject to the management objectives, site conditions, water movement, applicator knowledge and experience and label language. As suggested by Poovey et al., (2004) and confirmed in operational Renovate® 3 treatment programs, several strategies should be considered to mitigate rapid dissipation, extend the exposure time of triclopyr and ultimately improve control (beyond seasonal) when using triclopyr as a submerged plant management tool. Therefore, the use of weighted and variable depth subsurface injection hoses is suggested when applying Renovate® 3 when targeting deep water invasive weeds to assist in providing adequate exposure of triclopyr throughout the water column. As an alternative (and pending registration with New York), the use of Renovate® OTF may be a more appropriate formulation choice in certain situations where control of target macrophytes located at depth is the objective.

<u>Foliar application</u>
The other major form of treatment of Renovate® 3 is through foliar application. The target application rate of Renovate® 3 for foliar applications to emergent and floating species in aquatic sites and wetlands ranges from 2 to 8 quarts per acre (1.5 to 6 lbs. ae). Higher rates are recommended when plants are mature, when the weed mass is dense, or for difficult to control species. Repeat applications may be necessary to control regrowth or to control missed plants, but do not exceed 6 lbs. a.e. (8 quarts) of Renovate® 3 per acre per

annual growing season. Additional information on foliar application is provided in the labels contained in Appendix A.

4.4.4 Species Susceptibility

Sections 3.4 and 3.5 discuss the potential target macrophytes that are expected to be susceptible to Renovate® 3. Susceptibility will be related to the concentration of Renovate® 3 in the treated water. The aquatic macrophyte species identified by the federal label as controlled by Renovate® 3 are presented in Table 2-1. Table 4-1 presents a list of the woody plants and broadleaf weeds that may also be controlled by Renovate® 3, many of which would likely be located in adjacent riparian areas. Exposure of these plants to Renovate® 3 may occur intentionally, through application to control co-located purple loosestrife, or unintentionally as a result of drift or other accidental means. Table 4-2 provides an updated summary of the susceptibility of aquatic macrophytes, as based on experimental treatments and current lake aquatic vegetation management applications.

Table 4-1 Woody Plants and Broadleaf Weeds Controlled by Renovate ® 3

Woody Plants		
alder	cascara	maples
arrowwood	ceanothus	mulberry
ash	cherry	Oaks
aspen	Chinese tallow	poison ivy
bear clover (bearmat)	chinquapin	poison oak
beech	choke cherry	Poplar
birch	cottonwood	salt-bush (*Baccharis* spp.)
blackberry	crataegus (hawthorn)	sweetgum
blackgum	locust	waxmyrtle
Brazilian pepper	*Maleleuca* (seedlings)	willow
Annual and Perennial Broadleaf Weeds		
burdock	ligodium	tropical sodaapple
Canada thistle	plantain	vetch
curly dock	smartweed	wild lettuce
elephant ear	tansy ragwort	

List of obtained from Renovate® 3 label presented in Appendix A.

Table 4-2 Impact on Renovate to Common Aquatic Plants in New York

Aquatic Plant	Dicot (D) or Monocot (M)	Susceptibility
Emergent Species		
Hydrocotyle spp. (pennywort)	D	high
Ludwigia spp. (waterprimrose)	D	high
Lythrum salicaria (purple loosestrife)	D	high
Phragmites spp (reed grass)	M	medium **
Pontedaria cordata (pickerelweed)	D	high **
Sagittaria spp (arrowhead)	M	medium
Scirpus spp (bulrush)	M	low
Typha spp (cattails)	M	low
Floating Leaf Species		
Brasenia schreberi (watershield)	D	medium
Lemna spp (duckweed)	M	low
Limnobium spongia (American frogsbit)	M	high
Nuphar spp yellow water lily)	D	medium
Nymphaea spp (white water lily)	D	medium
Trapa natans (water chestnut)	D	medium
Submergent Species		
Ceratophyllum demersum (coontail)	D	low
Cabomba caroliniana (fanwort)	D	low
Chara spp (muskgrass)	*	low
Elodea canadensis (common waterweed)	M	low
Egeria densa (Brazilian elodea)	M	low
Heteranthera dubia (water stargrass)	M	medium
Hydrilla verticillata (hydrilla)	M	medium
Myriophyllum aquaticum (parrotfeather)	D	high

Aquatic Plant	Dicot (D) or Monocot (M)	Susceptibility
Myriophyllum sibiricum (northern watermilfoil)	D	high
Myriophyllum spicatum (Eurasian watermilfoil)	D	high
Myriophyllum heterophyllum (Variable milfoil)	D	high
Megalondonta beckii (water-marigold)	D	high
Najas flexilis (bushy pondweed)	M	low
Najas guadalupensis southern naiad	M	low
Potamogeton amplifolius (largeleaf pondweed)	M	low
Potamogeton diversifolius water-thread pondweed	M	low
Potamogeton crispus (curly-leafed pondweed)	M	low
Potamogeton epihydrus (ribbon-leaf pondweed)	M	low
Potamogeton gramineus (variable-leaf pondweed)	M	low
Potamogeton illinoensis (Ilinois pondweed)	M	low
Potamogeton natans (floating leaf pondweed)	M	low
Potamogeton praelongus (white-stem pondweed)	M	low
Potamogeton pusillus (small pondweed)	M	low
Potamogeton robbinsii (Robbins' pondweed)	M	low
Potamogeton zosteriformis (flat-stem pondweed)	M	low
Ranuculus longirostris (white-water crowfoot)	D	low
Stuckenia pectinatus (Sago pondweed)	M	low
Utricularia spp (bladderwort)	D	low
Vallisneria americanum (eelgrass)	M	low

* Macro -algae

** Multiple treatments typically needed to target regrowth

4.4.5 Dilution Effects

To prevent the dilution of the herbicide from reducing efficacy, several recommendations may be made in selecting the appropriate Renovate formulation. If submersed macrophytes in lakes or reservoirs are being targeted with Renovate® 3, it is recommended that treated areas be greater than 5 acres and application rates should be targeted in the higher rate range. Mid to high rates of Renovate® OTF should be selected to obtain effective submersed macrophyte control when targeting areas of higher water exchange, deep water sites, spot treatment of small (less than 5 acre) areas in large water bodies, such as when narrow boat lanes or dock areas are being treated. Application periods should be chosen when heavy rainfall is not expected. Where possible, the efficacy may be improved by restricting the flow of water. Entire littoral zone specific applications provide the greatest opportunity for the long-term control of an invasive species and restoration of native plant communities.

4.5 Triclopyr Product Solubility

Solubility is a physical end point useful for understanding potential environmental impact. High water solubility is frequently associated with mobility and affects distribution in water and soil (WDOE, 2001). The Renovate® 3 and the Renovate OTF MSDS (Appendix A) indicate that the product is miscible in water.

In 2006, SePRO conducted a Good Laboratory Practice (GLP) trial to determine herbicide release and to evaluate use rates in a laboratory system designed to simulate herbicide dilution from a spot treatment. The properties of Renovate® OTF result in a quick release of triclopyr to obtain threshold concentrations, followed by a continual release of triclopyr to maintain sufficient exposure time. Studies indicate that within 24 hours the concentration of triclopyr acid in the water is essentially identical for both granular and liquid forms of triclopyr (i.e., concentration of triclopyr from granular formulation was greater than or equal to 99% of the concentration from the liquid formulation). The liquid formulation reached equilibrium after 1 hour and the granular formulation reached equilibrium after 6 hours (Hahn, 2006). These data indicate that the dissolution rates are similar for both liquid and flake forms of triclopyr.

4.6 Surfactants

The purpose of a surfactant is to increase the surface activity of the applied herbicide, thus reducing both the application rate and the cost of the application. Surfactants are not necessary when using triclopyr products to control submersed vegetation. The Renovate® 3 label (Appendix A) indicates that the addition of a nonionic surfactant to the spray mixture is recommended to improve control of floating and emerged weeds (e.g., waterhyacinth, purple loosestrife). The surfactant manufacturer's label should be consulted for the appropriate application rate and any relevant precautions.

Care should be taken to select a surfactant that has been approved for aquatic use since these products will not harm resident fish or aquatic invertebrates. Some common surfactants used with aquatic herbicides are CideKick®, X-77®, PolyControl® and SunWet® (WDOE, 2001).

4.7 Fate of Triclopyr in the Aquatic Environment

As stated previously, the active ingredient in Renovate® 3 is triclopyr triethylamine salt (TEA). Triclopyr TEA is highly soluble in water and dissociates in less than a minute to the triclopyr acid/anion and triethanolamine. In aquatic conditions triethanolamine is stable (half-life of 14 to 18 days) and then proceeds to rapid microbial degradation to carbon dioxide. However, triethanolamine is stable to degradation under anaerobic aquatic conditions (half-life > 2 years). Because of the rapid microbial degradation under aerobic conditions, it is not expected that volatilization, photodegradation, or bioaccumulation in fish will contribute significantly to the dissipation of triethanolamine (USEPA, 1998). Triclopyr acid is a weak acid which will dissociate completely to the triclopyr anion when the pH is greater than 5 (dissociation constant $pK_a = 2.93$). Therefore, the triclopyr anion will be the predominant moiety present in the environment when products containing triclopyr TEA are used (USEPA, 1998).

Laboratory tests and field dissipation studies indicate that aquatic photolysis and microbial breakdown are significant degradation pathways for triclopyr (Green and Westerdahl, 1989). Dissipation half-lives of triclopyr in water range from 0.5 days to 7.5 days due to photolysis, microbial action, and dilution. In sediment, triclopyr dissipation rates ranged from 2.8 to 5.8 days in field studies. Triclopyr is, however, persistent under anaerobic aquatic conditions. It is highly water soluble and is not expected to bind with organic materials (Antunes-Kenyon and Kennedy, 2004).

4.7.1 Water

Laboratory tests show that aquatic photolysis is a significant degradation pathway for triclopyr (Woodburn et al., 1990). Field dissipation studies indicate that microbial mediated degradation is also important (Antunes-Kenyon and Kennedy, 2004). Photodegradation of triclopyr acid was rapid; the half-life was less than 1 day in sterile solutions and approximately 1 day in natural water. The major photodegradation product observed in sterile solutions was 5-chloro-3,6-dihydroxy-2-pyridinoloxyacetic acid (TCP); oxamic acid was the major degradation product in natural river water (USEPA, 1998). TCP has been shown in laboratory experiments to decompose rapidly upon exposure to UV radiation (half-life 25 min) producing carbon dioxide and many degradation products (Feng, et al., 1998).

Triclopyr acid photodegraded in sterile aqueous buffered solutions (pH 7) with half-lives of 0.6 days (8-9 hours) using natural light (August in Michigan) and 0.36 days using filtered mercury lamps (samples irradiated continuously). The half-lives in river water using natural and artificial light sources were 1.7 and 0.7 days, respectively. Triclopyr acid did not degrade in similar solutions incubated in the dark for up to 3 days. Identified degradates in both sterile solutions and river water were TCP and oxamic acid; TCP was the major degradate in the sterile solutions (up to 48% of the applied), while oxamic acid predominated in the river water (up to 16% of the applied) (USEPA, 1998).

Another metabolite, 3,5,6-trichloro-2-methoxypyridine, or TMP, may also be produced during the derogation of triclopyr acid. It is uncertain whether TMP is a direct degradate of triclopyr, TCP, or both (Petty, et al., 2003).

Laboratory testing suggests that in the absence of light due to murky natural water, direct shading, or floating vegetation mats, the degradation of triclopyr by microbial action would be quite slow, producing the metabolites TCP and TMP only after several months. In addition, chemical hydrolysis would not be a major route of triclopyr degradation. However, the evidence from field studies examining triclopyr dissipation in natural waters seems to contradict these laboratory studies. Field studies indicate that triclopyr in natural waters degrades rather quickly, but at least partially independent of the action of direct photolysis. Applications of triclopyr at the surface of the water or at the subsurface below dense plant mats yielded similar dissipation half-lives, with TCP and TMP being the major degradation products.

It appears that in open systems, water exchange is the most significant factor affecting the predicted dissipation of triclopyr. Triclopyr applied to enclosed systems (ponds) degraded at a predictable rate, regardless of geographic location and light intensity, producing TCP and TMP at predictable levels. This would suggest that a major mechanism for the removal of triclopyr from the aquatic environment is microbial degradation, though the role of photolysis likely remains important in near-surface and shallow waters (Petty, et al., 2003).

4.7.1.1 Aerobic

Triclopyr acid degraded slowly (half-life of 142 days) in a silty clay soil; water system incubated aerobically for 30 days. The only degradate observed was TCP at <5% of the amount applied at 30 days; however, the study was not conducted for a sufficient duration to adequately describe the formation and decline of the degradate TCP. The re-registration document indicated that additional information on the aerobic aquatic metabolism of TCP was required (USEPA, 1998).

4.7.1.2 Anaerobic

Triclopyr acid was persistent under anaerobic conditions in two sandy loam soils incubated anaerobically (flooding plus nitrogen) for 30 days prior to pesticide addition. Triclopyr acid levels decreased to approximately 80% of the applied portion after 365 days. A half-life of 1300 days was calculated from this study. However, confidence in this value is limited because of the extrapolation outside the duration of the study. The only identified degradate was TCP at maximum concentrations of approximately 25% of the original applied level at 365 days post-treatment (USEPA, 1998).

4.7.2 Sediment

The high water solubility of triclopyr acid (430 ppm) along with its partition coefficient values indicate that both triclopyr (K_{oc} 27mg/L) and the degradation product TCP (K_{oc} 151 mg/L) are likely to be mobile in soil and not adsorb to organic materials or sediment (Antunes-Kenyon and Kennedy, 2004). In terrestrial studies, triclopyr was moderately persistent, with persistence increasing as it reaches deeper soil levels and anaerobic conditions (USEPA, 1998). In terrestrial field dissipation studies, low concentrations of triclopyr were found at soil depths of up to 45 cm, however triclopyr did not persist at this depth (Antunes-Kenyon and Kennedy, 2004).

While triclopyr is persistent in anaerobic aquatic environments, it is not found to persist in sediment in field dissipation studies. Based on these studies, the dissipation rates for triclopyr ranged from 2.8 days in a pond in Columbia, Maryland to 5.8 days in Lake Minnetonka, Minnesota. The metabolite TCP also dissipates quickly from the sediment (half-lives ranged from 3.8 days to 13.3 days) (Antunes-Kenyon and Kennedy, 2004).

Based on adsorption/desorption studies using sand, sandy loam, silt loam, and clay loam soils, unaged triclopyr acid, aged triclopyr acid (15 and 30 days aging period), and the degradate TCP were all very mobile. Adsorption was not correlated with cation exchange capacity or organic carbon content. Adsorption of triclopyr was found to be extremely low and reversible with soil adsorption coefficients typically much lower than 1.0 L/Kg (typical range 0.012 to 1.7 L/Kg) (USEPA, 1998).

4.7.3 Aquatic Dissipation

The aquatic dissipation half-lives observed in the field are consistent with the shorter half-lives observed in the photolysis in water studies. In general, results of the available studies suggest that triclopyr acid is rapidly dissipated under aquatic conditions in the field (half-lives ranged from 0.5 to 3.5 days in Lake Seminole, Georgia). Some factors that could affect the rate of dissipation in cases where aqueous photolysis is an important dissipation factor include vegetative cover, type of vegetation, depth of the plot, and suspended sediment (USEPA, 1998).

Triclopyr acid (applied as the TEA salt at 27-30 lb ae/A) dissipated with calculated half-lives of 0.5 and 3.5 days in the surface waters of 10-acre plots located in the Spring Creek arm of Lake Seminole, Georgia, following surface and aerial applications, respectively. The plots were approximately 65-75% covered with vegetation at time of application. The degradate TCP was detected at 0.06-0.18 ppm in surface (1-foot depth) and bottom (3 feet above the bottom) waters 1 to 8 hours after application, but was not detected (<0.05 ppm) in surface or bottom water after 1 day post-treatment. Triclopyr was detected at up to 0.64 ppm in the sediment layer (up to 5-10 cm deep) immediately post-treatment, but was <0.10 ppm (detection limit) at all other sampling intervals. TCP was not detected in the sediment (<0.05 ppm) at any interval (USEPA, 1998).

4.7.4 Bioaccumulation/Biomagnification

The re-registration document for triclopyr indicates that the requirement for fish and non-target organism bioaccumulation studies was waived for triclopyr TEA due to its low octanol/water partition coefficient (K_{ow}<5). Information contained in supplemental studies showed that only slight bioaccumulation (<10x) was observed for triclopyr acid and its degradate TCP (USEPA, 1998).

4.8 Triclopyr Residue Tolerances

The registration of Renovate® 3 for aquatic use in ponds, lakes, reservoirs, and in non-irrigation canals or ditches, was granted after the completion of the 1998 Re-registration Eligibility Decision (RED) (USEPA, 1998), therefore the RED does not consider these uses. The RED considered uses on rice, rangeland and pasture, rights-of-way, forestry and turf, including home lawns, for control of broadleaf weeds and woody plants. At the time of re-registration there were 12-registered products containing triclopyr butoxyethyl ester (BEE) and 24 products containing triclopyr TEA (the active ingredient in Renovate® 3). The Agency determined that all uses, when labeled and used as specified in the RED, were eligible for re-registration (Antunes-Kenyon and Kennedy, 2004).

In establishing or reassessing tolerances, the Food Quality Protection Act of 1996 (FQPA) requires the EPA to consider aggregate exposures to pesticide residues, including all anticipated dietary exposures and other exposures for which there is reliable information, as well as the potential for cumulative effects from a pesticide and other compounds with a common mechanism of toxicity. The Act further directs EPA to consider the potential for increased susceptibility of infants and children to the toxic effects of pesticide residues, and to develop a screening program to determine whether pesticides produce endocrine disrupting effects (USEPA, 1998).

The 1998 RED considered only dietary and drinking water exposure in the aggregate assessment, since other non-occupational exposures to triclopyr were expected to be minimal. EPA uses residue chemistry data to estimate the exposure of the general population to pesticide residues in food and for setting and enforcing tolerances for pesticide residues in food or feed.

Triclopyr tolerances are established for the combined residues of the parent triclopyr acid and its metabolites TCP and TMP in or on the following raw agricultural commodities (40 CFR § 180.417(a)):

- Grass, forage – 500 ppm
- Fish – 3.0 ppm[1]
- Shellfish – 3.5 ppm[1]

Tolerances are also established for the combined residues of only the parent triclopyr acid and its metabolite TCP in or on the following raw agricultural commodities (40 CFR § 180.417(b)):

- Meat, fat, and meat byproducts (except liver and kidney) of cattle, goats, hogs, horses, and sheep – 0.05 ppm
- Liver and kidney of cattle, goats, hogs, horses, and sheep – 0.5 ppm
- Milk – 0.01 ppm
- Rice, grain – 0.3 ppm
- Rice, straw – 10.0 ppm
- Eggs – 0.05 ppm
- Meat, fat, and meat byproducts (except kidney) of poultry – 0.1 ppm

Temporary tolerances were also presented in the re-registration document (USEPA, 1998) for the parent triclopyr acid and its metabolite TCP in or on the following commodities:

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[1] Updated in Federal Register Volume 67 Number 181 September 18, 2002 (USEPA, 2002).

