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An Overview of Wetland Restoration

1.1 Introduction

Wetlands are widely known to be critical to protect water quality, to provide wildlife habitat, to mitigate floods, and to provide many other important natural functions. Although New Hampshire has been relatively successful in protecting wetland resources, many have been degraded by past and current land uses and more are impacted each year as the state grows. Restoration of these degraded areas holds great potential to help improve New Hampshire's water quality, wildlife habitat and general quality of life.

1.1.1 The ARM Fund

The recent development of the "Aquatic Resource Mitigation Fund" (ARM Fund) has provided a promising new source of grant money to help with wetland restoration efforts. These funds are available to New Hampshire cities and towns to implement programs to restore, protect or create aquatic habitats. The fund accepts payments ("in-lieu fees") made by applicants for state wetland dredge and fill permits under RSA 482-A, who pay into the fund to help offset ("mitigate") the impacts of their proposed projects. These funds are then pooled on a watershed basis and managed by the NH Department of Environmental Services (NHDES) and a Site Selection Committee made up of watershed stakeholders. The intent of the fund is to provide grants to environmental and community organizations to conduct worthwhile projects that will yield environmental benefits in the watershed.[1]

Figure 1-1 shows a map of the sixteen "HUC-8" watersheds in NH. The ARM Fund comprises 16 accounts which correspond to each one of the watersheds; the law requires that in-lieu fee payments made by a project within a particular watershed be

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[1] **Appendix A** contains the portion of RSA 482-A which references the establishment of the ARM Fund, as well as the Memorandum of Understanding between the NHDES and the US Army Corps of Engineers that allows use of "in-lieu fee" payments to be used for wetland mitigation.

spent within that same watershed [RSA 482-A:31,III(c)]. The Merrimack River Watershed contains the largest amount of funds collected to date (more than $650,000 through the end of January 2009), and it is also the first watershed for which ARM funds are available.[2]

1.1.2 Development of a Wetland Restoration Assessment Model (WRAM)

Conservation organizations have developed a tremendous amount of information on ecologically important areas in New Hampshire over the years - with a focus on preservation. Additionally, excellent progress has been made in NH's coastal region on restoring salt marsh habitat. But relatively little is known about potential wetland restoration sites in the Merrimack River Watershed and other watersheds in the state. To address the need, The NHDES, working with its partners at the NH Fish and Game Department, the US Environmental Protection Agency and other state and federal partners, have commissioned this study of the Merrimack River Watershed.

A thorough and systematic study of wetland restoration opportunities in the basin will help to promote environmental restoration and assist in the decision making process for public and private expenditures. A clear, science-based understanding of these wetlands will help focus energy on the approach for restoration efforts and will ensure that funds are used efficiently. The resulting information can be used by concerned citizens and community organizations to identify promising wetland restoration projects and to generate interest in planning and conducting projects.

Because of the large scale of this watershed (1,672 square miles), the development and application of an automated geospatial model to identify and prioritize potential wetland restoration sites was determined necessary. The overall goal of the project was to build a Geographic Information System (GIS) model of the Merrimack River watershed and to utilize the model to identify wetlands that may be impacted by past land uses and to understand which of those wetlands may benefit the most from restoration. The project aims to develop a model that is specific enough to provide reliable results in the Merrimack River Watershed, but general enough so that it can be applied to other watersheds in New Hampshire in the future. This model will be called the Wetland Restoration Assessment Model (WRAM), and its development and function is explained in detail in Chapter 2.

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The purpose of this report is to explain the GIS model and the results of this study, and it is hoped that the results will be helpful to those who want to help protect and restore wetlands. It is very important to understand that, due to the limitations of GIS, *the model cannot identify or assess all potential restoration opportunities*. While the results suggest that there are numerous opportunities throughout the watershed, and

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2 Funds for seven other watersheds will become available later in 2009, 2010 and into 2011; no ARM Fund payments have yet been made for the remaining eight watersheds.

that the model does a good job of identifying those opportunities, it is also clear that local Conservation Commissions and other local and regional organizations may know of other viable wetland restoration sites that are not included in this study. The exclusion of these sites should not be taken as evidence that such a site would not qualify for an ARM grant or other funding sources.

