Bulletin 909

# Vegetation Establishment and Management Guidelines for Constructed Basins for Agricultural Water Treatment

THE OHIO STATE UNIVERSITY EXTENSION

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# Contents

## Definitions

**Active revegetation:** deliberately planting or seeding an area to reestablish vegetation.

**Constructed wetland:** a basin created and maintained for one or more of the following goals: water quality improvement, temporary water storage, wildlife habitat, or replacing wetland acreage.

**Hummock:** rounded or other shape mounds of soil that extend above the average water surface. This area gives animals and birds a place to lounge, hide, or nest.

**Hydrophytic vegetation:** plants that have adaptations to survive in saturated soil conditions.

**Passive revegetation:** reliance on seeds or plant material in the soil or from local sources to revegetate an area. No seeds or plants are deliberately planted. Also referred to as recolonization.

**Revegetation:** establishing plants in an area after a disturbance, such as construction.

**Sedimentation basin:** a basin created and maintained for the primary purpose of creating a location for sedimentation to occur, preventing off-site loss and reducing potential harm to downstream reaches.

**Seed bank:** the reservoir of viable seeds both on the surface and in the soil profile.

**Shelves:** level areas of a basin that run across the slope at different average water levels, similar to terraces, but within the treatment basin.

**Treatment basin:** a basin created and maintained for the purpose of improving water quality of incoming waters.

**Weephole:** a hole created in a flashboard of the control structure that allows water to exit. This allows slow release of excess water during rain or snowmelt and return to an average water level in the basin over a number of days after a precipitation event.

**WRSIS:** Wetland Reservoir Subirrigation System; a system that collects drainage from overland and subsurface tiles from agricultural fields which is routed into a constructed wetland where it can undergo water quality enhancement. The water is moved from the wetland to be stored in a conjoined reservoir for use in subirrigation of the agricultural fields.

## Bulletin Focus

This bulletin has been written to help inform and educate farmers, site designers and managers, homeowners, natural resource professionals, and other interested parties on the importance of vegetation in treatment basins. The information will help readers understand the methods used to establish and manage appropriate vegetation in such basins. It also provides some real-life experiences and management approaches from three constructed wetlands used to treat agricultural drainage water.

## Introduction

Treatment basins, as referred to in this bulletin, are water bodies created to collect waters with elevated nutrients, sediment, or other pollutants and improve that water's quality using natural processes. These basins help protect downstream and off-site water quality by temporarily holding runoff and drainage water and reducing potential pollutants these waters may contain before they move off-site. Such basins are often called detention basins, sedimentation ponds, or constructed wetlands. Within these treatment basins, a number of processes can occur that help in reducing or removing nutrients and sediments from the incoming waters.

Sediment and nutrients such as phosphorus that are associated with the sediments are removed from incoming water by the process of sedimentation. Sedimentation occurs when incoming waters slow down as they encounter the vegetation and the water surface in the basin. As the waters slow, sediment particles fall out of the incoming water and settle to the bottom of the basin. Vegetation growing on and within the basin also helps prevent erosion from the basin itself, which prevents reduction of the basin's capacity to hold sediments from treated waters. Nutrients can be removed from waters in the treatment basin by uptake into plants and algae growing within the basin. Nutrients are also removed as conditions are created near the root zone of vegetation within the basin that promote microbial processes such as denitrification and result in the reduction of nitrates. Organic

matter from vegetation must be available as "food" for microbes involved in processes that reduce or remove chemicals and nutrients.

Vegetation is the common player in many of these water quality improvement processes that occur within the treatment basin. Because vegetation growing in the treatment basin is so important to water quality improvement, this bulletin presents information on techniques to establish and manage vegetation in such basins.

The timing and duration of various water depths are the most influential features of the treatment basin that control which species of plants can grow and where they will grow within the treatment basin. Different plant species have different germination needs, growth types, and different tolerances related to water depth and soil saturation timing and duration. The ability to control the water level in the basin is important in creating different conditions that promote vegetation germination, growth, and establishment, and in turn, treatment basin functions. Water level control allows the basin manager to change the average depth of the water and the length of time the water remains at the average level. Water level control thus allows the basin manager to create a variety of growth habits in the treatment basin that will encourage different species. A variety of species and growth types may provide the best potential to meet not only water treatment needs, but also provide needed habitat for wildlife, and may also help protect against loss of vegetative cover. Vegetative cover can be lost as a result of disease or selective feeding by wildlife.