- Fish – 0.2 ppm
- Shellfish – 0.2 ppm
- Water, potable – 0.5 ppm

Renovate® 3 is not registered for use on any agricultural commodities. Although the labeling does not bear any restrictions on fishing or livestock consumption of water from the treatment area, no significant contributions to dietary exposure are expected from the use of Renovate® 3. The following product label prohibitions mitigate much of the potential for additional residues of triclopyr in or on agricultural commodities:

- Prohibition for application via any irrigation system;
- Prohibition on applications where runoff water may flow onto agricultural land; and
- Prohibition on the use of treated water for irrigation until 120-days following application or until non-detectable by laboratory analysis (immunoassay) (Antunes-Kenyon and Kennedy, 2004).

5.0 Significant Environmental Impacts Associated with Renovate®

As a manufactured chemical that is released into the environment, triclopyr, the main component of Renovate®, has been extensively evaluated for non-desired impacts in terrestrial and aquatic ecosystems. Much of this testing and evaluation has been reviewed as a facet of the NYS registration process, which resulted in the registration of Garlon 3A® in New York to control woody plants and broadleaf weeds in selected terrestrial areas.

The following section discusses the potential impacts from the use of Renovate® in the waters of New York State.

5.1 Direct and Indirect Impacts to Non-target Species

Renovate® 3 is formulated as a selective aquatic herbicide for use in the management of unwanted aquatic macrophytes. The main component of Renovate® 3, triclopyr, has been evaluated during the registration process to determine potential adverse effects to non-target species. Direct impacts evaluated include toxicity, chronic changes in behavior or physiology, genetic defects or changes in breeding success or breeding rates for many test organisms. Indirect effects resulting from aquatic plant management may include changes in population size, changes in community structure or changes in ecosystem function. Both direct and indirect impacts can be evaluated at all stages of the life cycle of the non-target organism; though generally, the most sensitive stage of the organism (the young) is the period during which the organism is at greatest risk.

It should be noted that indirect impacts are often positive. For example, by controlling an exotic weed with Renovate® 3, the lake manager can facilitate the restoration of the native plant community. These desired changes in the community structure could be construed as a positive "impact". Additionally, the balance of potential impacts must be considered in relation to the potential impacts from the uncontrolled presence of an exotic nuisance weed in an aquatic environment. The prevention of long-term impacts caused by unwanted aquatic plants may offset a potential short-term impact of the management program.

The direct toxicity of triclopyr-based herbicides to fish and wildlife has been assessed using a variety of acute and chronic laboratory toxicity tests. As supported by extensive toxicological tests conducted during the product development and registration process, triclopyr is reported to be “slightly toxic” to “practically non-toxic” based on the USEPA’s ecotoxicological categories (Table 5-1).

The following sections summarize the potential impacts from the use of Renovate® 3 in the waters of New York State. The majority of the toxicological information was obtained from the USEPA’s *Reregistration Eligibility Decision (RED) for Triclopyr* (USEPA, 1998) and SePRO’s *Technical Bulletin for Renovate®* (SePRO, 2004). Supplemental information was also available in the Washington State’s Department of Ecology *Supplemental Environment Impact Statement Assessments of Aquatic Herbicides* (WDOE, 2001). Table 5-2 summarizes the toxicity data presented in the federal label as presented by the recent SePRO technical bulletin for a number of non-target organisms.

Table 5-1 USEPA Ecotoxicological Categories for Mammals, Birds, and Aquatic Organisms

Acute Oral Toxicity in Mammals (mg/Kg body wt)	Toxicity in Birds		Acute Toxicity in Fish and Invertebrates (mg/L test solution)	Toxicity Ranking
	Acute Oral (mg/Kg body weight)	Dietary (mg/Kg feed)		
<10	<10	<50	<0.1	Very Highly Toxic
10-50	10-50	50-500	0.1-1.0	Highly Toxic
>50-100	>50-500	>50-1000	>1-10	Moderately Toxic
>500-2000	>500-2000	>1000-5000	>10-100	Slightly Toxic
>2000	>2000	>5000	>100	Practically Non-Toxic

Source: Elizabeth Zucker, 1985. Hazard Evaluation Division, Standard Evaluation Procedure, and Acute Toxicity Test for Freshwater Fish. PB86-129277. EPA-540/9-85-006

5.1.1 Macrophytes and Aquatic Plant Communities

Table 2-1 and Section 2.4 discuss those aquatic plants considered to be sensitive to Renovate® 3. Impacts to non-target macrophytes will be dependent on the sensitivity of that macrophyte to Renovate® 3 at the application rate utilized, the time of year of application, and the use rate.

The loss of non-target plants within the aquatic plant community could alter the quality of functions that the vegetative community serves in the aquatic ecosystem. Loss of certain species from the community could alter the available habitat for fish species. The thinning of the macrophyte community could reduce the amount of refuge available to prey species and enhance the success of predators such as smallmouth bass. Such changes could benefit the fishery by altering the size distribution of the fishery (Andrews, 1989). Lillie and Budd (1992) and Pullman (1993) suggest that in plant communities where Eurasian watermilfoil is in its pioneer stage of invasion or in heterogeneous communities where watermilfoil is a component, habitat functions and values of this plant are considered to be comparable with native plant species. Therefore, the control of Eurasian watermilfoil in such communities could positively or negatively impact the associated fish community by temporarily reducing needed cover, shelter and food sources. However, it should be recognized that, once established, Eurasian watermilfoil is opportunistic and aggressive and demonstrates an ability to grow faster than, and displace, native plants (Pullman, 1993; Madsen et al., 1991b). The value of the fishery will then be degraded by loss of plant diversity resulting from excessive Eurasian watermilfoil growth.

According to the Washington State SEIS (WDOE, 2001), target macrophytes like watermilfoil and purple loosestrife will show damage within one to four weeks of application. The biomass of the target species is often reduced by more than 98% after treatment with triclopyr TEA and does not re-grow significantly for one year or more after treatment. Non-target species that were in low numbers and biomass prior to treatment increased in numbers and biomass to four times the levels found in the control. However, while numbers and biomass of the native species may decrease shortly (i.e., 1 to 12 weeks), after treatment of full label dosage, they often compete more effectively and dominate the water column by the end of the season and for a year or more after treatment (Getsinger et al, 1997; Gardner and Grue, 1996; Netherland and Getsinger; 1993 and Petty et al, 1998). Application at lower dosages (0.5 to 1.5 ppm ae) led to either a slight increase or unchanged status for native plants in 7 of 9 test plots (Poovey et al., 2004). Species which increased slightly or remained the same following treatment included bladderwort (*Utricularia vulgaris*), wild celery (*Vallisneria americana*), stargrass (*Zosterella* dubia), naiad (*Najas guadalupensis*), and water marigold (*Megalondonta beckii*). Note that the last two species are on the NYSDEC Protected Plant List (Young, 2004). One species that declined was northern milfoil (*M. sibericum*), a close taxonomic representative of Eurasian watermilfoil.

Table 5-2 Summary of Selected Triclopyr Toxicity

	Study	Organism	Results	Comments
Mammalian Studies [1,2]				
Acute	Oral LD50	Male rat	2,574 mg/kg	Practically non-toxic
	Eye irritation	Rabbit	Corrosive	Severe eye irritant
	Dermal LD50	Rabbit	>2,000 mg/kg	Practically non-toxic
Subchronic	Oral (90 days) NOEL	Mouse	20 mg/kg/day	No effects at this level
	Oral (90 days) NOEL	Rat	30 mg/kg/day	No effects at this level
	Oral (6 months) NOEL	Dog	2.5 mg/kg/day	No effects at this level
Chronic	Oral (22 month) NOEL	Mouse	5.3 mg/kg/day	Not oncogenic
	Oral (2 year) NOEL	Rat	3 mg/kg/day	Not oncogenic
Freshwater Organism Studies [1]				
Fish 96 hour LC50		Bluegill	891 mg/L	Practically non-toxic
Fish 96 hour LC50		Rainbow trout	552 mg/L	Practically non-toxic
Fish 96 hour LC50		Fathead minnow	44 mg/L	Slightly toxic
Non-target Insect		*Daphnia magna*	248 mg/L	No effect on number and size
Avian Studies [1]				
Avian 8 day LC50		Mallard Duck	>10,000 ppm	Practically non-toxic
Avian 8 day LC50		Bobwhite Quail	2,935 ppm	Practically non-toxic
Marine Organism Studies [1]				
Mollusc 96 hour EC50		Eastern oyster	58 mg/L	Slightly toxic
Vertebrate 96 hour LC50		Tidewater silverside	130 mg/L	Practically non-toxic
Invertebrate 96 hour LC50		Grass shrimp	326 mg/L	Practically non-toxic
Algae 120 hour EC50		*Skeletonema costatum*	11 mg/L	Slightly toxic

[1] – Studies conducted with triclopyr TEA unless otherwise noted.

[2] – Subchronic and chronic mammalian studies conducted with triclopyr acid.

Data obtained from SePRO's Technical Bulletin for Renovate® (SePRO, 2004)

As part of the product registration process, aquatic plant testing was required because aerial application and outdoor non-residential use may expose non-target aquatic plants to triclopyr. The results presented in the RED (USEPA, 1998) indicate that exposure levels of 8.80 or greater ppm active ingredient (a.i.) triclopyr TEA may cause detrimental effects to the growth and reproduction of vascular aquatic plant species.

5.1.2 Algal and Planktonic Species

Toxicity testing presented in the RED indicate that algae may be affected from exposure levels of greater than 5.9 ppm a.i. triclopyr TEA or 32.45 ppm a.i. of triclopyr acid (USEPA, 1998). The SePRO technical bulletin presented a 120 hour EC50 of 11 ppm of triclopyr TEA for *Skeletonema costatum* (SePRO, 2004). In ponds treated with triclopyr TEA for the control of Eurasian watermilfoil, the more sensitive blue-green algae forms may have been adversely impacted. However, healthy and diverse populations of algae remained in both treated and untreated ponds. The green algae dominated the water column with *Spirogyra, Cladophora*, *Mougeotia, Volvox, Closterium* and *Scenedesmus* being dominant (WDOE, 2001). The macroalgae (charophytes) also appeared to be unaffected by treatment with triclopyr TEA (Petty et al, 1998).

5.1.3 Fish, Shellfish, and Aquatic Macroinvertebrates

The RED presented acute LC50s for freshwater fish ranging from 240 ppm for the rainbow trout (*Oncorhynchus mykiss*) to 947 for the fathead minnow (*Pimephales promelas*). These result indicate that triclopyr TEA is “practically non-toxic” to freshwater fish on an acute basis (USEPA, 1998). Data presented in the SePRO technical bulletin results in a similar conclusion with acute LC50s ranging from 44 ppm for the fathead minnow (“slightly toxic”) to 891 ppm for the bluegill (“practically non-toxic”) (Mayes et al., 1984; Woodburn et al, 1993; SePRO, 2004).

Freshwater fish early life cycle testing indicated that triclopyr TEA may affect fish at levels greater than 104 ppm, based on a reduction in fish length (USEPA, 1998).

Freshwater invertebrate testing with the water flea (*Daphnia magna*) indicated that triclopyr TEA is “practically non-toxic” to aquatic invertebrates (LC50 or EC50 of 1,496 ppm) on an acute basis (USEPA, 1998). Data presented in the SePRO technical bulletin results indicates that no acute impacts *D. magna* were observed at 248 ppm (SePRO, 2004). Life cycle testing indicated that level of triclopyr TEA above 80.7 ppm may have an adverse effect on *D. magna* reproduction (USEPA, 1998).

Marine species were also included in the suite of registration tests conducted for triclopyr. Acute toxicity testing results indicated that triclopyr TEA is “slightly toxic” to “practically non-toxic” to estuarine/marine invertebrates and “practically non-toxic” to estuarine/marine fish. The lowest EC50 was 58 ppm for the Eastern oyster (*Crassostrea virginica*) based on shell deposition (USEPA, 1998; SePRO, 2004).

5.1.4 Birds

The toxic effects of triclopyr on birds have been investigated in a small number of studies conducted by the Dow Chemical Company and other investigators. These results, presented in the RED (e.g., mallard duck LD50 of 2,055 mg/kg), indicate that triclopyr TEA is considered “practically non-toxic” to avian species on an acute oral basis (USEPA, 1998).

The results of sub-acute dietary tests with the mallard duck and the bobwhite quail indicate that that triclopyr TEA is also “practically non-toxic” to avian species on a sub-acute dietary basis. The LC50s for sub-acute avian dietary assays ranged from 5,401 ppm to >10,000 ppm (USEPA, 1989). Avian LC50s presented in the SePRO Technical Bulletin for Renovate® (SePRO, 2004) ranged from 2,935 ppm for the bobwhite quail to >10,000 ppm for the mallard duck. These values are also within the “practically non-toxic” category.

Chronic avian reproduction studies were required for triclopyr registration because birds may be subject to repeated or continuous exposure to the pesticide, especially preceding or during the breeding season, and the pesticide is stable in the environment to the extent that potentially toxic amounts may persist in animal feed (USEPA, 1998). The avian toxicity discussion in the RED (USEPA, 1998) indicated that an avian reproduction study was not needed for triclopyr BEE and TEA. Therefore, testing for potential reproductive effects was only conducted with the triclopyr acid and not the TEA formulation. Based on this testing, reproduction of birds may be affected at levels greater than 100 ppm triclopyr acid (NOEC level for mallard duck study; USEPA, 1998).

Water fowl are likely to be the most highly exposed bird species, given that they potentially swim, drink and feed on lakes and ponds proposed for treatment with Renovate® 3. However, several factors are likely to mitigate this potential risk since (1) available toxicity values indicate that triclopyr is relatively non-toxic to avian species; (2) the nominal maximum exposure concentration in water is ~2.5 mg/L triclopyr as per maximum application rates; (3) the non-bioaccumulative properties of triclopyr and its metabolites; and (4) the environmental fate characteristics of triclopyr TEA and triclopyr acid demonstrate that they are short-lived in the aquatic environment (see Section 4.7). Overall, it would appear that there are negligible risks to avian species, including those whose diet might consist of aquatic vegetation treated with triclopyr.

5.1.5 Mammals

USEPA (1989) indicated that all three forms of triclopyr (triclopyr acid, TEA, and BEE) were considered bioequivalent with regard to toxicity to mammals. Mammalian acute and chronic testing was conducted with the triclopyr acid and not the TEA formulation. Acute oral rat data for triclopyr acid indicates an LD50 value of 729 and 630 mg/kg in male and female rats, respectively. This data indicates that triclopyr acid is "slightly toxic" to mammals (WDOE, 2001; USEPA, 1998). Data presented in the SePRO Technical Bulletin for Renovate® (SePRO, 2004) presents an oral LD50 of 2,574 mg/kg for male rats. This result indicates triclopyr acid is "practically non-toxic" to mammals on an acute oral basis.

Sub-chronic and chronic mammalian studies were conducted with triclopyr acid, but not with the TEA formulation. A 90 day sub-chronic oral exposure assay found no effects in mice at 20 mg/kg/day triclopyr acid and no effects in rats at 30 mg/kg/day triclopyr acid (SePRO, 2004). A 6-month oral exposure assay with dogs found no effects at 2.5 mg/kg/day triclopyr acid (SePRO, 2004).

Chronic mammalian toxicity data presented in the SePRO Technical Bulletin for Renovate® (SePRO, 2004) indicates that triclopyr acid is not oncogenic. This is based on a 22 month oral dosing rat study with a NOEL of 5.3 mg/kg/day and a 2 year study with a NOEL of 3 mg/kg/day (SePRO, 2004).

A two-generation rat reproduction study was performed using triclopyr acid. The reproductive/systemic NOEL for the rat reproduction study was found to be 25 mg/kg/day based on decreased litter size, decreased body weight and weight gain, and decreased survival of the F1 and F2 litters at the next highest dose level (250 mg/kg/day) (USEPA, 1998).

5.1.6 Reptiles and Amphibians

Limited information was identified on the effects of triclopyr TEA on reptiles or amphibians. The USEPA ECOTOX electronic database was reviewed (11/6/06) resulting in identified information (13 records) for two studies conducted with (3,5,6-trichloro-2-pyridyloxy)acetic acid. However, only two endpoints were recorded (ten records recorded no response (NR) as the endpoint). One study (Nishiuchi, 1989) identified a 48 hour LC50 of >100 mg/L for the frog (*Rana brevipoda porosa)*. Another study (Berrill,et al., 1994) reported 100% mortality values (identified as NR-LETH in the database) between 2.4 and 4.8 mg/L at 48 hours for the bullfrog (*Rana catesbeiana*) and the green frog (*Rana clamitans*). These results indicate a wide range of potential amphibian responses.

Garlon 3A (triclopyr TEA) and Garlon 4 (triclopyr BEE) have been specifically tested for malformations in the frog embryo teratogenesis assay (Perkins et al. 2000). In the Frog Embryo Teratogenesis Assay-Xenopus (FETAX) test, frog (*Xenopus laevis*) embryos were exposed to the test solution in petri dishes for 96-hours. Garlon 3A had an LC50 of 162.5 mg/L and Garlon 4 had an LC50 of 9.3 mg/L. These results indicate that triclopyr TEA is within the "practically non-toxic" ecotoxicity category for *X. laevis*. Field observations in one study indicated that *Rana pipiens* adults and tadpoles remained common 11 weeks after treatment of the Columbia, MO pond site at rates of 2.5 ppm ae (Petty et al, 1998).

5.1.7 Federal and State Listed Rare, Threatened, and Endangered Species

Of the many rare plant species that are native to New York State (see Appendix B for full list of NYSDEC Protected Plants), only six are listed as threatened or endangered under the Endangered Species Act of 1973. These federally-protected plants are an important piece of New York's natural heritage and biodiversity. They are given legal protection in order to ensure the continued survival of the species. These species are not considered to be aquatic plants and it is unlikely that they would come in contact with Renovate® 3 applied as directed on the product label.