1.2 Methods of Wetland Restoration

Before reviewing the GIS model and its results, it may be useful to discuss the various ways that a wetland can be degraded and the ways to remedy that impairment. This section therefore focuses on the common types of impacts to the freshwater wetlands in the watershed, and briefly summarizes some of the techniques that can be used to restore wetlands.

1.2.1 Wetland Fill Removal

Over the years, wetland areas were filled to accommodate development or in an effort to improve the land for residential, commercial or farming uses. This constitutes a common mode of wetland loss. Filled wetlands are nearly always destroyed and lose all wetland functions and values. However, removal of the fill - in cases where it would not impact a roadway, building or other structure - can be effective in restoring the area to a functional wetland. In some cases, the wetland can be expanded by extending the excavation into upland areas, a strategy that is often called "wetland creation" or "wetland construction."

Wetland restoration is the process of using ecological principles and experience to return a degraded wetland system to a more ecologically functional state. The goal of this process is to emulate the structure, function, diversity, and dynamics of the original wetland.

The creation of new wetlands and the restoration of filled wetlands are similar in many ways. The primary difference is that wetland creation projects begin with naturally occurring upland landforms whereas restoration of filled wetlands begin with filled landforms.[3] Both involve a sequence of similar planning and implementation, including shaping the landscape with heavy equipment, then establishing the right soil conditions and a wetland plant community from scratch on the graded substrate.

Implementation of a wetland restoration project begins by establishing project limits in the field and putting erosion and sediment control structures in place. Fill is removed to the level of the original wetland, or upland soils are excavated to desired elevations using heavy equipment. Graded surfaces are often left rough rather than graded smooth to simulate naturally occurring micro-topography (e.g. "pit and mound" topography characteristic of wetlands).

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3 Generally, it is not beneficial to impact undisturbed uplands to create wetlands. Thus, this wetland creation is most appropriate when limited to upland areas which have been disturbed or degraded.

Wetland restoration projects may utilize native topsoil if it is intact beneath the fill; however, most wetland creations and many restorations require topsoil placement over the graded substrate to provide conditions suitable for plant growth. Wetland topsoil may be salvaged from a permitted wetland fill area, upland topsoil may be salvaged from the upland creation area, or topsoil from an offsite source may be needed. Wetland soils generally have more organic matter than upland topsoil. If topsoil from an upland source is utilized, it is often combined with organic compost to assure it has adequate water holding capacity and nutrients for the wetland plant community. In all cases, the topsoil utilized must be free of seeds, tubers, and root fragments of invasive species.

When selecting planting stock, vegetation must be closely matched to various conditions within the restoration area. Generally, target cover types and the species to be planted are chosen after review of adjacent undisturbed areas (i.e., "reference sites"). However, variation in elevation of a few inches can result in different hydrological regimes suited for different sets of species. The establishment of wetland vegetation may be accomplished in a number of ways. Wetland topsoil with a live seed bank may be salvaged from an associated wetland impact project, as may live plants that would otherwise be destroyed. Wetland seed mixes are available from specialized suppliers, as are live plants. All plants and seeds introduced to the site should be native, non-ornamental varieties, preferably propagated from local genetic stock. Wetland plants and seed mixes should be obtained from a reliable grower and free of invasive species. In areas that are not inundated, a light application of weed-free mulch is useful in the planting design to help keep plants and seeds moist and to help stabilize soils while the vegetation becomes established. Heavy applications of mulch are utilized around plantings of woody species to prevent them from being outcompeted by wetland grasses and forbs until they have grown well above the surrounding plants.

1.2.2 Elimination of Ditching and other Hydrological Modifications

Wetland hydrology - the interaction of surface and ground water with the soil surface - is perhaps the defining characteristic of a wetland, and is the primary determinant of its ecological features including the composition of its dominant vegetation and faunal community, its biogeochemical dynamics, and its water quality. The natural hydrology of a wetland can be affected by excavation of drainage ditches, installation of field tile in agricultural fields, as well as construction of dikes or dams. This is a pervasive form of wetland impact throughout the watershed, and is one that is fairly easy to diagnose and remedy.