Hydrophytic vegetation is adapted for life in saturated soil conditions, and can withstand the "wet" conditions of the basin better than upland/dry species. Hydrophytic species grow in flooded conditions by means of specialized adaptations that allow the plant to grow and metabolize under non-optimal conditions such as flooding and limited air exchange. Because hydrophytic vegetation can grow in many water level and soil saturation conditions, such species will provide long-term vegetation cover in the basin and can often grow in the water column, thereby creating more treatment area within the basin. Hydrophytic vegetation species should be more dominant than dry or upland vegetation species in a properly managed treatment basin. If the creation of a constructed wetland is one of the goals of a basin, the presence of hydrophytic wetland vegetation is part of the legal definition of a wetland.

Hydrophytic vegetation has been characterized by its status as wetland indicator species, as defined by the National List of Plant Species that Occur in Wetlands (Reed

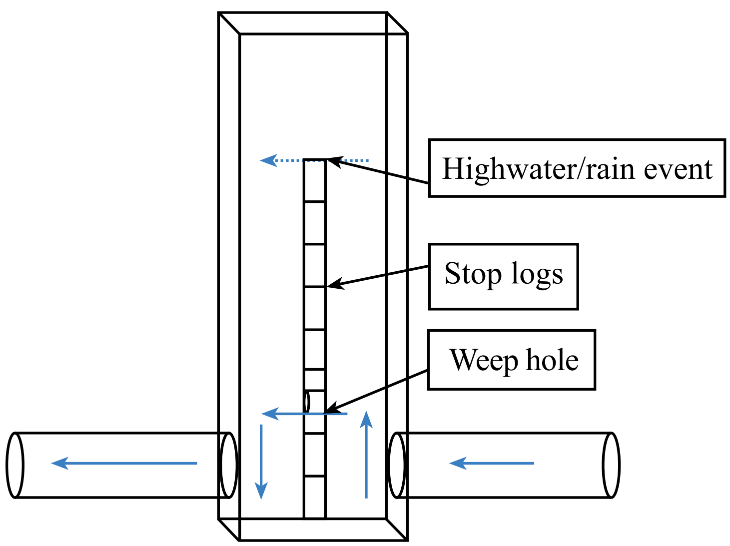
1988). Species are grouped by the frequency that they are found in wetlands. The obligate wetland category (OBL) comprises species that are found in wetlands >99% of the time. The facultative wetland category (FACW) includes species that are predominantly found in wetlands; their probability of being found in a wetland is very high (67–99%). The facultative category (FAC) are species that are equally common in both wetland and non-wetland areas (34–66%). The facultative upland category (FACU) comprises species that are considered non-wetland plants, occurring in wetlands 1–33% of the time. The last category consists of those that are obligate upland (UPL) species. These species are not wetland plants and are rarely found growing in wetlands (<1%). Wetland indicator species (WIS) are those species that are listed as OBL, FACW, and FAC for the region.

Hydrophytic plants can also be categorized by generalized tolerance to water depth and duration, referred to here as growth preferences. Floating species grow by floating on top of the water. Submersed species and species that grow floating but rooted to the basin floor can tolerate water greater than 30 cm, but typically less than 100 cm. Emergent species, species that grow partially out of the water, can tolerate average permanent shallow water levels of 30 cm or less. Mudflat species are species that grow best in saturated soils or areas with very shallow flooding, 15 cm, for very short periods of time. Woody hydrophytic species have various tolerances to water depth and flooding duration, depending on specific species requirements. The soil saturation and water level conditions required for growth of different species are strongly influenced by basin design and water level management.

## Basin Design Considerations to Encourage Revegetation in Treatment Basins

A treatment basin can be designed to have features that create multiple water depth and soil saturation conditions and therefore encourage establishment of different hydrophytic and/or WIS vegetation types. Various water depth and soil saturation conditions can be produced in the basin during construction by the creation of deep water areas, >30 cm, and shallow water areas, <30 cm, that occur at the average water level. The installation of a water control structure will allow the water level to be adjusted and allow control of water release from the basin. If a control structure is present, there can be more control over the average water level by allowing basin managers to adjust the depth, duration, and timing of water stored. A control structure

An example of a shelf within a constructed treatment basin in Defiance County, Ohio.