However for application in the aquatic environment, there are a number of potentially relevant New York State-protected plant species including endangered, threatened and rare categories (Young, 2004). For purposes of the SEIS, a sub-listing of the aquatic macrophytes (i.e., floating-leaved and submerged plants) was developed for consideration of potential impacts and is presented in Table 5-4. This list was adapted from the New York Natural Heritage Program Protected Plant List and identifies protected plants (endangered, threatened, rare) belonging primarily to the floating-leaved and submerged plant community. These would be the species of interest relevant for applications to treat submerged plants such as Eurasian watermilfoil.

Inspection of this list indicate that with the exception of the native milfoils (*M. alterniflorum, farwellii, pinnatum*), no adverse impacts are predicted at typical label application rates. Prior work has indicated that triclopyr does not adverse impact the monocotyledonous pondweeds (*Potamogeton* spp.) bladderworts (*Utricularia* spp.), and naiads (*Najas* spp.) which often constitute the desirable macrophytes in terms of growth structure and habitat formation (Mattson et al., 2004).

For applications for control of purple loosestrife a potentially much greater number of species may be present in the shoreline and riparian zones. For verification of the status of the much more numerous emergent and semi-aquatic plant species refer to the source document (Young, 2004). As with any herbicide application, whether aquatic or terrestrial in nature, the proponent should contact the New York State Natural Heritage Program to ascertain whether any State-listed protected plants are potentially present in treatment areas and, if present, provide adequate protection and mitigation.

Table 5-3 Federally Listed Threatened or Endangered Plant Species Found in New York State [1]

Name and Federal Status	Description
Northern wild monk's-hood (*Aconitum noveboracense*) Threatened	An herbaceous perennial with distinctive blue, hood-shaped flowers. The plants range from one to four feet in height, with wide, toothed leaves. They prefer to occupy cool sites such as stream sides or shaded cliff sides.
Sandplain gerardia (*Agalinis acuta*) Endangered	A small annual plant with delicate pink blossoms. Six of the twelve known natural populations in the world can be found in coastal grassland areas on Long Island.
Seabeach amaranth (*Amaranthus pumilus*) Threatened	An annual plant with reddish stems and small, rounded leaves. For years it was thought to be extirpated from New York State, until it was found again in 1990. It is found along sandy beaches of the Atlantic coast, where it grows on the shifting sands between dunes and the high tide mark.
Hart's-tongue fern (*Asplenium scolopendrium var americanum*) Threatened	A member of the spleenwort genus with large lanceolate to strap-shaped fronds. Over 90% of the U.S. population of this fern is found in Central New York, where it requires moist, sheltered locations and lime-rich soils.
Floating pennywort (*Hydrocotyle ranunculoides*) Endangered	A small stoloniferous perennial aquatic plant, with floating and emergent leaves. Propagates by rooting at nodes, stem fragments, seed. Found throughout most of eastern and southeastern United States except New England (i.e., northern limit in New York); also Pacific coast.
Leedy's roseroot (*Sedum integrifolium ssp. leedyi*) Threatened	A perennial with waxy, succulent leaves. The flowers are small and densely arranged, with four or five petals, and vary in color from dark red to orange or yellow. It grows on a few cliffs only in New York and Minnesota. This sub-species has probably always been rare, because of its very specific habitat requirements.
Houghton's goldenrod (*Solidago houghtonii*) Threatened	Grows only in the wetlands along the Great Lakes shoreline. It is a perennial with an upright stem and many yellow flower heads, which are arranged in somewhat flat-topped clusters. The leaves are narrow and grouped toward the base of the plant. There are many other goldenrods found in New York, some of which are similar-looking. One way to differentiate Houghton's goldenrod is by confirming the presence of tiny hairs on the flower stalks within the flower cluster.

[1] Information obtained from NYSDEC Endangered Plant Species in New York website http://www.dec.state.ny.us/website/dlf/privland/forprot/endspec/

Table 5-4 New York State Protected Aquatic Macrophytes [1]

Endangered Status	
Callitriche hermaphroditica	Autumn Water-Starwort
Hydrocotyle ranunculoides	Floating Pennywort
Hydrocoyle verticillata	Water-Pennywort
Lemna perpusilla	Minute Duckweed
Lemna valdiviana	Pale Duckweed
Myriophyllum pinnatum	Green Parrot's-Feather
Najas guadalupensis var. *muenscheri*	Muenscher's Naiad
Najas guadalupensis var. *olivacea*	Southern Naiad
Najas marina	Holly-Leaved Naiad
Potamogeton diversifolius	Water-Thread Pondweed
Potamogeton filiformis var.*alpinus*	Slender Pondweed
Potamogeton filiformis var.*occidentalis*	Sheathed Pondweed
Potamogeton ogdenii	Ogden's Pondweed
Potamogeton strictifolius	Straight-Leaf Pondweed
Sagittaria teres	Quill-Leaf Arrowhead
Utricularia inflate	Large Floating Bladderwort
Threatened Status	
Certatophyllum echinatum	Prickly Hornwort
Megalodonta (Bidens) beckii var. *beckii*	Water-Marigold
Myriophyllum alterniflorum	Water Milfoil
Myriophyllum farwellii	Farwell's Water Milfoil
Neobeckia (Rorippa) *aquatica*	Lake-Cress
Podostemum ceratophyllum	Riverweed
Potamogeton alpinus	Northern Pondweed
Potamogeton confervoides	Algae-Like Pondweed
Potamogeton hillii	Hill's Pondweed
Potamogeton pulcher	Spotted Pondweed
Proserpinaca pectinata	Combed-Leaved Mermaid Weed
Sagittaria calycina var. *spongiosa*	Spongy Arrowhead
Utricularia juncea	Rush Bladderwort
Utricularia minor	Lesser Bladderwort
Utricularia radiate	Small Floating Bladderwort
Utricularia striata	Bladderwort
Rare Status	
Isoetes (macrospore) *lacustris*	Large-Spored Quillwort

1 - This list was adapted from the New York Natural Heritage Program Protected Plant List and identifies protected plants belonging primarily to the floating-leaved and submerged plant community. For verification of the status of the much more numerous emergent and semi-aquatic plant species refer to the source document (Young, 2004).

5.2 Potential for Impact of Treated Plant Biomass on Water Quality

Reductions in dissolved oxygen (DO) may be caused by a number of natural events, such as a die-off of the microscopic green plants (phytoplankton) in the pond, or overturns in which oxygen deficient water from the deeper levels of the pond mixes with water in the upper levels and rapid decaying of dead macrophytes. One indirect effect of the use of any “fast acting” and non-selective effective aquatic herbicide is the creation of dead and decaying macrophyte biomass following application. Plants may begin to sink from the lake surface in 1 to 7 days and death of the plant is typically complete in 1 to 3 weeks. This organic material that sinks to the bottom, is subject to bacterial and fungal breakdown, and results in consumption of DO. If the oxygen demand is sufficiently large, a localized DO deficit may occur at the point of treatment that could result in the loss of sensitive fish or invertebrates. Based on the conditions (water temperature, wind/wave conditions, stratified state), these short-term effects may be severe.

If organic biomass is transported internally within the waterbody and enters the hypolimnion of a stratified lake, the severity and duration of hypolimnetic oxygen deficits could be increased. In addition to the lowered DO, water quality may also be affected by the release of nutrients from the dead and decaying macrophyte, with subsequent uptake by phytoplankton. This may lead to an algal bloom and decreased water transparency. Based on the relatively rapid uptake and response to target macrophytes to treatment by Renovate® 3 this release of nutrients could be phased over days to weeks. In the long-term, overall water quality should not be significantly affected since the organic material within the target macrophytes is subject to annual senescence and decay even in the absence of the herbicide.

Petty et al. (1998) reported that dense Eurasian watermilfoil stands in study plots suppressed DO levels in bottom waters by inhibiting circulation and exchange of surface waters, and by contributing greatly to oxygen-consuming respiration processes. Once the Eurasian watermilfoil was removed (2.5 ppm triclopyr applications to 16 acre plots), DO levels rebounded. In both treatment plots (targeting 2.5 ppm), DO levels increased within 1 week post-treatment in the lower half of the water column. When conducting entire littoral zone specific treatments, a significant decline in DO is greatly minimized, since even though the target plant is selectively controlled, the ambient DO is sustained from advective diffusion from untreated deeper waters and through photosynthesis by algae and macrophyte species not affected by triclopyr (Eichler, 2006)

Mitigation of the potential water quality impacts posed by the generation of large amounts of biodegradable biomass may be achieved by limiting the total amount of area treated to less than one half of the total water area. In addition, phasing the timing of treatments and/or providing adjacent untreated areas to act as temporary refugia for aquatic organisms should be incorporated as part of a site-specific IAVMP. In addition, the diversity and coverage of the plant community within the treatment area and susceptibility of select plant species should also be evaluated, as those species not impacted by a treatment (i.e. naiads, coontail, water celery, *Chara*) in many situations would allow adequate DO levels to be sustained following a Renovate® 3 treatment.

5.3 Impact of Residence Time of Renovate® 3 in the Water Column

Renovate® 3 is designed to remain in the water column long enough to produce its effects and then degrade and dissipate. There is no need to retain elevated dose concentrations in the water column for extended periods of time (days to weeks) or periodically reapply to “bump up” concentrations which may be required for other aquatic herbicides (e.g., fluridone). As discussed in the previous sections, Renovate® 3 is a relatively fast acting (effects observed within days to weeks) systemic herbicide that degrades with an average half-life in the laboratory of <1 to 3.5 days in the water column (see Section 4.7.3 for details). Field studies in geographically diverse locations (i.e., CA, GA, MN, MO, TX, WA) have shown triclopyr and its major breakdown products (i.e., TCP and TMP metabolites) dissipated from water with half-lives ranging from 5.9 to 7.5 (mean of 6.5 days) and 4.0 to 10 days (mean of 6.1 days), respectively (Petty et al., 2003). Therefore, it is not anticipated that an extended residence time in the water column would be a significant factor or would cause secondary potential impacts.

5.4 Recolonization of Non-target Plants after Control of Target Plants is Achieved

Following application of Renovate® 3, rapid recolonization and/or increase of pre-application cover of the bottom areas by non-susceptible native plants is expected. By selective removal and decrease of biomass of Eurasian watermilfoil, local native plants will likely experience an increase in light availability (particularly lower in the plant canopy) and available physical habitat, thus facilitating growth. Increases in submerged native pondweeds, bladderwort (*Utricularia vulgaris*), wild celery (*Vallisneria americana*), stargrass (*Zosterella dubia*), naiad (*Najas guadalupensis*), and water marigold (*Megalondonta beckii*), were noted in test plots given applications of 0.5 to 1.5 ppm ae in Minnesota ponds (Poovey et al., 2004). Important floating-leaved target species (e.g., *Nuphar, Nymphaea*) are susceptible when treated by direct foliar spray but they are largely unaffected by sub-surface application of Renovate® 3, therefore treatment for Eurasian watermilfoil should not decrease their abundance nor diminish their presence for fishery habitat. Release of nutrients following decay and breakdown of the milfoil could increase concentrations in the local environment, with potential uptake and growth by phytoplankton, periphyton, or benthic macroalgae (*Chara, Nitella*).

Overall, the colonization of native species expected after control of target nuisance plants is achieved should be rapid and effective. The relative success of the short-term expansion of the native plant community will be dependent on the percent reduction of the nuisance species, which is a function of the application dosage, contact period, size of application, and seasonal timing of application. The longevity of the increased native plant success will depend on the long-term suppression of the nuisance species through application of a successful IAVMP. Substantial removal of standing Eurasian watermilfoil shoots and reduced frequency of the plant can be obtained in the same season as the treatment, but complete kill of rootcrowns may not occur due to dosage or exposure limitations. Without further treatment recovery of milfoil to nuisance levels can occur within the next growing season (Poovey et al., 2004).

5.5 Impacts on Coastal Resource

At the present time, application of Renovate® 3 is expected to be limited to largely freshwater setting and is not currently intended for use in the marine environment (label indicates not to applied to saltwater bays or estuaries). However, potential downstream migration of the product from application areas into estuarine or marine environments is possible. As noted in Section 5.1.3, the use of Renovate® 3 at the recommended application rates has very little potential to result in an adverse impact to marine species. The likelihood of any affect is also small due to the short half-life of the product and the potential for significant dilution in estuarine and marine environments due to waves, tidal action, etc.

If the use of Renovate® 3 is proposed to be located within the NYS Coastal Zone and is determined to require federal licensing, permitting, or approval, or involves federal funding, then the action would be subject to the NYS Coastal Zone Management Program (19 NYCRR Section 600). This determination would be required during the preparation of an individual permit application.

6.0 Potential Public Health Impacts of Renovate®

6.1 Brief Overview of Triclopyr Toxicity

An overview of the toxicology information indicates that triclopyr is not considered to be a carcinogen, mutagen or to cause adverse reproductive effects or birth defects. Triclopyr is considered to have a low degree of systemic toxicity based on findings from acute and subchronic toxicology studies (WDOE, 2001).

6.1.1 Acute Toxicity

There are four FIFRA acute Toxicity Categories, numbers I through IV (USEPA, 2003). Category I designates pesticides being the most toxic or irritating, while Category IV represents the least toxic or irritating chemicals. Pesticides in Categories II and III fall in between the two extremes. The acute oral, acute dermal, and acute inhalation toxicity of triclopyr are in Categories III, IV and IV, respectively. The skin irritation study in rabbits placed triclopyr in Category IV, indicating that it is non-irritating to the skin. The main adverse health effect appears to be associated with eye contact with concentrated triclopyr, which can result in severe eye irritation and damage. Results of undiluted triclopyr in acute eye irritation studies place the chemical in Toxicity Category I as causing irreversible eye damage (WDOE, 2001).

The results of a rat acute oral toxicity study determined that the LD_{50} (dose causing lethality in 50% of the test animals) was approximately 2,000 mg/kg. The acute dermal LD_{50} was > 5,000 mg/kg based on a study in rabbits. A rat acute inhalation toxicity study resulted in a 4-hour LC_{50} (concentration causing lethality in 50% of the test animals) of >2.6 mg/L (WDOE, 2001).

SePRO recently conducted acute toxicity studies on the granular form of triclopyr (conducted by Product Safety Laboratories). These studies were completed in January, 2006. The results of these studies are generally similar to the previous acute toxicity study results summarized in WDOE (2001). An acute oral toxicity study in rats showed that the single dose acute oral LD_{50} of the test substance is greater than 5,000 mg/kg of body weight in male and female rats. An acute dermal toxicity study in rats showed that the single dose acute dermal LD_{50} of the test substance is greater than 5,000 mg/kg of body weight in male and female rats.

As part of the toxicity testing of triclopyr, inhalation studies were conducted even though the very low vapor pressure of triclopyr ($1.26*10^{-6}$ mmHg at 25^{o}C) makes it unlikely that the chemical vapor will be a health problem (Chakrabarti, 1988). An acute inhalation study based on the flake form of triclopyr showed the exposure acute inhalation LC_{50} for triclopyr is greater than 2.04 mg/L in male and female rats. Previous acute inhalation studies with triclopyr TEA resulted in an LC_{50} of >2.6 mg/L. The report by Product Safety Laboratories states that triclopyr meets the requirements for Toxicity Category IV for inhalation toxicity. Based on the results of the rat acute inhalation study and the large size of the spray droplets, it is considered unlikely that applicator workers or bystanders will be overexposed to triclopyr during aquatic herbicidal (WDOE, 2001).

A dermal sensitization study in guinea pigs indicated that triclopyr is not a contact sensitizer, since no skin response was noted at any of the doses tested. A primary skin irritation study conducted with rabbits showed that triclopyr is classified as non-irritating to the skin. A primary eye irritation study conducted with rabbits classified triclopyr as moderately irritating to the eye.

6.1.2 Subchronic and Chronic Toxicity

Results of a rat triclopyr 13-week dietary feeding study consisting of doses of 0, 5, 20, 50, 200 or 300 mg/kg-day demonstrated that animals in the 2 high dose groups displayed signs of decreased food consumption and body weight gain. None of the animals demonstrated any signs of systemic toxicity. No toxic effects were observed in a 1-year dog dietary study at doses of 5 mg/kg-day. In a 21-day rat subchronic triclopyr dermal study with doses up to 342 mg/kg-day, there were no signs of toxicity or deaths during the 21-day test period. However, there was a dose-response degree of dermal irritation (WDOE, 2001).

The chronic or lifetime exposure effects from triclopyr have been evaluated in the mouse and rat. The findings from the investigations all show that triclopyr does not demonstrate any carcinogenic potential. In 1995, USEPA classified triclopyr as a Group D chemical (not classifiable as to human carcinogenicity). A 2-year rat triclopyr dietary study at doses up to 36 mg/kg-day showed that the high dose groups had increased kidney weights, but no signs of systemic toxicity. A mouse triclopyr lifetime feeding study at doses up to 1,250 mg/kg-day showed that the high dose groups had a significant decrease in body weights, but no signs of systemic toxicity. Various reproduction and teratology toxicology studies have not shown any evidence that triclopyr is associated with reproductive dysfunction or teratological effects (WDOE, 2001).

6.1.3 Metabolism

Metabolism and distribution tests have shown that triclopyr is rapidly absorbed from the gut and primarily excreted in the urine as the parent compound. Tests in rats showed that approximately 94% of the dose was excreted in the urine with an average half-life of 10 hours. The parent compound was excreted mainly unchanged. Triclopyr is poorly absorbed through the skin. Results of rabbit acute and subchronic investigations and a human dermal penetration study revealed that the chemical does not readily absorb through the skin (WDOE, 2001).

6.2 New York State Drinking Water Standard

There are no specific drinking water standards available for triclopyr. Section 702.15 of 6 NYCRR (Derivation of Guidance Values) states that a “general organic guidance value” of 50 ug/L may be used for an individual organic substance. In the Reregistration Eligibility Decision (RED; USEPA, 1998) for triclopyr, USEPA has developed a Reference Dose (RfD) for triclopyr of 0.05 mg/kg-day. An RfD is defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used (USEPA, 2005). RfDs are used in risk assessments to assess risks and define acceptable limits of chemical exposure. The RfD may be used to develop a screening level acceptable concentration of triclopyr in drinking water. Using the RfD of 0.05 mg/kg-day and assuming that a 60-kg adult female drinks 2 L of water per day results in an acceptable concentration of triclopyr in drinking water of 1,500 ug/L.

$$Concentration(ug/L) = \frac{0.05mg/kg-day \times 60kg \times 1000ug/mg}{2L/day} = 1500ug/L$$

Even assuming a 20% source contribution factor (which is often used by USEPA in setting drinking water standards), the resultant concentration is 300 ug/L. This concentration is higher than 50 ug/L, so the 50 ug/L general organic guidance value should be adequately protective for drinking water.