Ditching was common practice throughout the state to drain wetlands for agriculture and for other purposes. When viewing aerial photographs, ditches typically appear as a grid pattern, although some ditch systems may more closely resemble natural channel patterns. In some cases, these ditches are, in fact, dredged stream channels – lowering the bed of the stream has the effect of lowering the groundwater table in the vicinity of the impacted stream.

Although not as apparent, subsurface drains were installed in many wet areas to improve the area for farming. “Drain tile” or “field tile” as it is often called, is usually made of clay or perforated plastic and buried at a depth of two to six feet. While surface water can be drained by open ditches, tile drainage was used extensively to lower subsurface water, and is still a common practice in some areas of the country. In a tile drainage system, a network of below-ground pipes allows subsurface water to move out from between soil particles and into the tile line. Water flowing through tile lines is carried to surface water discharge points -- lakes, streams, and rivers -- located at a lower elevation than the source. Water enters the tile line either via the gaps between tile sections, in the case of older tile designs, or through small perforations in modern plastic tile.

Ecologically, these drainage systems, while sometimes necessary to allow agricultural production, have obvious adverse effects on wetlands. By lowering the water table, the wetland is often effectively destroyed, while in other cases it decreases the diversity and productivity of the wetland. Invasive species often become dominant in drained wetlands. In bypassing the natural flow of water from the surface to the water table, drainage systems often prevent groundwater recharge and the natural filtration of water provided by soils and wetlands. Drainage systems can impact surface waters by directly discharging water laden with fertilizers, eroded soil, agrochemicals, and other types of runoff.

Wetland systems can also be affected by diking or damming. Although this mode of impact was considered in this study, it was ultimately decided that impounded sites would not be prioritized over other forms of impairment. Note that the objective of the damming often was to improve habitat or manage for a specific set of species (e.g., ducks and other waterfowl). While management sometimes involves an ecological tradeoff and can have adverse ecological effects on non-target species, it was determined that there is an abundance of good restoration sites without including these impounded sites.

Remediation of hydrological modifications can be relatively easy and inexpensive and is a very effective restoration technique.

The simplest restoration, a **tile break**, involves removing a section of underground agricultural tile that is draining a wetland. Generally, a contractor with a backhoe is used to remove or crush a 25 to 50 ft section of tile downstream of the wetland. The downstream end or outlet pipe can be plugged with concrete or clean clay fill, and the trench is filled. It is also possible to manage tile drains by connecting their outlet to a “riser” at the downstream (outlet) end of the tile line. The riser effectively raises the outlet elevation and will establish the controlling elevation in the entire upstream system. Water will fill the drain tile until it reaches the outlet of this riser. This can work well if adaptive management is desired (the height of the riser can be modified to manage water levels in the system) or where the location of the drain tiles is unknown. It can also be used to maintain downstream drainage if needed.

For excavated ditches, a **ditch plug** consisting of an earthen wall can effectively eliminate the influence of the ditch by establishing a new controlling elevation along the ditch or at its outlet. In practice, several ditch plugs may be necessary in a ditch system to be effective. This type of restoration uses equipment to fill a portion of a drainage ditch to natural ground level. Again, a riser or culvert may be used to let water flow through an outlet pipe once it reaches a certain level. A small dike or berm may also be used, which will impound the water that will begin to collect once the draining has been eliminated. A dike prevents the drainage of water downstream and requires a spill way or other water-control structure to regulate the water level and prevent the dike from being washed away during periods of heavy runoff.

1.2.3 Invasive Species Control

Over the last few decades, several invasive species have come to inhabit New Hampshire wetlands, and their presence in a wetland is usually indicative of anthropogenic disturbance. In southern New Hampshire, nearly all wetlands harbor some invasive species, with purple loosestrife (*Lythrum salicaria* L.) and common reed (*Phragmites australis* [Cav.] Trin. ex Steud), the two most well-known. Reed canarygrass (*Phalaris arundinacea* L.) is another introduced species which has also been recognized as having adverse effects when it becomes the dominant plant species in emergent wetlands.

1.2.3.1 Common Reed (*Phragmites australis* [Cav.] Trin. ex Steud)

Common reed can grow up to 10 feet high in dense stands and is long-lived. *Phragmites* is capable of reproduction by seeds, but primarily does so asexually by means of rhizomes. Recent research has now shown that native and introduced genotypes of this species currently exist in North America.