Conceptual diagram of a water control structure. The central portion of the diagram shows stacked stop-logs with gasket seals that control water level and storage capacity. The weephole establishes the designed average water level, and also allows slow water release after precipitation events.

also allows for creation of a "weephole" for slow release of storm water, reducing the risk of sediment loss off-site.

The development of shelves or "hummocks" can also help create different water depth and soil saturation conditions in the basin. Hummocks are small areas of soil mounded equal to or above the water surface. Shelves are similar to terraces placed at different average water levels in the basin. These basin features, shelves and hummocks, are important in reducing water velocity (increasing sedimentation) and in creating conditions that support the microbial community required for nutrient reduction. Also, "hummocks" and shelves increase habitat diversity for wildlife.

Basin design characteristics can also help encourage vegetation growth on basin side slopes. The basin perimeter should not merely be straight lines, but "wavy." Non-straight sides help reduce soil loss from the shore, create various water depth and soil saturation conditions on the bank, and provide wildlife habitat. Side slopes of one unit rise over 8–10 units run are recommended. This type of basin perimeter and gentle slope aids in vegetation establishment and helps to create areas that can increase water treatment capacity in the basin. A general example of a basin with very high potential for good hydrophytic vegetation coverage is a basin with gently sloping, "wavy" sides, and areas of soil that are exposed at or above the average water level.

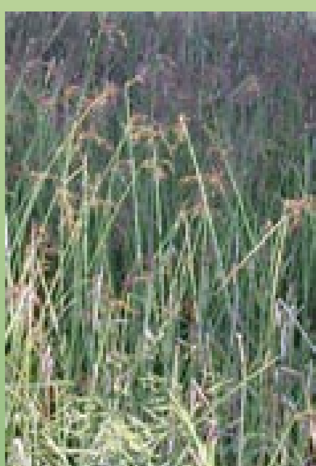
Vegetation growing on "gentle" slopes at a Fulton County treatment basin.

Vegetation growing on "wavy" basin banks at a constructed treatment basin in Defiance County, Ohio.

## Basin Construction Considerations That May Supply Revegetation Resources

A few construction considerations, such as location of the basin, topsoil replacement, and erosion control plantings can increase the potential number of species of plants available to the treatment basin after construction is finished. Areas such as woodlots, drainage ditches, wetlands, and streams in the immediate vicinity of the basin construction site may supply seeds or vegetative starts to the new basin. Seeds can also potentially be supplied by replacing topsoil across the basin after construction. The topsoil is where the majority of the seed bank or historic seed supply is stored. Returning the topsoil also returns soil fauna and nutrients that help promote vegetation establishment. If the area of basin construction had historically been "wet" or is a prior converted wetland, topsoil replacement may contain species that can increase the potential number of species of plants that can develop in the basin after construction is finished.

Erosion control plantings are often added to the basin side slopes or to the buffer surrounding the basin after construction. If so, the plantings should include wetland indicator species and/or hydrophytic species. Some desired species are: redtop *(Agrostis alba)*, panic grass *(Panicum sp.)*, bulrushes (*Schoenoplectus* and *Scirpus sp.*), sedges, *(Carex sp.)* rushes *(Juncus sp.)*, and mannagrass *(Glyceria acutiflora)*. More information on species suggestions is included in the following section. Dense erosion control plantings help prevent soil loss around the basin after construction by slowing water flow and removing turbidity and sediments. Erosion control vegetation also creates conditions which support microbial activities that improve water quality. Erosion control plantings for a location should take into consideration its soil types, climate, and patterns of water depth and duration that match vegetation tolerances.



Soft stemmed Bulrush: *Scirpus validus or Schoenoplectus tabernaemontani.*

## Examples of Hydrophytic Species and Growth Preferences

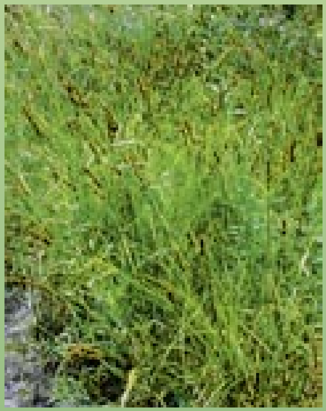
An ideal treatment basin should provide multiple water depths and soil saturation conditions, which in turn support a variety of hydrophytic species and growth types. Below are some suggestions of different species, their growth types, and associated water level and soil saturation level and duration tolerances. The reference section of this bulletin contains bibliographic information for books that provide information on water depth and soil saturation tolerances and germination requirements of many other hydrophytic/wetland indicator species.