While it is very unlikely that triclopyr would impact a drinking water source, potential risk to humans via drinking water due to application of Renovate® 3 is minimal because:

- Triclopyr use in waters of New York used for drinking water purposes is highly regulated and expected to result in intermittent exposures to those using such waters;

- Renovate® 3 labeling requires minimum setback distances in order to make applications in proximity to functioning potable water intakes (see: Table 4: Minimum Setback Distances from Functioning Potable Water Intakes in Appendix D): and
- Functioning potable water intakes must be turned off until the triclopyr level in the intake water is determined to be 50 ppb or less by laboratory analysis or immunoassay.

6.2.1 Risk from Recreation Exposure

A more likely exposure scenario would be someone swimming in a pond or lake that has been treated with triclopyr. The Washington State Department of Ecology (Triclopyr Questions and Answers; WDOI, undated) conducted a swimmer exposure assessment. The most conservative scenario considered was a six-year old who swims for three hours and inadvertently swallows 150 ml of water from a lake treated with the maximum allowable rate of triclopyr. The estimated amount the child would absorb in this scenario was still more than 100 times less than the daily dose animals were fed over their lifetime with no observable adverse effects. These results indicate that triclopyr application would not harm humans who may be exposed while swimming in a lake.

The Renovate® 3 product labeling does not bear any restrictions on use of water in the treatment area for recreational purposes, including swimming and fishing. Given that triclopyr residues in water degrade rapidly via photolysis, the risks from exposure to triclopyr via a recreational uses should be negligible based on the following:

- That triclopyr is slightly toxic via acute oral and dermal route of exposure and is not a dermal sensitizer;
- That triclopyr use in waters of New York used for recreational purposes is highly regulated and expected to result in intermittent exposures to those using such waters; and

6.2.2 Summary of Human Health Risk Concerns

When the USEPA established the tolerance for combined residues of triclopyr and its metabolites it conducted a comprehensive risk assessment using modeling and risk assessment techniques to estimate maximum exposure potential from all sources (total aggregate exposure) including food, drinking water, and residential uses. This risk assessment concluded that there is a reasonable certainty that no harm will result to the general population and to infants and children from aggregate exposure to triclopyr and TCP (Antunes-Kenyon and Kennedy, 2004).

7.0 Alternatives to Renovate ® 3

This section details various alternatives to the proposed action. Specifically, this evaluation considers the advantages and disadvantages of potential macrophyte control treatment alternatives other than use of Renovate® 3. These other potential alternatives to the use of Renovate® 3 include those based on physical control (manipulations of light, water depth, substrate, etc.), chemical control (other aquatic herbicides), and biological controls (herbivorous fish, insects, etc.), as well as the no-action alternative (which entails the lack of any aquatic macrophyte control measure). The no-action alternative does not preclude the ability of an applicant to apply for a permit for the use of those products described in the Final Programmatic Environmental Impact Statement on Aquatic Vegetation Control (NYSDEC, 1981a). Each of the possible macrophyte control treatment alternatives should be evaluated from the standpoint of efficacy, positive and negative environmental impacts, and relative costs. The choice of a particular alternative over the proposed use of Renovate® 3 should be based on the management objectives for the waterbody and the specific characteristics of the problem.

7.1 Identification of Relevant Macrophyte Control Treatment Alternatives

There are a large number of control treatments potentially available for use to control non-desirable macrophyte populations. The various methods typically used to control aquatic plants are summarized in Table 7-1 (adapted from Wagner (2001), categorized by the principal mode of action (i.e., either physical, chemical or biological)). Table 7-1 provides a quick summary of the mode of action, advantages and disadvantages for these alternatives. The three classes of macrophyte treatment control alternatives are introduced briefly below, with additional detailed information on the specific alternatives provided later in this section.

Physical treatment alternatives refer to macrophyte control treatment alternatives that work primarily by altering the light regime, the depth or nature of the benthic substrate, or the elevation of overlying surface water. These macrophyte control treatment alternatives include:

- Benthic Barriers - Placement of materials on the bottom of a lake to cover and impede the growth of macrophytes;
- Dredging – removal of underlying sediment through various methods (dry, wet, pneumatic) to either remove suitable or nutrient-rich substrate or to decrease available light (attenuation);
- Dyes and surface covers – Addition of coloring agents or sheet material to inhibit light penetration and reduce vascular plant growths;
- Harvesting - Multiple methods of mechanical plant cutting, with or without removal, and algal collection; and
- Drawdown - Lowering of the water level to dry and freeze susceptible vegetation.

Table 7-1 Management Options for Control of Aquatic Plants (adapted from Wagner, 2001)

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
PHYSICAL CONTROLS			
1) Benthic barriers	• Mat of variable composition laid on bottom of target area, preventing growth • Can cover area for as little as several months or permanently • Maintenance improves effectiveness • Usually applied around docks, in boating lanes, and in swimming areas	• Highly flexible control • Reduces turbidity from soft bottoms • Can cover undesirable substrate • Can improve fish habitat by creating edge effects	• May cause anoxia at sediment-water interface • May limit benthic invertebrates • Non-selective interference with plants in target area • May inhibit spawning/feeding by some fish species
1.a) Porous or loose-weave synthetic materials	• Laid on bottom and usually anchored by weights or stakes • Removed and cleaned or flipped and repositioned at least once per year for maximum effect	• Allows some escape of gases which may build up underneath • Panels may be flipped in place or removed for relatively easy cleaning or repositioning	• Allows some growth through pores • Gas may still build up underneath in some cases, lifting barrier from bottom
1.b) Non-porous or sheet synthetic materials	• Laid on bottom and anchored by many stakes, anchors or weights, or by layer of sand • Not typically removed, but may be swept or "blown" clean periodically	• Prevents all plant growth until buried by sediment • Minimizes interaction of sediment and water column	• Gas build up may cause barrier to float upwards • Strong anchoring makes removal difficult and can hinder maintenance
1.c) Sediments of a desirable composition	• Sediments may be added on top of existing sediments or plants. • Use of sand or clay can limit plant growth and alter sediment-water interactions. • Sediments can be applied from the surface or suction dredged from below muck layer (reverse layering technique)	• Plant biomass can be buried • Seed banks can be buried deeper • Sediment can be made less hospitable to plant growths • Nutrient release from sediments may be reduced • Surface sediment can be made more appealing to human users • Reverse layering requires no addition or removal of sediment	• Lake depth may decline • Sediments may sink into or mix with underlying muck • Permitting for added sediment difficult • Addition of sediment may cause initial turbidity increase • New sediment may contain nutrients or other contaminants • Generally too expensive for large scale application

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
2) Dredging	• Sediment is physically removed by wet or dry excavation, with deposition in a containment area for dewatering/disposal • Dredging can be applied on a limited basis, but is most often a major restructuring of a severely impacted system • Plants and seed beds are removed and re-growth can be limited by light and/or substrate limitation	• Plant removal with some flexibility • Increases water depth • Can reduce pollutant reserves • Can reduce sediment oxygen demand • Can improve spawning habitat for many fish species • Allows complete renovation of aquatic ecosystem	• Temporarily removes benthic invertebrates • May create turbidity • May eliminate fish community (complete dry dredging only) • Possible impacts from containment area discharge • Possible impacts from dredged material disposal • Interference with recreation or other uses during dredging • Usually very expensive
2.a) "Dry" excavation	• Lake drained or lowered to maximum extent practical • Target material dried to maximum extent possible • Conventional excavation equipment used to remove sediments	• Tends to facilitate a very thorough effort • May allow drying of sediments prior to removal • Allows use of less specialized equipment	• Eliminates most aquatic biota unless a portion left undrained • Eliminates lake use during dredging
2.b) "Wet" excavation	• Lake level may be lowered, but sediments not substantially dewatered • Draglines, bucket dredges, or long-reach backhoes used to remove sediment	• Requires least preparation time or effort, tends to be least cost dredging approach • May allow use of easily acquired equipment • May preserve most aquatic biota	• Usually creates extreme turbidity • Tends to result in sediment deposition in surrounding area • Normally requires intermediate containment area to dry sediments prior to hauling • May cause severe disruption of ecological function • Impairs most lake uses during dredging

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
2.c) Hydraulic (or pneumatic) removal	• Lake level not reduced • Suction or cutterhead dredges create slurry which is hydraulically pumped to containment area • Slurry is dewatered; sediment retained, water discharged	• Creates minimal turbidity and limits impact on biota • Can allow some lake uses during dredging • Allows removal with limited access or shoreline disturbance	• Often leaves some sediment behind • Cannot handle extremely coarse or debris-laden materials • Requires advanced and more expensive containment area • Requires overflow discharge from containment area
3) Dyes and surface covers	• Water-soluble dye is mixed with lake water, thereby limiting light penetration and inhibiting plant growth • Dyes remain in solution until washed out of system. • Opaque sheet material applied to water surface	• Light limit on plant growth without high turbidity or great depth • May achieve some control of algae as well • May achieve some selectivity for species tolerant of low light	• May not control peripheral or shallow water rooted plants • May cause thermal stratification in shallow ponds • May facilitate anoxia at sediment interface with water • Covers inhibit gas exchange with atmosphere
4) Mechanical removal ("harvesting")	• Plants reduced by mechanical means, possibly with disturbance of soils • Collected plants may be placed on shore for composting or other disposal • Wide range of techniques employed, from manual to highly mechanized • Application once or twice per year usually needed	• Highly flexible control • May remove other debris • Can balance habitat and recreational needs	• Possible impacts on aquatic fauna • Non-selective removal of plants in treated area • Possible spread of undesirable species by fragmentation • Possible generation of turbidity
4.a) Hand pulling	• Plants uprooted by hand ("weeding") and preferably removed	• Highly selective technique	• Labor intensive • Difficult to perform in dense stands
4.b) Cutting (without collection)	• Plants cut in place above roots without being harvested	• Generally efficient and less expensive than complete harvesting	• Leaves root systems and part of plant for re-growth • Leaves cut vegetation to decay or to re-root • Not selective within applied area

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
4.c) Harvesting (with collection)	• Plants cut at depth of 2-10 ft and collected for removal from lake	• Allows plant removal on greater scale	• Limited depth of operation • Usually leaves fragments which may re-root and spread infestation • May impact lake fauna • Not selective within applied area • More expensive than cutting
4.d) Rototilling	• Plants, root systems, and surrounding sediment disturbed with mechanical blades	• Can thoroughly disrupt entire plant	• Usually leaves fragments which may re-root and spread infestation • May impact lake fauna • Not selective within applied area • Creates substantial turbidity • More expensive than harvesting
4.e) Hydroraking	• Plants, root systems and surrounding sediment and debris disturbed with mechanical rake, part of material usually collected and removed from lake	• Can thoroughly disrupt entire plant • Also allows removal of stumps or other obstructions	• Usually leaves fragments which may re-root and spread infestation • May impact lake fauna • Not selective within applied area • Creates substantial turbidity • More expensive than harvesting
5) Water level control	• Lowering or raising the water level to create an inhospitable environment for some or all aquatic plants • Disrupts plant life cycle by dessication, freezing, or light limitation	• Requires only outlet control to affect large area • Provides widespread control in increments of water depth • Complements certain other techniques (dredging, flushing)	• Potential issues with water supply • Potential issues with flooding • Potential impacts to non-target flora and fauna

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
5.a) Drawdown	• Lowering of water over winter period allows desiccation, freezing, and physical disruption of plants, roots and seed beds • Timing and duration of exposure and degree of dewatering are critical aspects • Variable species tolerance to drawdown; emergent species and seed-bearers are less affected • Most effective on annual to once/3 yr. basis	• Control with some flexibility • Opportunity for shoreline clean-up/structure repair • Flood control utility • Impacts vegetative propagation species with limited impact to seed producing populations	• Possible impacts on contiguous emergent wetlands • Possible effects on overwintering reptiles and amphibians • Possible impairment of well production • Reduction in potential water supply and fire fighting capacity • Alteration of downstream flows • Possible overwinter water level variation • Possible shoreline erosion and slumping • May result in greater nutrient availability for algae
5.b) Flooding	• Higher water level in the spring can inhibit seed germination and plant growth • Higher flows which are normally associated with elevated water levels can flush seed and plant fragments from system	• Where water is available, this can be an inexpensive technique • Plant growth need not be eliminated, merely retarded or delayed • Timing of water level control can selectively favor certain desirable species	• Water for raising the level may not be available • Potential peripheral flooding • Possible downstream impacts • Many species may not be affected, and some may be benefitted • Algal nuisances may increase where nutrients are available
CHEMICAL CONTROLS			
6) Herbicides	• Liquid or pelletized herbicides applied to target area or to plants directly • Contact or systemic poisons kill plants or limit growth • Typically requires application every 1-5 yrs	• Wide range of control is possible • May be able to selectively eliminate species • May achieve some algae control as well	• Possible toxicity to non-target species • Possible downstream impacts • Restrictions of water use for varying time after treatment • Increased oxygen demand from decaying vegetation • Possible recycling of nutrients to allow other growths

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
6.a) Forms of endothall (7-oxabicyclo [2.2.1] heptane-2,3-dicarboxylic acid)	• Contact herbicide with limited translocation potential • Membrane-active chemical which inhibits protein synthesis • Causes structural deterioration • Applied as liquid or granules	• Moderate control of some emersed plant species, moderately to highly effective control of floating and submersed species • Limited toxicity to fish at recommended dosages • Rapid action	• Non-selective in treated area • Toxic to aquatic fauna (varying degrees by formulation) • Time delays on use for water supply, agriculture and recreation • Safety hazards for applicators
6.b) Forms of diquat (6,7-dihydropyrido [1,2-2',1'-c] pyrazinediium dibromide)	• Contact herbicide • Absorbed by foliage but not roots • Strong oxidant; disrupts most cellular functions • Applied as a liquid, sometimes in conjunction with copper	• Moderate control of some emersed plant species, moderately to highly effective control of floating or submersed species • Limited toxicity to fish at recommended dosages • Rapid action	• Non-selective in treated area • Toxic to zooplankton at recommended dosage • Inactivated by suspended particles; ineffective in muddy waters • Time delays on use for water supply, agriculture and recreation
6.c) Forms of glyphosate (N-[phosphonomethyl glycine)	• Contact herbicide • Absorbed through foliage, disrupts enzyme formation and function in uncertain manner • Applied as liquid spray	• Moderately to highly effective control of emersed and floating plant species • Can be used selectively, based on application to individual plants • Rapid action • Low toxicity to aquatic fauna at recommended dosages • No time delays for use of treated water	• Non-selective in treated area • Inactivation by suspended particles; ineffective in muddy waters • Not for use within 0.5 miles of potable water intakes • Highly corrosive; storage precautions necessary

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
6.d) Forms of 2,4-D (2,4-dichlorophenoxyl acetic acid)	• Systemic herbicide • Readily absorbed and translocated throughout plant • Inhibits cell division in new tissue, stimulates growth in older tissue, resulting in gradual cell disruption • Applied as liquid or granules, frequently as part of more complex formulations, preferably during early growth phase of plants	• Moderately to highly effective control of a variety of emersed, floating and submersed plants • Can achieve some selectivity through application timing and concentration • Fairly fast action	• Variable toxicity to aquatic fauna, depending upon formulation and ambient water chemistry • Time delays for use of treated water for agriculture and recreation • Not for use in water supplies
6.e) Forms of fluridone (1-methyl-3-phenyl-5-[-3-{trifluoromethyl} phenyl]-4[IH]-pyridinone)	• Systemic herbicide • Inhibits carotenoid pigment synthesis and impacts photosynthesis • Best applied as liquid or granules during early growth phase of plants	• Can be used selectively, based on concentration • Gradual deterioration of affected plants limits impact on oxygen level (BOD) • Effective against several difficult-to-control species • Low toxicity to aquatic fauna	• Impacts on non-target plant species possible at higher doses • Extremely soluble and mixable; difficult to perform partial lake treatments • Requires extended contact time

Chemical treatment alternatives refer to macrophyte control treatment alternatives that work primarily by application of chemical agents (aquatic herbicides) to directly kill the aquatic macrophytes. These include registered aquatic herbicides which differ in both application and mode of chemical action (general, systemic). For purposes of this analysis we will consider five of the major pesticides registered for use in New York State: Diquat, Endothall, Glyphosphate, 2,4-D, and Fluridone.

Biological treatment alternatives refer to macrophyte control treatment alternatives that work primarily by interaction of other species with the target macrophytes. These may include the stocking or manipulation of phytophagous (i.e., plant-eating) fish and invertebrates to control macrophytes through biological interactions.

7.2 Integrated Plant Management

As described briefly above and discussed in greater detail in the following sections, there is a potentially large selection of possible macrophyte control treatments or technologies that exist. However, not all techniques are appropriate for a given lake and/or to effectively address nuisance macrophyte concerns. Furthermore, techniques may either be non-compatible or may exacerbate the problem (e.g., harvesting of pioneer water milfoil stand leading to fragmentation and widespread colonization of the lake). Given the potentially high costs necessary for extensive whole lake treatments, it is important that the appropriate techniques be used to maximize the benefits that such treatments can provide. In addition, there are potential societal conflicts that can occur between groups of lake users, who may have very different ideas regarding the best use of the lake. Therefore, it is important that the selection of any macrophyte control treatment, including herbicides, be conducted as a result of a well thought-out long-term Integrated Aquatic Vegetation Management Plan (IAVMP). This approach is also consistent with NYSDEC guidance, which endorses the development of an

Aquatic Plant Management Plan as an important component of any strategy to deal with nuisance macrophytes (Appendix A in NYSDEC, 2005).