Common reed can invade marsh and wet meadow habitat to create a monoculture environment that eventually will reduce the diversity of the native plant community by crowding out other species. Typically, this results in a reduced diversity of fish, birds, and other species that rely on marshes. Common reed can grow so densely that vertebrates have a difficult time utilizing the marsh. In addition, common reed can be a fire hazard since the dry stems can fuel large fires.

1.2.3.2 Purple Loosestrife (*Lythrum salicaria* L.)

Purple loosestrife, a herbaceous perennial native to Eurasia, was introduced to eastern North America in the early to mid 1800's and has rapidly spread to reach every state in the U.S, with the heaviest populations found in the Northeast. It is a semi-aquatic species which prefers moist organic soils, fluctuating water levels, and full sunlight, establishing itself in primarily freshwater wetlands. However, its high tolerance to a wide range of environmental conditions and its ability to grow on a variety of substrates enables it to invade a large number of habitats from marshes, bogs, and swamps to disturbed areas such as roadside ditches and construction sites. The absence of a natural predator in North America further enhances its strength and ability to out-compete native vegetation and form dense monotypic stands within wetlands.

Species characteristics mentioned above, as well as high seed production and dispersion, makes purple loosestrife a serious problem to native plant diversity and wildlife. Through the displacement of native flora and fauna and formation of a monotypic stand, it eliminates viable sources of food, nesting, and shelter for wildlife as well as reducing fish spawning areas and waterfowl habitat. It also reduces wetland recreational opportunities and diminishes agricultural areas by blocking flow in drainage and irrigation ditches.

1.2.3.3 Reed Canarygrass (*Phalaris arundinacea* L.)

Reed canarygrass (*Phalaris arundinacea L.*) is a tall-growing, perennial grass which is widely distributed across the northern states. Reed canarygrass forms dense, highly productive single species stands that pose a threat to many wetland ecosystems. The species grows so vigorously that it is able to inhibit and eliminate competing species (Apfelbaum and Sams 1987). In addition, areas that have existed as reed canarygrass monocultures for extended periods may have seed banks that are devoid of native species. Unlike native wetland vegetation, dense stands of reed canarygrass have little value for wildlife. Few species eat the grass, and the stems grow too densely to provide adequate cover for small mammals and waterfowl. Once established, reed canarygrass is difficult to control because it spreads rapidly by rhizomes.

1.2.3.4 Control Methods

Four methods have been used to control and reduce the spread and presence of invasive species in wetland communities. These methods must typically be used in combination with a carefully-planned multiple year management strategy in order to be effective. Even then, they often cannot eliminate the species entirely, but can be successful in restricting the species to a sub-dominant position in the plant community. The first three methods include mechanical, chemical and environmental control. Biological control of purple loosestrife is also possible, although no such biological control exists for common reed.

Herbicides can be effective, and have been used to control common reed and other invasive species in New Hampshire salt marshes. But, their use can raise health concerns, especially where wetlands intersect residential neighborhoods and developed areas. Two broad-spectrum herbicides, glyphosate and imazapyr, are commercially available and known to control Phragmites effectively when used properly. These two herbicides are considered safe to use in an aquatic environment.

Mechanical removal involves cutting or plowing or grading of the impacted wetland. It is generally most practical and effective in areas with small pockets or stands of purple loosestrife or common reed. Prior to 1997, mechanical removal was common; however it does require a substantial investment of labor, its short-term effectiveness has not always met expectations, and it often requires maintenance.

Mechanical treatments can be used most effectively following an herbicide treatment to remove dead stems and promote native plant growth. This also aids in the identification of new invasive growth for subsequent herbicide spot treatments. When burning is not feasible, mechanical treatment is recommended.

Prescribed fire is a tool that can be used after an herbicide treatment to remove excess biomass, potentially kill any living rhizomes and promote native plant growth. In situations where prescribed fire can be implemented it is easier to locate Phragmites regrowth and spot-treat those plants with herbicides once a site has been cleared of the thick, dead stems. In situations where it can be implemented safely and effectively, prescribed fire is a cost-effective and ecologically sound tool to help control Phragmites. Prescribed fire is recommended where Phragmites exists in large dense stands. Use of prescribed fire without first treating with herbicides does not control Phragmites, and instead may encourage rhizome growth and cause Phragmites populations to become more vigorous (Michigan DEQ, 2008).