Deep water species that can tolerate standing water of up to approximately 11 inches/30 cm to 20 inches/50 cm include: *Potamogeton sp.*—Pondweeds, grows submersed under water; *Ceratophyllum*—Coontail, grows submersed under water; *Nelumbo lutea*—water lotus, floats on top of the water, but is rooted at the bottom of the basin; *Lemna sp.*—Duckweed, floats on top of the water; *Azolla sp.*—water fern, floats on top of the water; *Salvinia sp.*—water fern, floats on top of the water; and *Typha sp.*—Cattails, "emergent" or grows in standing water (typically no more than 30 cm). Cattails often arrive to a basin without planting and can be aggressive growers requiring additional management.

Shallow water species, or emergent species that can tolerate saturated soil and/or fluctuating shallow (optimally 6 inches/15 cm or less) water include: *Leersia oryzoides*—Rice cut grass; *Carex sp.*—Sedges; *Scirpus and Schoenoplectus (*esp. *Scirpus cyperinus, Scirpus fluviatilis, Schoenoplectus validus, Scirpus atrovirens)*—Bulrushes; *Zizania aquatica*—Wild rice; *Eleocharis sp.*—Spikerush; and *Sparganium sp.*—Burreed.

Pondweed: *Potamogeton sp.*

Cattails: *Typha angustifolia.*



Fox sedge: *Carex vulpinoidea.*

Dark green Bulrush: *Scirpus atrovirens.*

Blunt spikerush: *Eleocharis obtusa or E. ovata.*

Foxtail barley: *Hordeum jubatum.*

Smartweeds: *Polygonum sp.*

Willows: *Salix sp*.

Mudflat/wet meadow species, or emergent species that grow best in saturated soil, but will tolerate occasional short-term inundation include: *Echinochloa crus-galli*—Barnyard grass (not classified as a wetland species in Ohio—but is a hydrophyte); *Agrostis alba*—Redtop or bentgrass; *Hordeum jubatum*—Foxtail barley; *Polygonum sp.*—Smartweeds; *Panicum virgatum*—Switchgrass; *Asclepias incarnata*—Butterfly weed; and *Alisma plantago-aquatica*—water plantain.

Woody species are often tolerant of flooding through part of the growing season. Examples of woody hydrophytic species include: *Salix sp.*—Willows; *Quercus sp.*—Oaks; *Cornus stolonifera*—Red Osier Dogwood; *Rhus typhina*—Staghorn sumac; and *Cephalanthus occidentalis*—Buttonbush.

## Determination of On-site Species Availability

In review, vegetation has been discussed as being very important in water quality improvement processes that occur in treatment basins. Vegetation growth within the basin is strongly influenced by the duration and timing of water depth. Design characteristics and water control in the basin are important to creating various water depth and soil saturation conditions that encourage growth of hydrophytic vegetation on and within the treatment basin. Basin construction near "wet" areas, topsoil replacement after construction, and the use of hydrophytic species in erosion control are suggested to supply a variety of potential seeds that can establish within the basin. But how does one know if hydrophytic species are available in the basin soil, replaced topsoil, or near the construction location?

It is important to estimate what species are already available for revegetation at the proposed treatment basin site, so that decisions can be made as to which, if any, species will need to be purchased or otherwise supplied. Evaluation of the soil seed bank, the reservoir of seeds in the soil available for germination, in addition to surveying the local plant communities near the construction location can give basin managers an idea of how many and which growth types are potentially available within the local area for the constructed treatment basin. Seed bank analysis and examination of potential local hydrophytic plant sources will also give managers an idea of any potential nuisance species for the basin such as *Lythrum salicaria* (purple loosestrife), *Polygonum cuspidatum* (Japanese knotweed), *Rhamnus frangula* or *R. cathartica* (glossy or common buckthorn), *Phalaris arundinaceae* (reed canary grass), and *Phragmites australis* (common reed). Nuisance species could also include crop pests such as *Cirsium sp.* (thistles). Additional information on Ohio's top invasive and nuisance species can be found though the Ohio Department of Natural Resources' Division of Natural Areas and Preserves. Seed bank analysis of the location prior to construction can be conducted to determine what species are present for passive revegetation after construction. Soil collection, separation, and analysis methods include the germination method and a manual sieving method. The methodology for both are described in the Appendix.