There are many guidance documents that describe the steps and necessary data to be collected in developing an IAVMP (e.g., Hoyer and Canfield, 1997; WA DOE, 2004; NYSDEC, 2005). These methodologies are roughly equivalent and are likely to include the following components (adapted from WA DOE, 2004):

- **Develop a Problem Statement** – the problem statement summarizes the types, locations, and density of problem aquatic vegetation, and identifies the nature and the extent to which beneficial water uses are being impaired;
- **Describe Past Management Efforts** – summarizes the previous efforts at chemical and non-chemical plant control methods (for last 5 years or longer) and identifies the organizations (e.g., county, lake association, beach association, etc) that sponsored them (this last step is important in identifying possible stakeholders);
- **Define Management Goals** – based on the problem statement and previous experiences in plant control, and the characteristics of the lake, the management goals define what is to be achieved in response to the aquatic plant problems. Defining goals helps in selection of appropriate control treatments. The scope of the management efforts should cover at least 5 years:
- **Determine Waterbody and Watershed Characteristics** – identify geographic limits, land use, potential point and non-point sources, and tributary systems within the waterbody watershed. Provide basic information on the lake size, depth, water quality, residence time, sediment types, water uses, riparian uses (including wetlands), biotic communities (aquatic plants, fish, amphibians, waterfowl), and identify any listed threatened or endangered (T&E) species within or adjacent to the lake;
- **List the Beneficial Uses of the Waterbody** – list the beneficial uses of the waterbody; map their location (this will allow for matching control treatments to within lake habitats and/or recreational focal points);
- **Map Aquatic Plants** – map the approximate location and species of aquatic plants, the sediment depth and type, water depths (bathymetry), locations of wetlands, and location of any T&E species. Correct identification is essential in order to prevent the eradication of rare and endangered species and to document the plant population so that it can be monitored over time (Hellquist, 1993; Crow and Hellquist, 2000). A listing of plants considered rare, threatened or endangered in New York is available in Appendix B. Based on the beneficial uses identified in the step above, indicate whether a high or low level of aquatic plant control is desired. In some cases, no control may be appropriate (i.e., leaving intact aquatic vegetation in selected locations to support fish populations);
- **Identify the Aquatic Plant Control Treatment Alternatives** – identify and screen potential control treatment alternatives, their effectiveness, environmental impacts, human health risks, and costs. For some lakes, several treatment techniques may be immediately eliminated from further consideration, based on the waterbody and watershed characteristics;
- **Select the Aquatic Plant Control Treatment Method(s)** – an IAVMP plan needs to be waterbody-specific and is likely to involve a combination of methods. This step involves choosing the best control treatment (or set of methods) that best achieves the long-term management goals, with least impacts to the environment and is cost-effective;
- **Public Involvement** - the IAVMP should be a consensus document, with support or acceptance by major stakeholders and permitting agencies. The draft IAVMP should be presented in public meeting and public and regulatory comments sought. The final IAVMP will be revised according to this feedback;
- **Develop an Action Strategy** – Based on the final IAVMP, take initial steps or immediate actions (e.g., install BMPs, purchase harvester, etc), provide foundations for later actions, and institute monitoring; and

- **Monitoring and Evaluation of Plan** – monitoring plans should include sampling for concentrations of an applied herbicide, at various time and locations (a pre-treatment sample is recommended). Other field monitoring may be required for other techniques (e.g., turbidity for dredging project). A pre- and post-treatment measurement of plant density and biomass is recommended to evaluate the effectiveness of various treatment alternatives.

The IAVMP should be considered a constantly evolving document. The IAVMP, its supporting information, and management goals should be periodically re-evaluated. The results of the post-treatment monitoring should be evaluated to see how well a particular treatment is controlling nuisance plants or whether unexpected side effects are noted. Quantitative criteria for target plant species reduction are useful benchmarks, but a more important measure of success will be the amount of increase (or decrease) or improvement in the beneficial uses of a waterbody.

7.3 Physical Controls

Physical controls involve the direct alteration of the plant itself, the substrate, water column or general environment in which it depends on for survival. Physical controls for milfoil include benthic barriers, dredging, dyes, surface covers, harvesting, and water level controls. Each of these techniques is described below. Much of this information is adapted from Mattson et al. (2004) and Wagner (2004).

7.3.1 Benthic Barriers

The use of benthic barriers, or bottom covers, is predicated upon the principles that rooted plants require light and cannot grow through physical barriers. Applications of clay, silt, sand, and gravel have been used for many years, although plants often root in these covers eventually, and current environmental regulations make it difficult to gain approval for such deposition of fill. Artificial sediment covering materials, including polyethylene, polypropylene, fiberglass, and nylon, have been developed over the last three decades. A variety of solid and porous forms have been used. Manufactured benthic barriers are negatively buoyant materials, usually in sheet form, which can be applied on top of plants to limit light, physically disrupt growth, and allow unfavorable chemical reactions to interfere with further development of plants. Various plastics and burlap have also been used, but are not nearly as durable or effective in most cases.

In theory, benthic barriers should be a highly effective plant control technique, at least on a localized, area-selective scale. In practice, however, there have been difficulties with the deployment and maintenance of benthic barriers, limiting their utility over the broad range of field conditions. Benthic barriers can be effectively used in small areas such as dock spaces and swimming beaches to completely terminate plant growth. The creation of access lanes and structural habitat diversity is also practical. Large areas are not often treated, however, because the cost of materials, application and maintenance is high.

Benthic barrier problems of prime concern include long-term integrity of the barrier, billowing caused by trapped gases, accumulation of sediment on top of barriers, and growth of plants on porous barriers. Successful use is related to selection of materials and the quality of the installation and subsequent maintenance.

Bottom barriers will eventually accumulate sediment deposits in most cases, which allow plant fragments to root. Barriers must then be cleaned, necessitating either removal or laborious in-place maintenance (Eichler et al., 1995). Despite application and maintenance issues, a benthic barrier can be a very effective tool. Benthic barriers are capable of providing control of rooted plants on at least a localized basis, and have such desirable side benefits as creating more edge habitat within dense plant assemblages and minimizing turbidity generation from fine bottom sediments.

7.3.2 Dredging

Dredging is perhaps best known for maintaining navigation channels in rivers, harbors and ports or for underwater mining of sand and gravel, but dredging can also be an effective lake management technique for the control invasive growth of macrophytes (Holdren et al., 2001). The management objectives of a sediment removal project are usually to deepen a shallow lake for boating and fishing, or to remove nutrient rich sediments that can cause algal blooms or support dense growths of rooted macrophytes.

Dredging can be accomplished by multiple methods that can be conveniently grouped into four categories:

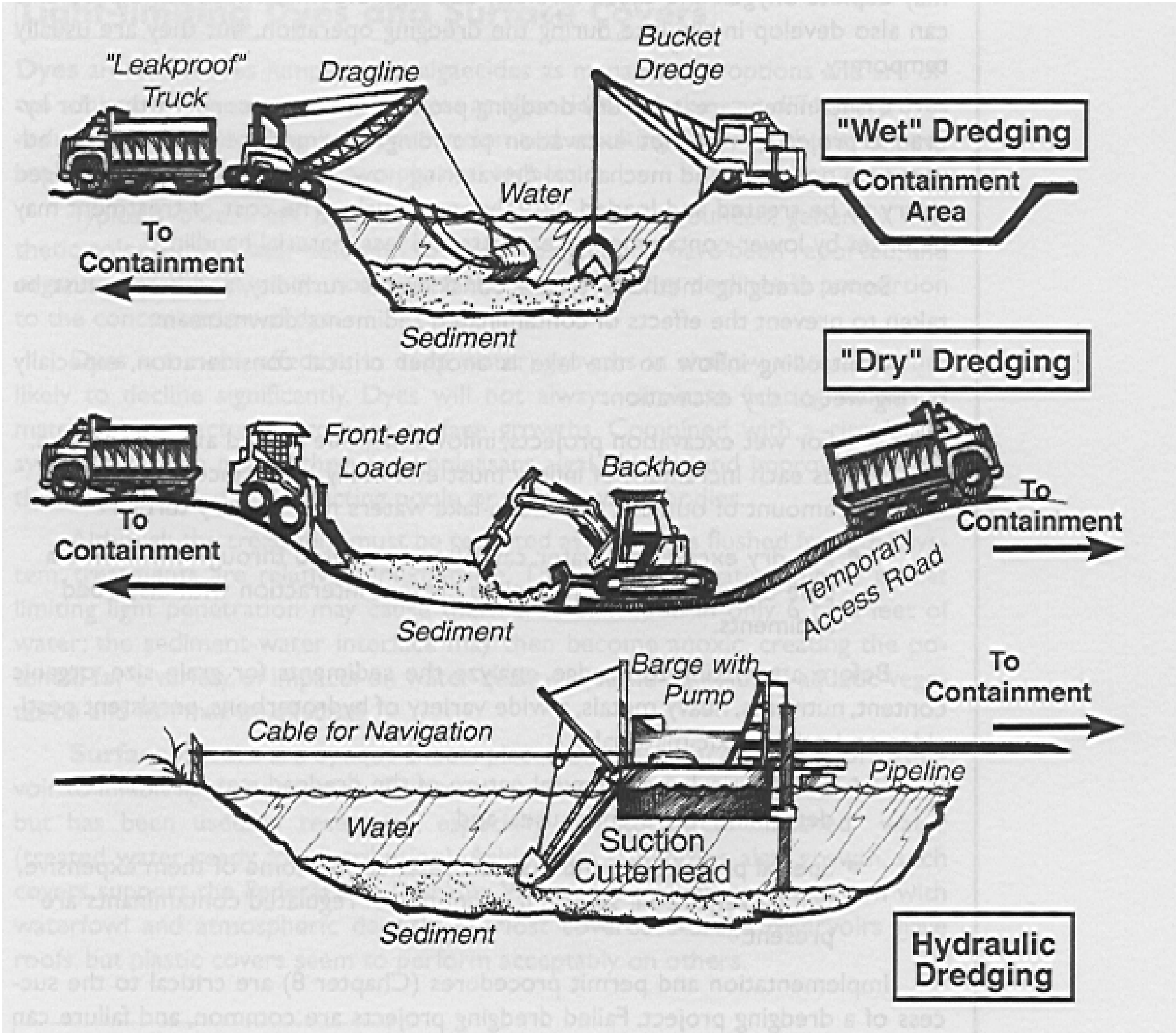
- Dry excavation, in which the lake is drained to the extent possible, the sediments are dewatered by gravity and/or pumping, and sediments are removed with conventional excavation equipment such as backhoes, bulldozers, or draglines.
- Wet excavation, in which the lake is not drained or only partially drawn down (to minimize downstream flows), with excavation of wet sediments by various bucket dredges mounted on cranes or amphibious excavators.
- Hydraulic dredging, requiring a substantial amount of water in the lake to float the dredge and provide a transport medium for sediment. Hydraulic dredges are typically equipped with a cutterhead that loosens sediments that are then mixed with water and transported as pumped slurry of 80 to 90% water and 10 to 20% solids through a pipeline that traverses the lake from the dredging site to a disposal area.
- Pneumatic dredging, in which air pressure is used to pump sediments out of the lake at a higher solids content (reported as 50 to 70%). This would seem to be a highly desirable approach, given containment area limitation in many cases and more rapid drying with higher solids content. However, few of these dredges are operating within North America, and there is little freshwater experience upon which to base a review. Considerations are much like those for hydraulic dredging, and pneumatic dredging will not be considered separately from hydraulic dredging for further discussion.

Dry, wet and hydraulic methods are illustrated in Figure 7-1. Cooke et al. (1993) provides a discussion of dredging considerations that will be helpful to some readers. Recent developments, methods, impact assessment and methods for handling dredged material can be found in McNair (1994). No technique requires more up front information about the lake and its watershed, and there are many engineering principles involved in planning a successful dredging project. No technique is more suitable for true lake restoration, but there are many potential impacts that must be considered and mitigated in the dredging process. Failed dredging projects are common, and failure can almost always be traced to insufficient consideration of the many factors that govern dredging success.

Dredging works as a plant control technique when either a light limitation on growth is imposed through increased water depth or when enough “soft” sediment (muck, clay, silt and fine sand) is removed to reveal a less hospitable substrate (typically rock, gravel or coarse sand). The amount of sediment removed, and hence the new depth and associated light penetration, is critical to successful long term control of rooted, submerged plants. There appears to be a direct relation between water transparency, as determined with a Secchi disk, and the maximum depth of colonization by macrophytes (Canfield et al.,1985). Dredging also removes the accumulated seed bed established by many vascular plants and the resting cysts deposited by a variety of algae.

Partial deepening may limit the amount of vegetation that reaches the surface, but may also favor species tolerant of low light, some of which are non-indigenous species with high nuisance potential, such as Eurasian watermilfoil. Where funding is insufficient to remove all soft sediment, it is more effective to create a depth or substrate limitation in part of the lake than to remove some sediment from all target areas of the lake, if rooted plant control is the primary objective of dredging.

Figure 7-1 Dry, Wet and Hydraulic Dredging Approaches (from Wagner, 2001)



If the soft sediment accumulations that are supporting rooted plant nuisances are not especially thick, it may be possible to create a substrate limitation before a light-limiting depth is reached. If dredging exposes rock ledge or cobble, and all soft sediment can be removed, there will be little rooted plant growth. Yet such circumstances are rare to non-existent; either the soft sediment grades slowly into coarser materials, or it is virtually impossible to remove all fine sediments from the spaces around the rock or cobble. Consequently, some degree of regrowth is to be expected when light penetrates to the bottom. With successful dredging, this regrowth may be only 25% of the pre-dredging density or coverage, and will not contain more recently invading species at a dominant level. Yet some rooted plant regrowth is expected, and is indeed desirable for proper ecological function of the lake as a habitat and for processing of future pollutant inputs.

A properly conducted dredging program removes accumulated sediment from a lake and effectively sets it back in time, to a point prior to significant sedimentation. Partial dredging projects are possible and may be appropriate depending upon management goals, but for maximum benefit it is far better to remove all "soft" sediment to achieve restpration objectives.

7.3.3 Dyes

The use of dyes as algal or vascular plant control agents is often grouped with herbicides in lake management evaluations, but this can be very misleading with regard to how dyes work. Dyes are used to limit light penetration and therefore restrict the depth at which rooted plants can grow or the total amount of light available for algal growth. They are only selective in the sense that they favor species tolerant of low light or with sufficient food reserves to support an extended growth period (during which a stem could reach the lighted zone). Dyes are generally non-toxic to all aquatic species, including the target species of plants. In lakes with high transparency but only moderate depth and ample soft sediment accumulations, dyes may provide open water where little would otherwise exist. Repeated treatment will be necessary, as the dye eventually flushes out of the system. Dyes are typically permitted under the same process as herbicides, despite their radically different mode of action.

Although dyes can be an effective method of algae and plant control in small ornamental and golf course ponds, dyes have not provided consistently acceptable control in larger systems and are not generally applied as a control method for either rooted aquatic plants or algae in larger lakes. The dye should be applied early in the growing season for greatest effectiveness. Dyes can usually only be used in lakes and ponds without a flowing outlet, making it a logical choice for small, contained ornamental ponds. There is insufficient information available to evaluate field applications of dyes other than AQUASHADE®, but the light attenuating mechanism is the same for other commercially available dyes.

7.3.4 Harvesting

There are several methods of harvesting with varying degree of scale costs. These techniques include hand pulling, suction harvesting, mechanical harvesting (cutting with and without collection), rototivation, and hydroraking. Each of these harvesting methods is described in detail below.

Hand pulling is exactly what it sounds like; a snorkeler or diver surveys an area and selectively pulls out unwanted plants on an individual basis. This is a highly selective technique, and a labor intensive one. It is well suited to vigilant efforts to keep out invasive species that have not yet become established in the lake or area of concern. Hand pulling can also effectively address non-dominant growths of undesirable species in mixed assemblages, or small patches of plants targeted for removal (Eichler et al., 1991). This technique is not well suited to large-scale efforts, especially when the target species or assemblage occurs in dense or expansive beds.

Hand pulling can be augmented by various tools, including a wide assortment of rakes, cutting tools, water jetting devices, nets and other collection devices. McComas (1993) provides an extensive review of options. Suction dredging is also used to augment hand pulling, allowing a higher rate of pulling in a targeted area, as the diver/snorkeler does not have to carry pulled plants to a disposal point. Use of these tools transitions into more mechanized forms of harvesting.

Suction harvesting, or suction dredging, is mechanically augmented hand pulling. The diver hand pulls the unwanted plants and allows them to be transported through a vacuum hose to the surface into a mesh bag or other collection device. This technique accelerates the hand pulling process allowing pulling for denser assemblages but generally does not increase the area of control (Eichler et al., 1991; Mattson et al. 2004).

Mechanical harvesting is most often associated with large machines on pontoons that cut and collect vegetation, but encompasses a range of techniques from simply cutting the vegetation in place to cutting, collecting, and grinding the plants, to collection and disposal outside the lake. In its simplest form, cutting, a blade of some kind is applied to plants, severing the active apical meristem (location of growth) and possibly much more of the plant from the remaining rooted portion. Regrowth is expected, and in some species that regrowth is so rapid that it negates the benefits of the cutting in only a few weeks (Nichols and Lathrop, 1994). If the plant can be cut close enough to the bottom, or repeatedly, it will sometimes die, but this is more the exception than the rule. Cutting is defined here as an operation that does not involve collecting the plants once they are cut, so impacts to dissolved oxygen and nutrient release are possible in large-scale cutting operations.

Harvesting usually refers to more advanced technology cutting techniques involving the use of mechanized barges with harvesting operations, in which plants are collected for out-of-lake disposal. In its use as a cutting technology, the “harvester” cuts the plants but does not collect them. A modification in this technique employs a grinding apparatus that ensures that viable plant fragments are minimized after processing. There is a distinct potential for dissolved oxygen impacts and nutrient release as the plant biomass decays, much like what would be expected from many herbicide treatments.

Harvesting may involve collection in nets or small boats towed by the person cutting the weeds, or can employ smaller boat-mounted cutting tools that haul the cut biomass into the boat for eventual disposal on land. It can also be accomplished with larger, commercial machines with numerous blades, a conveyor system, and a substantial storage area for cut plants. Offloading accessories are available, allowing easy transfer of weeds from the harvester to trucks that haul the weeds to a composting area. Choice of equipment is really a question of scale, with larger harvesting operations usually employing commercially manufactured machines built to specifications suited to the job. Some lake associations choose to purchase and operate harvesters, while others prefer to contract harvesting services to a firm that specializes in lake management efforts.

Rotovation is basically the application of an underwater rototiller to an area of sediment, typically one with dense growths of an unwanted rooted aquatic plant. A rotovator is a hydraulically operated tillage device mounted on a barge. The tiller can be lowered to depths of 10 to 12 feet for the purpose of tearing up roots. On a much simpler scale, cultivation equipment or even old bed springs pulled behind tractors can accomplish much root disturbance. Rototilling and the use of cultivation equipment are highly disruptive procedures normally applied on a small scale. Rotovation has a limited track record, mostly in British Columbia. Use of a variety of cultivation equipment has been practiced in New England for many years, but is rarely documented. Potential impacts to non-target organisms and water quality are substantial, but where severe weed infestations exist, this technique could be appropriate.

Hydroraking involves the equivalent of a floating backhoe, usually outfitted with a york rake that looks like a farm implement for tilling or moving silage. The tines of the rake attachment are moved through the sediment, ripping out thick root masses and associated sediment and debris. A hydrorake can be a very effective tool for removing submerged stumps, water lily root masses, or floating islands. Use of a hydrorake is not a delicate operation, however, and will create substantial turbidity and plant fragments. Hydroraking in combination with a harvester can remove most forms of vegetation encountered in lakes.

Hydroraking is effective in the short-term in that it removes plants immediately. It is not an especially thorough or selective technique, and is therefore not well suited to submergent species that can reroot from fragments (e.g., milfoil) or mixed assemblages with desirable species present at substantial densities. It is particularly effective for water lilies (white or yellow) and other species with dense root masses. Hydroraking is also often used to remove subsurface obstructions such as stumps or logs.