Environmental control involves decreasing the vitality of the invasive population by manipulating certain elements of the surrounding environment such as soil moisture (e.g., temporary flooding) and pH, or the amount of sunlight through the over-story. This has proven to be effective in controlling loosestrife in two NHDOT mitigation sites in the state (Littleton and Nashua), but it must be used in combination with other techniques to be successful in controlling Phragmites.

Biological control of purple loosestrife is achieved through the use of herbivorous insects and is regarded as one of the most efficient, sustainable, and cost-effective strategies to date as a means of reducing the species to a level where it is still present but not dominant within a wetland system. The insects remain in the wetland system indefinitely making long term control possible. In 1992, the US Department of Agriculture (USDA) approved four insects native to Europe to use in the United States that solely rely on purple loosestrife for their food source. These include two species of beetle (*Galerucella calmariensis* and *G. pussilla*) and two species of weevils (*Hylobius transversovittatus* and *Nanophyes marmoratus*). Stunting purple loosestrife by feeding on foliage, terminal buds, and stem tissue, preventing sexual reproduction and seed production, and causing extensive root damage are all characteristic of these species feeding regimes, thus allowing native species and wildlife habitat to be restored.

In 1997, NHDOT and New Hampshire Department of Agriculture, Market, and Food (NHDAMF) worked together to start a pilot study on using biological methods to control purple loosestrife in New Hampshire. Sites were selected among NHDOT mitigation areas based on purple loosestrife population size and density, lack of standing water for the growing season, and accessibility. Both species of beetle (*Galerucella calmariensis* and *G. pussilla*) were selected due to previous success rates in other states, cost, and easy establishment at sites. Monitoring occurred during the growing season and developmental stages of the beetles and included visual assessments of plant populations, quantifying percent-feeding damage, documenting any negative impacts that the beetles have upon native plant species, noting any predation of the leaf-feeding beetles. In the spring of 1999, an Integrated Pest Management grant was awarded to DAMF to develop a Community Purple Loosestrife IPM Project (Durkis, 2003). As of 2004, the project had resulted in approximately 217,000 beetles being purchased for release into wetlands invaded with purple loosestrife throughout the state, including all ten counties with the incorporation of the NHDOT mitigation sites. More information on this approach can be obtained by contacting Mr. Doug Cygan at the DAMF.

1.2.4 Installation of Water Quality BMPs

It is well understood that increased urbanization is associated with stormwater runoff pollution. Urban runoff pollutants are many and varied depending on the land uses and pollutant sources present in an urban area. Typically, loadings of urban pollutants are greatest from industrial and commercial areas, roads and freeways, and higher density residential areas. Major categories of urban pollutants include sediments, nutrients, microbes, and toxic metals and organic compounds. Additionally, farming can contribute to sediment and nutrient pollution due to the effect of fertilizers, and livestock wastes.

Structural Stormwater BMPs in NH

Stormwater Ponds
- Dry Extended Detention Pond With Micropool Wet Pond
- Wet Extended Detention Pond
- Multiple Pond System
- Pocket Pond

Stormwater Wetlands
- Shallow Wetland
- Extended Detention Wetland
- Pond/Wetland System
- Gravel Wetland

Infiltration Practices
- Infiltration Trench & Drip Edge
- Infiltration Basin
- Dry Well
- Permeable Pavement

Filtering Practices
- Surface Sand Filter
- Underground Sand Filter
- Bioretention System
- Tree Box Filter
- Permeable Pavement
- Flow-through Treatment Swale

Vegetated Buffer (Vegetated Filter Strip)
- Residential or Small Pervious Area Buffer
- Developed Area Buffer
- Buffer on the Downhill Side of Roadway
- Ditch Turn-out Buffer

Source: *NH Stormwater Manual, NHDES, December 2008*

One of the key functions of a wetland system is its ability to serve as a sink for sediments and nutrients, and the uptake of metals by wetland vegetation has been clearly demonstrated. For these reasons, wetland restoration almost always improves water quality in the areas downstream of the project. However, in many cases, the discharge of excessive sediment and nutrients can have an adverse effect on the wetland itself, impacting its ability to provide other important functions. Therefore, an appropriate restoration technique is the construction of stormwater quality best management practices (BMPs) outside of the wetland. The purpose of the BMP installation is to capture the non-point source pollution before it enters the wetland or surface water.

Rapid advancement in the design of stormwater BMPs has occurred over the last decade as the focus on limiting non-point source pollution has increased. Traditional stormwater BMPs focused on detaining runoff and treatment by the use of vegetated swales. However, newer BMPs have better pollutant removal efficiencies than these older approaches. With the release of an updated New Hampshire Stormwater Manual by NHDES in December 2008, a number of new BMPs are now accepted. These can include a number of different structures including “gravel wetlands,” “infiltration tranches,” “sand filters” and other structures which are intended to mimic natural systems and to encourage infiltration of stormwater rather than direct discharge to wetlands or surface waters. In many cases, installation of these types of BMPs at the interface of the upland and wetland can help restore the overall ecological integrity of the wetland system.

1.3 Implementing a Wetland Restoration Project

The process of planning, designing and implementing a wetland restoration project can take time and involves several steps, outlined in this section.

1.3.1 Restoration Goals

The first step in any wetland restoration involves establishing goals for the project. This usually involves one or more of three types of goals: 1) wetland area goals; 2) ecosystem function and value goals; and 3) and ecosystem structure goals.

The area goals for wetland restoration projects are generally defined by the extent of an existing impact that is to be restored or created. The conceptual restoration plans developed for certain sites as part of this project, for example, always provide a target area goal. This goal should be interpreted carefully – it is based on a quick field review and review of mapped site conditions. The areas shown on the concept plans are very preliminary and will generally be the maximum amount of restoration or creation possible for a given site.

Ecosystem function and value goals include providing beneficial qualities such as flood flow alteration, pollutant attenuation, wildlife habitat, or recreation opportunities. These goals will generally be tied to replacement of lost wetland functions and values. In the case of the ARM Fund, these lost functions and values are directly tied to the functions and values lost as a result of the projects that contributed to the fund. In most cases, functional goals will be determined by the nature of the site – it is usually feasible to restore the previously lost functions when the restoration site was drained or filled.

Ecosystem structure goals include the establishment and distribution of broad wetland community types, such as forested, scrub-shrub, and emergent wetlands, as well as the species compositions, abundance, and/or survivorship targets within those broad types. Ecosystem goals are often based on the characteristics of nearby reference wetlands with environmental conditions similar to those of the planned wetland. Some goals may take decades longer to achieve than the typical wetland monitoring period of five years or less, so the goal may be limited to starting the wetland on a successful trajectory that is predicted to lead to the desired results.

1.3.2 Site Selection and Baseline Data

Site selection is closely related to the project goals, landscape context, and available hydrology. A wetland primarily intended for floodflow alteration and water quality improvement may be targeted functions in a developed area, whereas one intended primarily for wildlife habitat may be better sited away from development. The source and quality of water used to achieve the desired wetland hydrology is a critical factor in site selection. The presence of a large wetland or surface water directly adjacent to the project provides relative assurance that adequate hydrology is present, whereas construction of a groundwater based system may require a detailed water budget analysis. Degraded water inputs, such as untreated stormwater from areas with fertilized lawns, pet wastes, and paved surfaces can encourage the growth of unfavorable species and should be avoided unless the wetland is specifically designed and constructed to handle those inputs. Other landscape related factors, such as the presence nearby of favorable or unfavorable species, equipment access, and the likelihood of success all play a role in site selection.

Once the site is selected, baseline data should be collected at the site as well as nearby reference site(s), if available. Typical baseline data include information on topography, soils, vegetation, and hydrology as these are that environmental factors that are manipulated during wetland construction. Additional data on wetland functions and values is often collected from the reference sites.

1.3.3 Design and Implementation

Wetland restoration involves (re-)creating a landscape configuration that will result in the desired hydrology and ecological community for the site. Wetland construction designs generally utilize a topographic base plan to depict existing and proposed grading as well as detailed planting zones with various hydrological regimes.