7.3.5 Water Level Control

Control of rooted aquatic plants can be achieved through water level control. Two methods can be used, flooding and drawdown. Flooding, increasing water depth in an effort to achieve light limitation for aquatic plant control, is rarely used since water quantity and potential flooding impacts to urban areas limit the utility of this technique. Drawdown is often used, however, and is described below.

Drawdown is a process whereby the water level is lowered by gravity, pumping or siphoning and held at that reduced level for some period of time, typically several months and usually over the winter. Drawdown can provide control of plant species that overwinter in a vegetative state, and oxidation of sediments may result in lower nutrient levels with adequate flushing. Drawdowns also provide flood control and allow access for nearshore clean ups and repairs to structures. The ability to control the water level in a lake is affected by area precipitation pattern, system hydrology, lake morphometry, and the outlet structure. The base elevation of the outlet or associated subsurface pipe(s) will usually set the maximum drawdown level, while the capacity of the outlet to pass water and the pattern of water inflow to the lake will determine if that base elevation can be achieved and maintained. In some cases, sedimentation of an outlet channel or other obstructions may control the maximum drawdown level.

Several factors affect the success of drawdown with respect to plant control. While drying of plants during drawdowns may provide some control, the additional impact of freezing is substantial, making drawdown a more effective strategy during late fall and winter. However, a mild winter or one with early and persistent snow may not provide the necessary level of drying and freezing. The presence of high levels of groundwater seepage into the lake may mitigate or negate destructive effects on target submergent species by keeping the area moist and unfrozen. The presence of extensive seed beds may result in rapid re-establishment of previously occurring plant species, some of which may be undesirable. Recolonization from nearby areas may be rapid, and the response of macrophyte species to drawdown is quite variable.

Aside from direct impact on target plants, drawdown can also indirectly and gradually affect the plant community by changing the substrate composition in the drawdown zone. If there is sufficient slope, finer sediments will be transported to deeper waters, leaving behind a coarser substrate. If there is a thick muck layer present in the drawdown zone, there is probably not adequate slope to allow its movement. However, where light sediment has accumulated over sand, gravel or rock, repetitive drawdowns can restore the coarse substrate and limit plant growths. Expected response of target species (Table 7-2) is of particular importance when plant control is the major goal.

7.4 Chemical Controls

Chemical treatment is one of the oldest methods used to manage nuisance aquatic weeds, and is still the most frequently applied approach. Other than perhaps drawdown, few alternatives to herbicides were widely practiced until relatively recently. Those considering chemical use should become aware of all possible benefits, known limitations and constraints, and possible negative impacts, and should carefully evaluate the applicability and efficacy for the target lake.

Herbicides and algaecides contain active ingredients that are toxic to target plants. For convenience, we will refer to this collective group of chemicals as herbicides here, with inclusion of algaecides inferred. Herbicides are typically classified as contact or systemic herbicides based on the action mode of the active ingredient. Contact herbicides are toxic to plants by uptake in the immediate vicinity of external contact, while systemic herbicides are taken up by the plant and are translocated throughout the plant. In general, contact herbicides are more effective against annuals than perennials because they may not kill the roots, allowing perennials to grow back. Seeds are also not likely to be affected, but with proper timing and perhaps several treatments, growths can be eliminated much the same way harvesting can eliminate annual plants. Systemic herbicides tend to work more slowly than contact herbicides because they take time to be translocated throughout the plant. Systemic herbicides generally provide more effective control of perennial plants than contact herbicides, as they kill the entire plant under favorable application circumstances. Systemic herbicides will also kill susceptible annual species, but regrowth from seeds is usually substantial. If annual species are the target of control, additional treatment will be required, normally a year after initial treatment and for as long as the seed bank facilitates new growths.

Table 7-2 Anticipated Response of Some Common Aquatic Plants to Winter Drawdown (adapted from Cooke et al., 1993)

Change in Relative Abundance			
	Increase	**No Change**	**Decrease**
Acorus calamus (sweet flag)	E		
Alternanthera philoxeroides (alligator weed)	E		
Asclepias incarnata (swamp milkweed)			E
Brasenia schreberi (watershield)			S
Cabomba caroliniana (fanwort)			S
Cephalanthus occidentalis (buttonbush)	E		
Ceratophyllum demersum (coontail)			S
Egeria densa (Brazilian Elodea)			S
Eichhornia crassipes (water hyacinth)		E/S	
Eleocharis acicularis (needle spikerush)	S	S	S
Elodea canadensis (waterweed)	S	S	S
Glyceria borealis (mannagrass)	E		
Hydrilla verticllata (hydrilla)	S		
Leersia oryzoides (rice cutgrass)	E		
Myrica gale (sweetgale)		E	
Myriophyllum spp. (milfoil)			S
Najas flexilis (bushy pondweed)	S		
Najas guadalupensis (southern naiad)			S
Nuphar spp. (yellow water lily)			E/S
*Nymphaea odorata (*water lily)			S
Polygonum amphibium (water smartweed)		E/S	
Polygonum coccineum (smartweed)	E		
Potamogeton epihydrus (leafy pondweed)	S		
Potamogeton robbinsii (Robbins' pondweed)			S
Potentilla palustris (marsh cinquefoil)			E/S
Scirpus americanus (three square rush)	E		
Scirpus cyperinus (wooly grass)	E		
Scirpus validus (great bulrush)	E		
Sium suave (water parsnip)	E		
Typha latifolia (common cattail)	E	E	
Zizania aquatic (wild rice)	E		

E=emergent growth form
S=submergent growth form (includes rooted species with floating leaves)
E/S=emergent and submergent forms

Another way to classify herbicides is by whether the active ingredients are selective or broad spectrum. Selective herbicides are more effective on certain plant species than others, with control of that selectivity normally dependent on dose and exposure duration. Plant factors that influence selectivity include plant morphology, physiology and the stage of growth. Even a selective herbicide can kill most plants if applied at high rates. Likewise, contact herbicides may show some selectivity based on dose and plant features, but tend to induce impacts on a broad spectrum of plant species.

The choice of herbicide to manage an undesirable plant population depends on the properties of the herbicide, the relative sensitivity of the target and non-target plants and other organisms that will be exposed, water use restrictions after herbicide use, and cost. Effectiveness in controlling the target plant species is normally the primary consideration. Other factors determine possible choice between two or more potentially effective herbicides, dose, and whether a treatment is actually feasible.

Herbicide effectiveness may be influenced by such factors as timing, rate and method of application, species present and weather conditions (Westerdahl and Getsinger, 1998a,b). Additionally, dose determination should consider hydraulic residence time, morphometry and water hardness to maximize effectiveness. Herbicide treatment can be an effective short-term (and sometimes, longer) management procedure to produce a rapid reduction in algae or vascular plants for periods of weeks to months. Although long-term effectiveness of herbicide treatments is possible, in most cases herbicide use is considered a short-term control technique.

Five aquatic herbicides currently approved for aquatic use by the United States Environmental Protection Agency (USACE 2002) and registered for use in New York State are described below. Information for individual herbicidal active ingredients in use today is further discussed in association with each active ingredient in subsequent parts of review. Copper is not generally used to control milfoil growth and is therefore not included in this discussion. The relative effectiveness of control by New York-registered herbicides on common nuisance aquatic plants is listed in Table 7-3 (NYSDEC, 2005).

7.4.1 Diquat

Diquat is a fast acting contact herbicide, producing results within 2 weeks of application through disruption of photosynthesis. It is a broad-spectrum herbicide with potential risks to aquatic fauna, but laboratory indications of invertebrate toxicity have not been clearly documented in the field. A domestic water use restriction of 3 days is normally applied. Irrigation restrictions of 2 to 5 days are applied, depending on dose and crop to be irrigated. Regrowth of some species has been rapid (often within the same year) after treatment with diquat, but two years of control have been achieved in some instances.

Diquat is used as a general purpose aquatic herbicide, both as a primary control agent for a broad range of macrophytes and as a follow-up treatment chemical for control of plants (especially milfoil) missed by other herbicides or physical control techniques. Treatment with diquat is recommended early in the season to impact early growth stages, but can be applied any time. Diquat is less effective in turbid, muddy water due to adsorption onto sediments and other particles.

Since diquat is a broad spectrum herbicide, it can be expected to impact non-target plants when they are present. Loss of vegetative cover may have some impact on aquatic animals, but short-term effects are not expected. The acute toxicity of diquat for fish is highly variable depending on species, age, and hardness of water. Young fish are more sensitive than older fish. Toxicity is decreased as water hardness increases.

Table 7-3 Impact of NYS Registered Herbicides on Common Nuisance Aquatic Plants (adapted from NYSDEC, 2005)

Susceptibility to Herbicide:						
Aquatic Plant	**Diquat**	**2,4-D**	**Endothall**	**Glyphosate**	**Fluridone**	**Triclopyr**
Emergent Species						
Lythrum salicaria (purple loosestrife)	low	low	low	high	low	high
Phragmites spp (reed grass)	low	low	medium	high	low	medium
Pontedaria cordata (pickerelweed)	low	medium	low	medium	low	high
Sagittaria spp (arrowhead)	low	high	low	high	low	medium
Scirpus spp (bulrush)	medium	high	low	high	low	low
Typha spp (cattails)	medium	medium	low	high	medium	low
Floating Leaf Species						
Brasenia schreberi (water shield)	medium	medium	medium	low	medium	medium
Lemna spp (duckweed)	high	medium	medium	low	high	low
Nuphar spp yellow water lily)	low	medium	medium	high	medium	medium
Nymphaea spp (white water lily)	low	medium	medium	high	medium	medium
Trapa natans (water chestnut)	low	medium	low	low	low	medium
Submergent Species						
Ceratophyllum demersum (coontail)	high	medium	high	low	medium	low
Cabomba caroliniana (fanwort)	medium	medium	high	low	high	low
Chara spp (muskgrass)	low	low	low	low	low	low
Elodea canadensis (common waterweed)	high	medium	low	low	high	low
Heteranthera dubia (water stargrass)	high	high	medium	low	medium	low
Myriophyllum spicatum (Eurasian watermilfoil)	high	high	high	low	high	high
Najas flexilis (bushy pondweed)	high	medium	high	low	high	low
Potamogeton amplifolius (largeleaf pondweed)	low	low	medium	low	medium	low
Potamogeton crispus (curly-leafed pondweed)	high	low	high	low	high	low
Potamogeton robbinsii (Robbins' pondweed)	low	low	medium	low	medium	low
Stuckenia pectinatus (Sago pondweed)	high	low	medium	low	medium	low
Utricularia spp (bladderwort)	high	medium	low	low	medium	low
Vallisneria americana (wild celery)	low	low	medium	low	high	low

Adapted from Holdren, et al, 2001 and others.

7.4.2 Endothall

Endothall is a contact herbicide, attacking a wide range of plants. The method of action of endothall is suspected to inhibit the use of oxygen for respiration. Only portions of the plant with which the herbicide can come into contact are killed. There are two forms of the active ingredient; the inorganic potassium salt that is found in the products Aquathol® Granular and Aquathol® K and the alkylamine salt formulations of Hydrothol® 191 Granular and Hydrothol® 191. Effective control can range from weeks to months. Most endothall compounds break down readily and are not persistent in the aquatic environment, disappearing from the water column in under 10 days and from the sediments in under 3 weeks.

Endothall acts quickly on susceptible plants, but does not kill roots with which it cannot come into contact, and recovery of many plants occurs. Rapid death of susceptible plants can cause oxygen depletion if decomposition exceeds re-aeration in the treated area, but this can be mitigated by conducting successive partial treatments. Toxicity to invertebrates, fish or humans is possible but not expected at typical doses, but endothall is not typically permitted for use used in drinking water supplies.

Endothall is primarily a broad spectrum vascular plant control chemical. Endothall has not been very effective against milfoil, but works well on most species of pondweeds, coontail and naiads. It is used less than most other herbicides, mainly due to dose limits that are observed to avoid impacts to non-target fauna.

Hydrothol® 191 is an alkylamine salt formulation of endothall. This formulation is effective against algae as well as macrophytes, but is much more toxic to fish than Aquathol® K. The environmental hazards listed on the Hydrothol® 191 (Dimethylalkylamine endothall granular and liquid) labels warn that fish may be killed by dosages in excess of 0.3 ppm. Hydrothol® 191 is less toxic to fish in cool water (<65°F). However, Hydrothol® 191 granular is sometimes not used because of potential dust problems and possible toxicity to the applicator. Aquathol® K is much less toxic and is used more frequently than Hydrothol® 191. Aquathol® K application rates vary with water depth. Although usually applied at lower rates, the maximum rate of 269 lbs per 2 acre feet or 6.4 gallons per 2 acre-feet for spot treatment would result in a maximum concentration of 5 ppm according to the product labels.

7.4.3 Glyphosate

Glyphosate is a systemic, broad spectrum herbicide. Glyphosate is used to control emergent vegetation and to create open areas for waterfowl or human use. Its mode of action is to disrupt the plant's shikimic acid metabolic pathway. Shikimic acid is a precursor in the biosynthesis of aromatic amino acids. The disruption in the pathway prevents the synthesis of aromatic amino acids and the metabolism of phenolic compounds. The net effect is that the plant is unable to synthesize protein and produce new plant tissue. Glyphosate penetrates the cuticle of the plant and moves to the phloem where it is translocated throughout the plant, including the roots. Its aquatic formulation is effective against most emergent or floating-leaved plant species, but not against most submergent species. Rainfall shortly after treatment can negate its effectiveness, and it readily adsorbs to particulates in the water column or to sediments and is inactivated. It is relatively non-toxic to aquatic fauna at recommended doses, and degrades readily into non-toxic components in the aquatic environment. The maximum concentration for treated water is typically about 0.7 mg/L, but a dose of no more than 0.2 mg/L is usually recommended.

The most common aquatic use of glyphosate is for control of emergent and floating leaf species, in particular water lilies (*Nuphar spp., Nymphaea spp*.), reed grass (*Phragmites spp*.), purple loosestrife (*Lythrum salicaria*) and cattail (*Typha spp*.). Glyphosate is not effective for control of submerged macrophytes because it is water soluble and the concentration after dilution would be insufficient to damage a submergent plant. It is, however, recommended for control of many wetland and floodplain species that include trees, shrubs and herbs. Glyphosate effectiveness is greater in soft water. Additives such as ammonium phosphate are recommended for hard water glyphosate applications, and non-ionic surfactants are often recommended to increase overall effectiveness.

Because it is a broad spectrum herbicide, glyphosate should be expected to impact non-target emergent or floating leaf plants if the spray contacts them. Control of the spray can therefore greatly limit impacts to non-target vegetation. The LC_{50} levels for fish species vary widely, perhaps due to variations in formulations tested (i.e., with or without surfactant). Most applications would result in aquatic concentrations far lower than any toxic threshold. Invertebrates do not appear to be harmed directly by the herbicide, but may be impacted by the alteration of vegetation.

7.4.4 2,4-D

2,4-D, the active ingredient in a variety of commercial herbicide products, has been in use for over 30 years. This is a systemic herbicide; it is absorbed by roots, leaves and shoots and disrupts cell division throughout the plant. Vegetative propagules such as winter buds, if not connected to the circulatory system of the plant at the time of treatment, are generally unaffected and can grow into new plants. Seeds are also not affected. It is therefore important to treat plants early in the season, after growth has become active but before such propagules form.

2,4-D is sold in liquid or granular forms as sodium and potassium salts, as amine salts, and as an ester. Doses of 50 to 150 pounds per acre are usually applied for the control of submersed weeds, most often of the dimethylamine salt (DMA) or the butoxyethanolester (BEE) in granular formulation. Lower doses are more selective but require more contact time; a range of one to three days of contact time is typically needed at the range of doses normally applied. 2,4-D has a short persistence in water but can be detected in the sediment for months.

Experience with granular 2,4-D in the control of nuisance macrophytes has generally been positive, with careful dosage management providing control of such non-indigenous nuisance species as Eurasian watermilfoil with only sublethal damage to many native species. 2,4-D has variable toxicity to fish, depending upon formulation, dose and fish species. The 2,4-D label does not permit use of this herbicide in water used for drinking or other domestic purposes, or for irrigation until the concentration is less than 0.1 ppm, typically about 3 weeks. While there is overlap in the species to which 2,4-D and triclopyr would be applied, the drinking water use restrictions are much more limiting for 2,4-D.

7.4.5 Fluridone

Fluridone is a systemic herbicide that comes in two general formulations, an aqueous suspension and a slow release pellet, although several forms of pellets are now on the market. This chemical inhibits carotene synthesis, which in turn exposes the chlorophyll to photodegradation. Most plants can be damaged by sunlight in the absence of protective carotenes, resulting in chlorosis of tissue and death of the entire plant with prolonged exposure to a sufficient concentration of fluridone. When carotene is absent the plant is unable to produce the carbohydrates necessary to sustain life. Some plants, including Eurasian watermilfoil, are more sensitive to fluridone than others, allowing selective control at low doses.

For susceptible plants, lethal effects are expressed slowly in response to treatment with fluridone. Existing carotenes must degrade and chlorosis must set in before plants die off; this takes several weeks to several months, with 30-90 days given as the observed range of time for die off to occur after treatment. The slow rate of plant die-off minimizes the risk of oxygen depletion. Fluridone concentrations should be maintained in the lethal range for the target species for at least 6 weeks, preferably 9 weeks, and ideally 13 weeks. This presents some difficulty for treatment in areas of substantial water exchange, and indicates the value of an alternative herbicide for many of the same target species, represented by triclopyr.

The selectivity of fluridone for the target species depends on the timing and the rate of application. Early treatment (April/early May) with fluridone effectively controls overwintering perennials before some of the beneficial species of pondweed and naiad begin to grow. Variability in response has also been observed as a function of dose, with lower doses causing less impact on non-target species. However, lesser impact on target plants has also been noted in some cases, so dose selection involves balancing risk of failure to control target plants with risk of impact to non-target species.

Fluridone is considered to have low toxicity to invertebrates, fish, other aquatic wildlife, and mammals, including humans. The USEPA has set a tolerance limit of 0.15 ppm for fluridone or its degradation products in potable water supplies, although some state restrictions are lower. Substantial bioaccumulation has been noted in certain plant species, but not in animals.