Wetland design is typically conducted in two phases. First a conceptual design is developed with the major goals and objectives determined. The conceptual design is reviewed by regulatory and sponsoring agencies, which may provide input on the final design. Once all stakeholders are in agreement, a final design is submitted for regulatory approval and contractor bidding. NHDES rules provide a list of required plan elements for wetland restoration or creation as included in following excerpt:

> ***Env-Wt 805.03 Plans for Wetland Restoration or Creation Projects.***
> *The applicant shall include the following in the [project] plans:*
>
> *(a) Existing and proposed grades, with critical and typical cross sections showing:*
>
> *(1) Existing and proposed grades;*
>
> *(2) Predicted water fluctuations; and*
>
> *(3) Proposed wetland cover types for the mitigation area;*
>
> *(b) Construction procedures and timing as follows:*
>
> *(1) The name of the qualified professional responsible for oversight of the mitigation work;*
>
> *(2) The proposed contingency measures for unexpected issues; and*
>
> *(3) The timing and sequence of events;*

(c) A planting proposal, with preference given to native wetland plants and natural communities with localized genetic material, as follows:

(1) Plant species and quantities;

(2) Source of planting materials or whether the plan relies on natural re-vegetation;

(3) Plant stock size and zones of predicted plant occurrence;

(4) Plant survival goals;

(5) The proposed locations of native plant stock and the rate and type of seeding;

(6) When and where seeding or planting will take place; and

(7) Notation of dead snags, tree stumps, or logs per acre, where appropriate, to provide structure and cover for wildlife and food chain support;

(d) Documentation of existing and proposed soils as follows:

(1) The existing soils on the proposed mitigation site;

(2) The source of soils to be placed on the site;

(3) The likely seed bank composition of soils;

(4) The depth of proposed growing medium; and

(5) The soil properties such as texture and organic content;

(e) Erosion control notes and details to minimize or prevent sediment from entering adjacent, undisturbed wetlands or surface waters;

(f) Invasive species in the vicinity;

(g) If applicable, an invasive species control plan; and

(h) Activities that will be allowed and not allowed within the restoration or creation area.

Construction is most often accomplished by hiring an outside contractor, although NHDES and the NH Fish and Game Department have construction equipment and crews which are capable of implementing many of the restoration techniques described in Section 1.2.

1.3.4 Monitoring, Reporting and Adaptive Management

Typically the construction and post-construction phases of the project are monitored to help assure project success. Monitoring of project implementation includes checking grades, hydrology, topsoil quality, erosion controls, proper quality and quantities of planting materials, and planting methods.

Post-construction monitoring involves assessing whether or not the project meets the intended goals and measurable success criteria, or is on a trajectory to meet those targets. It often includes assessments of achieved functions and values, vegetation establishment, hydrology, dominance by wetland vegetation, the presence of invasive species, erosion controls, and the need for any remedial measures.

Typically post-construction monitoring is conducted once or twice per year for three to five years, with annual reports submitted to regulatory and sponsoring agencies. The new wetland is likely to be undergoing natural changes in community structure by the end of the monitoring period, but it should be a self-regulating and self-sustaining dynamic ecosystem that needs no further human intervention.[4] In particular, NHDES administrative rules provide guidance on evaluating the success of restoration and creation sites. Specifically, Env-Wt 806.02(b), Annual Monitoring Report, requires that:

> *…the annual monitoring report shall document that the hydrology of the mitigation site(s) is appropriate and the area has a 75% success rate of coverage of non-invasive hydrophytic vegetation after 3 full growing seasons following completion of the mitigation work or following additional remedial measures...*

In certain cases, the monitoring of a restoration site can be part of an adaptive management approach. Because of the complexity of natural systems, the outcome of even a well-conceived restoration plan can be difficult to predict. **Adaptive management** is particularly useful approach to cope with the complexity of natural systems, and is based on establishing indicators, systematically trying interventions, monitoring their effects and learning from the ecological response of the system. An adaptive management approach recognizes that future changes to the restoration plan may be necessary to maximize results, and ensures that the appropriate resources are included in the project.

[4] Structures such as weirs, dams, stand pipes and similar items, while sometimes necessary, should be avoided in wetland creation or restoration sites, particularly if those structures require maintenance and/or need to be seasonally adjusted to properly operate.