7.5 Biological Controls

Interest has grown in biological control methods over the last two to three decades. Most methods are still experimental and have a limited degree of achieved effectiveness. Most methods have the potential to inflict negative impacts on the environment. Biological methods differ from other plant control methods in that there are more variables to consider and usually a longer time span needed to evaluate effectiveness. These methods are unusual in that the treatments consist of either altering conditions to favor certain organisms or introducing live organisms that may be difficult or impossible to control or recall once introduced. For this reason non-indigenous introductions are restricted in most cases. Biological control has the advantage that it is perceived as a more “natural” or “organic” plant control option, but it still represents human interference within an ecological system. The potential for long-term effectiveness with limited maintenance is attractive, but has been largely illusive with biological controls.

7.5.1 Herbivorous Fish

The grass carp (*Ctenopharyngodon idella*), also known as the white amur, is a species of fish that is used to control aquatic macrophytes in New York State (Stang, 1994). The native range of grass carp includes the Pacific slope of Asia from the Amur River of China and Siberia, south to the West River in southern China and Thailand. They are typically found in low gradient reaches of large river systems. Grass carp can grow to 4 feet long and attain weights of over 100 pounds, making them the largest member of the cyprinid family. They have a very high growth rate, with a maximum at about 6 pounds per year. They typically grow to a size of 15-20 pounds in North American waters and have adapted quite well to life in reservoirs where they are stocked for aquatic vegetation control.

As with other carp species, they are tolerant of wide fluctuations in water quality including water temperatures from 0 to 35°C, salinities up to 10 ppt, and oxygen concentrations approaching 0 mg/L. Grass carp do not feed when water temperatures drop below 11°C (52°F) and feed heavily when water temperatures are between 20°C and 30°C (68°F and 86°F). Dietary preference is an important aspect of grass carp, as pertains to their use as a plant control mechanism. Grass carp have exhibited a wide variety of food choices from study to study. In some cases grass carp have been reported to have a low feeding preference for *Myriophyllum spicatum*. Yet in a recently completed Connecticut study, grass carp did consume milfoil more readily than other submergent species. Grass carp readily eat other non-indigenous plants such as *Cabomba caroliniana* and *Egeria densa* as well as various native species. In some cases grass carp will also eat and control filamentous algae (e.g., *Pithophora*). Generally, grass carp avoid cattails and water lilies, but the high level of variability in grass carp diet among lakes should be kept in mind.

The major difficulty in using grass carp to control aquatic plants is determining what rate will be effective and yet not so high as to eradicate the plants completely. Effective grass carp stocking rates are a function of grass carp mortality, water temperature, plant species composition, plant biomass and desired level of control. The fish usually live ten or more years but the typical plant control period is reported to be 3 to 4 years with some restocking often required. They are difficult to capture and remove unless the lake is treated with rotenone that will kill other fish species as well. Grass carp may also decrease the density or even eliminate vascular plants, although in a Connecticut study, the carp preferred milfoil to other plants. Algal blooms resulting from nutrients being converted from plant biomass by the grass carp have been common, even without elimination of vascular plants.

7.5.2 Herbivorous Invertebrates

Biological control has the objective of achieving control of plants without introducing toxic chemicals or using machinery. Yet it suffers from an ecological drawback; in predator-prey (or parasite-host) relationships, it is rare for the predator to completely eliminate the prey.

Biological control using invertebrates (mainly insects) from the same region as the introduced target plant species include the root boring weevil (*Hylobius transversovittatus*) and two leaf beetles (*Galerucella calmariensis* and *G. pusilla*) for the control of purple loosestrife (*Lythrum salicaria*). Augmentation of a native insect population has been studied with the milfoil midge (*Cricotopus myriophylli*), a moth (*Acentria ephemerella*) and the milfoil weevil (*Euhrychiopsis lecontei*). Releases in Massachusetts of the native weevil (*Euhrychiopsis lecontei*) for the control of Eurasian milfoil have occurred since 1995, and there are signs of success in two of the original test lakes (Creed and Sheldon, 1994; Sheldon, 1995; Sheldon and Creed, 1995; Sheldon and O'Bryan, 1996a,b)

Euhrychiopsis lecontei is a native North American insect species believed to have been associated with northern watermilfoil (*Myriophyllum sibericum*), a species largely replaced by non-indigenous, Eurasian watermilfoil (*M. spicatum*) since the 1940's. It does not utilize non-milfoil species. In controlled trials, the weevil clearly has the ability to impact milfoil plants through structural damage to apical meristems (growth points) and basal stems (plant support). Adults and larvae feed on milfoil, eggs are laid on it, and pupation occurs in burrows in the stem. Field observations linked the weevil to natural milfoil declines in nine Vermont lakes and additional lakes in other states (Johnson et al., 2000).

Lakewide crashes of milfoil populations have generally not been observed in cases where the weevil has been introduced into only part of the lake, although localized damage has been substantial. Widespread control may require more time than current research and monitoring has allowed. As with experience with introduced insect species in the south, the population growth rate of the weevil is usually slower than that of its host plant, necessitating supplemental stocking of weevils for more immediate results. Just what allows the weevil to overtake the milfoil population in the cases where natural control has been observed is still unknown.

Acentria ephemerella is a European aquatic moth first reported in North America near Montreal in 1927 (Sheppard, 1945; as reported in Johnson and Blossey, 2002). While it is considered a generalist herbivore, significant declines in Eurasian watermilfoil populations in Ontario and New York lakes have been associated with population explosions of the species (Johnson et al., 1998; Gross et al., 2001). Cayuga Lake is the best studied of these declines, with a greater than 90% reduction of Eurasian watermilfoil (Johnson et al., 1998; Gross et al., 2001); a reduction that has been maintained for 15 years since the initial decline (R. Johnson, pers. comm.. 12/20/06). This selective suppression of Eurasian watermilfoil has led to a strong recovery by native macrophyte species, which now dominate the plant community (Johnson and Blossey, 2002). Further investigations of the effects of population augmentation and long-term control of watermilfoil by *A. ephemerella* are being conducted in several New York lakes including Chautauqua, Otisco, and Owasco (R. Johnson, pers. comm. 12/20/06).

For the control of purple loosestrife, a measure of success has been achieved with the introduction of two European leaf beetles (*Galerucella calmariensis* and *G. pusilla*) (Blossey, 2002; MA CZM, 2006). Two other potential insect control agents for purple loosestrife (*Hylobius transversovittatus* and *Nanophes marmoratus*) have been identified, but their effectiveness has not been fully established.

Mass releases of the *Galerucella* sp. beetles have been successfully used in the United States to control purple loosestrife infestations since the early 1990s (approved in 1992 by U.S. Department of Agriculture for their use in biocontrol). While these natural beetle predators cannot eliminate purple loosestrife entirely, at several release sites complete defoliation of large stands have been reported with local reductions of more than 95% of the biomass (Blossey, 2002). Published literature indicates that the beetles are host-specific and no significant long-term significant impacts on native plant species have been observed (MA CZM, 2006). Several states and academic institutions have established programs to provide information and guidance on this form of biological control (e.g., MA CZM Purple Loosestrife Biocontrol Project, Cornell University Biological Control of Non-indigenous Plants Species Program). Efforts are also being made to mass-produce the biocontrol bettles to make them available to interested parties or state agencies (MA CZM, 2006).

7.5.3 Plant Competition

Although invasive nuisance plant species are just what the name implies, there is evidence that the presence of a healthy, desirable plant community can minimize or slow infestation rates. Most invasive species are favored by disturbance, so a stable plant community should provide a significant defense. Unfortunately, natural disturbances abound, and almost all common plant control techniques constitute disturbances. Therefore, if native and desirable species are to regain dominance after disturbance, it may be necessary to supplement their natural dissemination and growth with seeding and planting. The use of seeding or planting of vegetation is still a highly experimental procedure, but if native species are employed, it should yield minimal controversy.

Experiments indicate that the addition of dried seeds to an exposed area of sediment will result in rapid germination of virtually all viable seeds and rapid cover of the previously exposed area. However, if this is not done early enough in the growing season to allow annual plants to mature and produce seeds of their own, the population will not sustain itself into the second growing season. Transplanting mature growths into exposed areas has generally been found to be a more successful means of establishing a seed producing population. The use of cuttings gathered by a harvester has not been successful in establishing native species, so it appears that whole, viable plants must be added.

Areas of dense, healthy, indigenous plants tend to resist colonization by invasive species. Resistance may not be complete or lasting, but invasions have been greatly slowed where bare sediment is minimized. More research is needed, but establishment of desired vegetation is entirely consistent with the primary plant management axiom: if light and substrate are adequate, plants will grow. Rooted plant control should extend beyond the limitation of undesirable species to the encouragement of desirable plants.

7.6 No-Action Alternative

The no action or no management alternative for aquatic plants would exclude all active lake management programs, but would include normal monitoring and would also include normal operations such as drawdowns for flood control or dam repair and other activities as permitted or required by law. The normal tendency for lakes is to gradually accumulate sediments and associated nutrients and to generally become more eutrophic. Although macrophytes may be excluded from deeper areas of the lake due to light limitation, as sediments fill in the lake a greater proportion of the lake area becomes suitable for aquatic macrophytes. In consideration of this, the no management alternative would allow lakes to become ever more eutrophic in the future, even if no human additions of nutrients, sediments or non-indigenous plants were considered. In cases where there is development in the watershed leading to increased erosion and sediment transport to the lake, the rate of infilling and expansion of macrophyte beds would be expected to increase more rapidly.

In addition, activities that involve boat transport among lakes may introduce non-indigenous plant species into lakes that previously did not have infestations. One of the major modes of introduction is assumed to be boating activities. The no management alternative would provide neither prevention nor remediation efforts other than those required by current laws, which contain minimal provisions intended to stop the spread of invasive species or preserve the desirable features of lakes.

7.7 Alternatives Analysis

As discussed in Sections 2.0 and 3.0 of the SEIS, the uncontrolled growth of nuisance aquatic macrophyte species can substantially impact the natural diversity, ecological function, and recreational uses of a waterbody. However, as noted in Section 7.2, is important that the appropriate control techniques are selected which are appropriate for effectively removing the nuisance species, which minimize potential adverse ecological effects (or mitigative measures can be included), that are practicable and cost-effective, and which reduces potential societal conflicts that can occur between groups of lake users. Therefore, it is important that the selection of any macrophyte control treatment, including herbicides, be conducted as a result of a well thought-out long-term IAVMP, consistent with NYSDEC guidance (NYSDEC, 2005). Part of the development of the IAVMP is an alternative analysis, which is considered in a series of steps below.

7.7.1 Management vs. No Management

The first consideration is the determination that a problem aquatic infestation is occurring within a waterbody of interest. This primary determination is typically the responsibility of a lake association or lake manager (if applicable) and should be based on current aquatic plant surveys and/or monitoring efforts. This information should include the areal size of the waterbody, the location, nature, and acreage of the infestation, the recreational uses of the waterbody, and the presence of sensitive species. This is analogous to the first step in development of a problem statement for the IAVMP (see Section 7.2) If, through these monitoring and information gathering efforts, the infestation of the waterbody by Eurasian watermilfoil or excessive growths of other potential targets species (see Section 2.4) is detected, then a decision to treat the waterbody is made.

In some cases, no treatment may be elected for the short-term, with a “wait-and-see” attitude taken, using monitoring efforts to keep tabs on the size and impact of the infestation until further information, equipment, funding, etc, may be available. For some waterbodies, the no management approach may also be a long-term strategy, based on factors such as size of the waterbody, current and future uses, the presence of sensitive receptors, proximity to residential or recreational uses, or other factors. However, for many ponds and lakes with important ecological and/or recreational uses, there is likely to be a decision to manage the macrophytes, particularly if this is an initial infestation of exotic invasives and rapid response is vital. As with any IAVMP, any subsequent decisions regarding macrophyte management approaches must consider all permit requirements.

7.7.2 Renovate® 3 vs. Physical Treatment Alternatives

As part of the development of a waterbody-specific IAVMP, the potential usefulness of physical treatment alternatives needs to be considered. As identified in Section 7.3., physical treatment alternatives include benthic barriers, dredging, dyes, harvesting, and water level controls. Any initial screening may be based on the scale of potential treatment required or practicable. Smaller scale treatments include installation of benthic barriers and harvesting (variable scale); while the other alternatives (dredging, dyes, water level control) tend to be conducted over a significant portion or the entire waterbody.

Since Renovate® 3 is anticipated to be used mostly for selective control of Eurasian watermilfoil, several physical treatment alternatives can be easily eliminated from the alternatives analysis. Dredging can be eliminated because it has significant impacts, is very costly, often requires a lengthy permitting process, and low light limitation may not be effective on watermilfoil. Similarly, the use of dyes is inappropriate since they are mostly restricted to small volume waterbodies due to the need to maintain high color concentrations; they may not be able to suppress watermilfoil with light limitation, and could have impact to other vegetation. Conventional harvesting is not appropriate due to the potential for fragmentation and spreading of Eurasian watermilfoil (Painter, 1988).

Physical treatment alternatives that should be considered for control of Eurasian watermilfoil include small-scale harvesting, (hand pulling or diver-assisted), benthic barriers, and water level control (Eichler et al., 1991; 1993; 1995). The first two alternatives are potentially useful in the early invasion phase when the size of the infestation is spatially limited. These alternatives are often considered when formulating a rapid response to aquatic invasives. Both are labor-intensive and need significant involvement of either trained volunteers or hired lake management firms over a significant period of the growing season.

Water level control has been shown to be effective against Eurasian watermilfoil (see Table 7-2) but is dependent on the ability of lake managers to draw the lake down to the areas and depths where the milfoil is present. This may be limited by the lack of an impounding structure, the bottom elevation of the existing outlet or drainage pipe, or secondary restrictions within the lake to free drainage (e.g., internal pooling areas). In addition, the presence of sensitive plant or wildlife species or significant fishery resources in the waterbody or in adjacent wetlands may restrict the amount of drawdown permitted. Therefore, water level control may be considered as a tool for use in an IAVMP for suppression or general control of Eurasian watermilfoil, but will rarely be sufficient as a stand-alone option. It is not generally considered as a rapid response technique for elimination of any early infestation.

Control of purple loosestrife by physical methods has generally proven problematic. Experience has shown that many mechanical and cultural methods (water level management, burning, manual removal, and cutting) have been tried and have proven ineffective in controlling purple loosestrife and are largely impractical on a large scale (MA CZM, 2006). In many cases mechanical methods and controlled burns have resulted in the promotion of further spread of the loosestrife (CDFA, 2006). For early infestations, small patches of young plants can be removed by hand with little effort, but care needs to be taken to remove all root fragments. It is necessary to dispose of plants and roots by drying and burning or by composting in an enclosed area, and important to take care to prevent further seed spread from clothing or equipment during the removal process. It is difficult to remove all of the roots in a single digging, so monitoring of the infestation area for several growing seasons is recommended to ensure that purple loosestrife has not regrown from roots or seed. In summary, physical control of purple loosestrife is possible for small isolated primary infestation areas, but is largely impractical at larger scales (> 0.5 acres).

7.7.3 Renovate® 3 vs. Biological Treatment Alternatives

As part of the development of a waterbody-specific IAVMP, the potential usefulness of biological treatment alternatives needs to be considered. As identified in Section 7.5, biological treatment alternatives include herbivorous fish and invertebrates. For selective control of Eurasian watermilfoil, grass carp do not provide a good alternative treatment because they tend to be general grazers of available macrophytes (see Section 7.5.1) with no specialized preference for the watermilfoil. In contrast, the herbivorous weevils (see Section 7.5.2), have high specificity for that species. However, the effectiveness of these introduced invertebrates is still largely uncertain, with localized success reported in some locales and little or no effect in others. Moreover, keeping weevil populations at levels capable of controlling watermilfoil populations has been problematic. There has been a well-documented rapid reduction and long-term suppression of Eurasian watermilfoil by larvae of the aquatic moth, *A. ephemerella* in Cayuga Lake. Further investigations on the applicability of enhancing ambient populations by stocking of larvae to create a quicker reduction response are being conducted in several other New York lakes (R. Johnson, pers. comm.) , but results will not be available for full evaluation for several years. At the current time, Renovate® 3 would likely be preferred over herbivorous macroinvertebrates in a rapid response plan due to its greater reliability and replicability of macrophyte control. Further investigation and studies with herbivorous weevils in the Northeast may be required to see whether they are an effective long-term solution and/or should be incorporated into an IAVMP.

As discussed in Section 7.5.2, the most likely biological treatment alternative for control of purple loosestrife is the mass introduction of *Galerucella* sp. beetles. Release of these beetles, possibly in combination with the root-eating weevil (*H. transversovittatus*) or the flower-eating weevil (*N. marmoratus*), may prove to be a very effective means of control. While results from early release sites indicate that successful suppression of purple loosestrife can be achieved, it is still not predictable which replacement communities will develop in their place. At several release locations in New York, a resurgence of cattails and other wetland plants has been observed, but this is not always the case as other invasives (*Phragmites australis*, *Phalaris arundinacea*) may expand (Blossey, 2002). Studies are being made to investigate whether a combination of biocontrol coupled with physical means (fire, disking, flooding, mowing, etc) may be useful in accelerating the return of nature plant communities. Nationwide, purple loosestrife biocontrol program are conducting standardized long-term monitoring programs to follow and evaluate the effectiveness of releases and the secondary redevelopment of wetland plant populations (Blossey, 2002). Investigations are also on-going regarding changes in animal communities (insects, amphibians, birds) associated with changes in purple loosestrife populations. At the current time, Renovate® 3 would be a viable alternative to herbivorous macroinvertebrates in a rapid response plan due to its greater reliability and replicability of macrophyte control.

7.7.4 Renovate® 3 vs. Other Chemical Treatment Alternatives

As discussed earlier, aquatic herbicides can be very effective in controlling target plant species in lakes. Herbicides have advantages over most techniques when getting a problem species under control is an immediate goal. No other technique can address infestations over a wider area faster and at lower cost. Herbicides may also be particularly applicable in cases of recent invasions by non-indigenous plants, as more complete control can often be exercised with herbicides before invasive species become widespread.

Renovate® 3 is anticipated to be used mostly for selective control of Eurasian watermilfoil. Comparison of the effectiveness of the five aquatic herbicides registered in New York (Table 7-3) indicates that four are considered to have high effectiveness with *M. spicatum* – diquat, 2,4-D, endothall, and fluridone (NYSDEC, 2005). However, diquat and endothall are considered general purpose, broad-spectrum contact herbicides which are used when removal of most aquatic vegetation is desired and not selective for specific control of watermilfoil. In many cases, this broad-spectrum toxicity may limit application of diquat and endothall to spot treatments of limited area. In contrast, Renovate® 3 is highly selective against Eurasian watermilfoil and other select dicotyledons, and has little to no effect on most common native monocotyledons (e.g., naiads, pondweeds, etc). Therefore, these two aquatic herbicides would not be considered good alternatives to Renovate® 3 for selective treatment of Eurasian watermilfoil.

Renovate® 3 was therefore compared to the two herbicides typically used of control of Eurasian watermilfoil: 2, 4-D and fluridone. When comparing these three herbicides, the factors which would favor selection of Renovate® 3 include: selectivity, requirement of a short contact time, short half-life, and low toxicity.

Both fluridone and 2,4-D are systemic herbicides that are effective against Eurasian watermilfoil, but may also cause collateral damage to other aquatic macrophytes (particularly at higher doses). For fluridone, this is typically avoided by maintaining a low effective concentration (but one which does not impact native pondweeds) for a lengthy period of time. Maintenance of the effective concentration may be problematic if the area to be treated is small, there is potential for dispersion and dilution (e.g., rapid flushing time of the waterbody) and due to unexpected meteorological events. In contrast, Renovate® 3's rapid uptake and short exposure requirement (hours to days) for effective macrophyte control is a useful attribute for selecting an herbicide for treating a waterbody where water quality or hydrology may be dynamic (e.g., impoundment with significant stormwater inputs).

Due to the rapid breakdown (i.e., half-life for triclopyr can range from 12 hours to 29 days), lack of significant bioaccumulation, and low toxicity of triclopyr and its major metabolites (TMP, TCP), Renovate® 3 is considered to pose very little risk of adverse risk to fish and higher wildlife receptors. Due to its selectivity and short-half life, there would be low concern regarding potential overexposure of the vegetation. The low toxicity of Renovate® 3 would be a useful attribute when selecting an aquatic herbicide where there are concerns with potential transport of treated water downstream to habitats of sensitive receptors.

Another potential selective advantage for Renovate® 3 is the distance-based label restrictions for application to waters used for certain uses (e.g., drinking swimming, irrigation). There are some cases where differences in necessary distance of applications from a potable water intake may allow use of Renovate ® 3 (particularly for control of floating or emersed invasives) in locations where other aquatic herbicides would be prohibited. For example, Renovate® 3 may be used for spot-treating floating or emersed invasives at distances from 500 to 1,100 ft from potable water intakes, whereas both 2,4-D (1,500 setback distance for active potable or irrigation intake) or glyphosate (no application within 1,320 feet upstream of a potable water intake) require greater distances. [Note: glyphosate may be considered an alternative for treatment of purple loosestrife].

As with all management techniques, an important selective factor is cost effectiveness. Presently, submersed Renovate® 3 treatments in deep water applications (> 4 ft. average depth) are expected to be a more expensive option for single treatments than for 2,4-D or fluridone. However, the use of Renovate® OTF allows for treatment of aquatic macrophytes in deeper water (depths exceeding 4 feet deep) using less volume and active ingredient and thus a reduced cost over Renovate® 3 (and more comparable to the cost 2,4-D.

Even if a significant cost differential exists betweens these two herbicide, Renovate® 3 may still be used as the primary substitute for 2,4-D or diquat due to use restrictions which prohibit the use of these chemicals in waters with depth >6 ft (see applicable restrictions under Conservation Law 15-0313 Part 327 Pesticide Control Regulations). In addition, the selective properties of triclopyr may result in Renovate® 3 as the primary tool in certain entire littoral specific treatment programs and/or as part of a IAVMP; for example, as a follow-up “spot” management (e.g., < 4 acres) of Eurasian watermilfoil following a lakewide fluridone management program.

Careful use of aquatic herbicide has been reported to be an effective, efficient, and a less destructive (compared with physical techniques) means of removing large purple loosestrife stands in California (CDFA, 2006). Chemical control of purple loosestrife may be accomplished by application of glyphosate or triclopyr. Glyphosate is the only currently- approved herbicide in New York shown to have high effectiveness for this species (see Table 7-3). Control of small purple loosestrife stands is reported by spot treatments with glyphosate commercial products (e.g., Rodeo) typically applied at a 1-1.5 % solution, during early to late bloom (CDFA, 2006). Renovate® 3 also provides an alternative, effective chemical control agent for purple loosestrife. However, as noted in Section 7.4.3, glyphosate is a broad spectrum (i.e., non-selective) herbicide which would potentially affect other emergent species. Application of Renovate® 3, which provides selective control of broadleaf plants with minimal impact to most monocot species, could be used for spot treatment of smaller loosestrife stands, particularly in areas which overlap aquatic waterbodies or where there is a need to protect native monocot species.

As noted earlier, watershed and waterbody specific characteristics, aquatic and/or wetland plant community coverage and composition, water uses and stakeholders’ expectations and preferences will need to be considered when selecting any aquatic herbicide as part of an integrated aquatic vegetation management plan.

8.0 Mitigation Measures to Minimize Environmental and Health Impacts from Renovate®

Mitigation measures describe guidelines or procedures used to mitigate or lessen the potential for impacts from the use of Renovate® in the waters of New York State. While no impacts to humans are expected from the use of Renovate® (see Section 6.0), there is the potential for some ecological effects (see Section 5.0). The mitigation measures described in this section will reduce, or mitigate that potential for ecological effects, without reducing the efficacy of the product.

8.1 Use Controls

As of April 7, 1993, all pesticides labeled for use in aquatic settings were classified as restricted use products by regulation of the NYSDEC. Under this regulation, 6 NYCRR Parts 325 and 326, the use of aquatic pesticides is limited to persons privately certified, commercially certified in Category 5, or possessing a purchase permit for the specific application that is proposed. Additionally, only those persons who are certified applicators, commercial permit holders, or have a purchase permit may purchase aquatic use pesticides.

8.2 Label Identification

The herbicide label is a USEPA required document describing the legal use of the registered product. Registrants are allowed to provide part of the label text in the form of a booklet or other “pull off” type labeling, when it is not feasible or possible to literally “fit” the entire label on the container [40 CFR 156.10.] Additional information regarding instructions for application in New York State is listed separately on a NYSDEC 24(c) Special Local Need (SLN) Registration supplemental label (provided in Appendix E). Currently, the application of Renovate® 3 is only allowed in NYS under the provisions of the SLN label, [note: SePRO has also applied for SLN registration for Renovate® OTF but this has been accepted to the date of this document].

For the buyer, the label is the main source of information about how to use the product safely and legally. In addition, the label provides information for the user regarding any safety measures needed for appropriate use of the product (i.e., personal protective equipment, acceptable application methods).

8.2.1 Label Components

Final printed labels or labeling must be filed and accepted by the USEPA prior to product registration. The following information is required by the Agency to appear on the herbicide label:

- Product name;
- Ingredient statement including name and the percentage of each active and inert ingredient;
- "Keep Out of Reach of Children" statement;
- Signal word corresponding to appropriate USEPA toxicity categories;
- First Aid statement;
- "Skull & crossbones" symbol & the word "POISON" if the product is in Toxicity Category I;
- Net contents/Net weight;
- EPA registration and establishment numbers;
- Company name and address;

- Applicable precautionary statements related to hazards to humans and domestic animals and environmental, physical or chemical hazards;
- Directions for use;
- Storage and disposal;
- Warranty statement; and
- Worker protection labeling.

8.2.2 Label Instructions

This section of the label provides instructions to the user on how to use the product, and identifies the pest(s) to be controlled, the application sites, application rates and any required application equipment. Label use precautions and directions for aquatic applications of Renovate® 3 (including provisions on NYS 24(c) Supplemental Label) include the following:

- Obtain required state or local permits prior to application.
- Do not apply the product through any type of irrigation system.
- Do not use treated water for irrigation for 120 days, or until triclopyr level is determined to be < 1 ppb by laboratory assay (typically determined by high performance liquid chromatography (HPLC) or by enzyme-linked immunosorbent assay (ELISA) (Poovey et al. 2004).
- Do not apply Renovate® 3 directly to, or otherwise permit it to come into direct contact with (via spray drift or other mechanism), grapes, tobacco, vegetable crops, flowers or other desirable broadleaf plants.
- Do not apply to saltwater bays or estuaries.
- Do not apply directly to un-impounded rivers or streams.
- Do not apply on ditches or canals used to transport irrigation water. It is permissible to treat non-irrigation ditch banks.
- Do not apply where runoff water may flow onto agricultural land as injury to crops may result.
- When applying on banks or shorelines of moving water sites, minimize overspray to open water.
- Use of a mistblower is not recommended.
- Review chart provided in Renovate® 3 NYS SLN label to identify setback distances if product is applied to lakes, reservoirs or ponds that contain a functioning potable water intake for human consumption (distance varies from 1,300 to over 11,500 feet and depends on application rate and number of acres treated).
- Swimming is prohibited in water treated with Renovate® 3 for three hours after treatment.
- There are no restrictions on fishing in treatment areas.
- There are no restrictions on livestock consumption of water from the treatment area.

8.3 Relationship to the NYS Drinking Water Standard

The Renovate® 3 USEPA label indicates that the target triclopyr concentration in the treated water should not exceed 2.5 ppm ae and recommends setback distances for applications near functioning potable water intakes. The USEPA label recommends that potable water intakes be turned off until the triclopyr concentration in the water is determined to be 0.4 ppm or less by laboratory analysis or immunoassay. However, as indicated in Section 6.2, the drinking water standard established in New York State for organic chemical compounds not specifically identified in the standards is 0.050 ppm. Therefore, the SLN for application in New York will contain specifications and setback distances commensurate with this State water quality standard and specify that potable water intakes be turned off until the triclopyr concentration in the water is determined to be 0.05 ppm or less by laboratory analysis or immunoassay. Modified setback distances calculated for this purpose are provided in Appendix E.

The Renovate® 3 product SLN labeling indicates that swimming should be prohibited in the treatment areas for three hours after application, but does not bear any restrictions on use of water in the treatment area for other recreational purposes, including fishing. Risks from exposure to triclopyr via drinking water or recreational uses should be negligible since triclopyr degrades rapidly in water via photolysis (Antunes-Kenyon and Kennedy, 2004).

8.4 Spill Control

Care should be taken to use Renovate® 3 properly and in accordance with the approved labels. Any leaks or spills should be promptly addressed. Liquid spills on an impervious surface should be cleaned up using absorbent materials and disposed of as waste. Liquid spills on soil may be handled by removal of the affected soil, and disposal at an approved waste disposal facility. Leaking containers should be separated from non-leaking containers and either the container or its contents emptied into another container.

8.5 Permitting and Mitigation Considerations

The State of New York regulates activities potentially affecting water resources and wetlands through several programs and multiple regulatory agencies. Pertinent to the application of aquatic herbicides for the control of invasive species are the Freshwater Wetland Program and Coastal Wetlands Program, both administered by NYSDEC. Generally speaking, the Clean Water Act (CWA) and other programs administered by the U.S. Army Corps of Engineers do not directly regulate the application of herbicides for invasive species control. Consequently, the NYSDEC Freshwater and Coastal Wetlands Programs represent the primary agency issuing permits for the use of herbicides and pesticides potentially affecting wetland areas. These permits and the associated conditions also represent the means by which site-specific characteristics and applicable mitigation measures can be incorporated.

The New York Freshwater Wetlands Act (Article 24 of New York Environmental Conservation Law) provides the NYSDEC with the ability to regulate and issue permits for activities potentially affecting wetlands. Generally, this program exerts regulation over wetland areas that are mapped by the state (note: currently 12.4 acres or 5 hectares, but eventually to be reduced to 7.4 acres or 3 hectares as state wetland mapping is completed) or greater in size. Article 25 of New York Conservation Law represents the state's tidal wetland permit program. Similar to the freshwater wetland program, the state actively maps jurisdictional tidal wetlands, though there is no prescribed size limit for mapping and regulation.

Use of herbicides for invasive species control within wetlands, whether fresh or tidal, will likely require a permit from the NYSDEC. Such a permit is obtained through the general provisions of New York's Uniform Procedures Act (UPA), which allows for joint review among any state or federal agencies reviewing or commenting upon such applications in a timely manner. Permit applications must provide a clear description of the project purpose and details of the proposed activities, practicable alternatives to the activity, plans and specifications as needed, as well as proof of compliance (if applicable) with the state's Environmental Quality Review Act (SEQR) and Historic Preservation Act (SHPA). There are no applicable exemptions for either proactive invasive species control or filings conducted by government agencies under the freshwater or coastal wetland programs. New York State Environmental Conservation Law section 9-1503 provides protection for rare plant species. It is important to note that the application of herbicides to areas known to harbor rare plants is strictly controlled and may subject to a long list of specific conditions (or, in some cases, may be simply prohibited). As noted in Section 5.1.7, information on the location and status of known rare plants may be obtained through the NYSDEC's Natural Heritage Program.

As part of the permitting activities identified above, application may be subject to ways in which any adverse impacts may be reduced or eliminated by incorporation of mitigating measures into the permit provisions. The following measures may be considered on a site-specific basis as to their ability to further reduce, or mitigate any potential for environmental effects, without reducing the efficacy of the product.

8.5.1 Timing

When the aquatic plant management objective is to control Eurasian watermilfoil, while minimizing impacts to other aquatic macrophytes, Renovate® 3 may be used early in the season and throughout the active growth stage of target species. As was discussed in Section 3.4.1, Eurasian watermilfoil is essentially evergreen and begins to grow rapidly at the beginning of the growing season. This enables this plant to often develop significant biomass before native macrophyte species begin growing (Smith and Barko, 1990). The use of Renovate® 3 early in the growing season would target Eurasian watermilfoil, while minimizing the impact on other aquatic vegetation. In addition, the selective nature of triclopyr would also allow the resource manager to use Renovate® 3 during mid- to late season treatment programs with minimal impact to those less susceptible native plants (i.e., monocots) established in the treatment area.

For control of purple loosestrife in wetland areas, foliar application should be made in the early-mid growing season when the plant development is at the bud to mid-flowering stage of growth. It is recommended that follow-up applications of Renovate® 3 be conducted in the following year on any regrowth to achieve increased control of this species. Application during the early part of the growing season may encourage the development of suppressed native species. For further details refer to Appendix E.

8.5.2 Application Techniques

For removal of Eurasian watermilfoil, it is suggested that Renovate® 3 be uniformly applied across the entire area to be treated. Applicators should follow an application pattern that minimizes concentration of the product in local areas. In most cases for selective treatment of Eurasian watermilfoil, subsurface application is recommended. In some cases, spray application may be used and, if conducted, measures to prevent overspray should be used. Renovate® OTF should be applied using a mechanical spreader such as a fertilizer spreader or mechanical seeder or similar equipment capable of uniformly applying the flakes.

Purple loosestrife can be controlled with foliar applications of Renovate® 3. For broadcast applications, use a minimum of 4 ½ to 6 lb a.e. of triclopyr (6 to 8 quarts of Renovate® 3) per acre. If using a backpack sprayer, a spray mixture containing 1% to 1.5% Renovate® or 5 to 7 fluid ounces of Renovate(3) per 4 gallons of water should be used. All purple loosestrife plants should be thoroughly wetted. For further details refer to Appendix E.

8.5.3 Consideration of Hydrologic Setting / Mixing Regime

When making lake-wide treatments it is recommended that application rates, calculated as ppb of triclopyr, are based only on the water volume in which mixing is expected to occur. Rates should be selected according to the rate chart provided in the label as specified for a particular concentration and water depth and adjusted for mixing regime.

It should be noted that for thermally stratified waterbody, rate calculations should be based on water depth in the epilimnion above any deep water areas and generally not include waters below the metalimnion or thermocline. This is because the stratified conditions effectively concentrate the Renovate® 3 in the upper waters (or delay diffusion into the hypolimnion sufficiently long that the product is typically biodegraded). In non-stratified conditions, the entire depth of the water column should be considered for the application rate calculations. A table indicating the proper volume of Renovate to use as a function of treatment surface area and water depth is provided in the SLN label (see Appendix E).

Adjustments to application rates will also need to be made for rapidly-flushed waterbodies (e.g., run-of-river impoundments, rivers, etc.). These should be made a site-specific basis, using estimates of water exchange to adjust concentrations or to consider multiple applications (not to exceed total of 2.5 ppm ae). If the water exchange is too rapid, the applicator may wish to consider alternative means to control macrophytes or delay treatment until water exchanges slows or may be temporarily halted (e.g., installing flashboards at a dam) until treatment is completed. This last option should only be tried following careful consideration of related effects (e.g., flooding, downstream effects, etc).

9.0 Unavoidable Environmental Impacts if Use of Renovate® 3 is Implemented

The use of Renovate® 3 has been evaluated during the federal registration process and in this SEIS for various impacts to target plants and non-target organisms in the aquatic setting. There are several unavoidable impacts that will occur when Renovate® 3 is used in the waters of NYS to manage unwanted invasive macrophytes such as Eurasian watermilfoil or purple loosestrife. It is important to note that the mitigation approaches described in Section 8.0 will lessen the magnitude and extent of those impacts. Those impacts are:

- **Impact to Habitat** - When Renovate® 3 is introduced into a waterbody, it will result in the death of the target macrophytes. Once these target macrophytes have dropped out of the water column, there may be a potential for decreased dissolved oxygen and impacts to aquatic wildlife. There will be a period of time before the native non-target macrophytes reestablish themselves in the vacant niches. During that period of time, before the non-target species reestablish themselves, the aquatic macrophyte community will be reduced in size and habitat function will be reduced.
- **Impacts to Non-target Species** - A review of the literature indicates that there are some native macrophytes (e.g., native *Myriophyllum* species) which would be impacted to some extent by the use of triclopyr in a waterbody. This has been detailed in Section 5.1. However, one of the most appealing features of triclopyr is that it does not adversely affect most of the important monocotyledonous native pond weeds (e.g., *Potamogeton* pondweeds, naiads, bladderworts). The literature indicates that a plant community composed of native plant species will initiate reestablishment during the season following Renovate® 3 use.
- **Possible Reinfestation** - In areas of significant water flow, such as lake inlets, Eurasian watermilfoil and other target plants may not be sufficiently controlled due to the dilution of applied Renovate® 3 with untreated water or rapid product biodegradation unless application rates take this into account. Even after a successful application, the reinfestation of Eurasian watermilfoil or purple loosestrife may occur within one to two growing seasons, dependent on the level of control reached in the original application). This may necessitate the re-application of Renovate® 3 in further seasons and/or utilization of alternative means of controlling Eurasian watermilfoil or purple loosestrife in those areas.

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Appendix A

Renovate®3, Granular, and OTF USEPA Labels, and MSPS Sheets

Appendix B

New York Natural Heritage Program Rare Plant Status List

Appendix C

A Primer on Aquatic Plant Management in New York

Appendix D

Submersed and Emerged Weed Control Setback Tables for Renovate® 3 Herbicide in the State of New York

Appendix E

Supplemental Labeling (Chapter 24(c) Special Local Need (SLN) Registration for use if Renovate® 3 in New York

Appendix F

Public Comments and Responses (reserved)

Appendix G

Rulemaking Decisions (reserved)