Equipment set-up for a germination seed bank study.

Walking surveys of existing vegetation near the proposed basin site (approximately a 600-foot circle) should be conducted in early summer and mid-fall to determine which species are potentially available for revegetation. This survey should include woodlots, road ditches, stream banks, ponds, or other "wet" areas in the vicinity that may contain potential seed sources. Keep in mind the way the seeds or propagules of these species disperse (wind, animal consumption or transport, water drainage, etc.) and consider if they can realistically be delivered to the proposed site.

Also consider such things as:

- Are there many locally available seed sources?
- Were approximately 50% or more of the local species or species in the seed bank hydrophytic species?
- Were there more than two growth types (floating, emergent, shallow, etc.) available locally or in the seed bank?
  - → If so, passive (non-planted and non-seeded) revegetation should provide a very good hydrophytic vegetation source and is a good revegetation option.
  - → If less than 50% of locally available and seed bank species were hydrophytic, but there were many represented growth habits, a combination of passive and other revegetation methods would increase revegetation success.
  - → If there are very few hydrophytic species or if only one or two growth habits are represented, active revegetation methods should be considered. Revegetation options are discussed in the next section.

## Revegetation Considerations

There are multiple factors that may influence which revegetation option is chosen. General considerations should include how much time, money, and effort the manager is willing to invest. A general comparison of cost, time, and effort of methods to revegetate the basin are given further discussion below. Managers should evaluate specific costs such as the cost of seed or transplant stock if planting, transport and labor for seeding, soil application, or seedling planting; risks of vegetative cover loss; future management of those species; and aggressiveness of the growth habits of species involved.

Also, consider basin characteristics when choosing species to plant or seed: How much of the site(s) requires planting or seeding? What is the average water level and flooding frequency? What water level and soil saturation regimes will be created with the proposed average water level? What are the basin characteristics, soil characteristics, water supply quality, site climate, and site priorities (i.e., water quality improvement and water storage versus either alone) that can influence which species will do well in the treatment basin? Are there any special requirements, such as soil preparations, for the selected species?

## Revegetation Strategies

Revegetation strategies have different money, time, and effort requirements that are necessary to improve chances for successful development of hydrophytic vegetation within a treatment basin. Managers must decide the amount of money and time they are willing to invest and weigh this against the risks and benefits of each revegetation strategy or combination of revegetation strategies.

Passive (or natural) revegetation from the seed bank and local seed/plant sources is an inexpensive method and requires little initial effort on the manager's part to establish plants within the basin. This method results in establishment of species that disperse well, but can also result in many undesired species in the basin. Reliance on this methodology alone may not result in establishment of adequate hydrophytic vegetation diversity and coverage within a timeline of 3–5 years. Passive revegetation should only be used if there is evidence of available seed/plants sources. Methods to determine on-site availability and suggestions on applicability of this strategy based on percentages of types of hydrophytic vegetation are discussed above.

Active revegetation methods involve physically adding material or plant sources to the basin. Active revegetation methods include adding salvage soils, seeding, and planting after construction. Using salvage soil from a wetland (the source wetland must already be scheduled to be destroyed and mitigated elsewhere) can have good diversity and establishment, but can also contain unwanted species. This method can also be very costly. There are three large time and monetary costs for this method including collection of soil from a wetland site that is being destroyed, transport of the soil from the old site, and spreading of soil onto the new site. **NOTE:** The salvage soils method is only applicable when soil from a wetland that is planned to be mitigated (destroyed in its current location, but another wetland will be constructed in exchange for it at a different location) is available. Permission and/or permits for soil removal may be required. Collecting soil from a natural wetland not slated for destruction can severely damage the natural wetland and is not recommended. Salvage soil application is significantly less common than seeding and planting as a method of active revegetation in constructed basins.

Seeding is relatively inexpensive and can result in a diverse mix of species and growth types. But seed can be lost if not applied at the proper time and conditions, or if fed upon by wildlife grazing. Some time will be involved applying seeds to the basin, and application may be restricted to certain seasons, i.e., grasses are best seeded in the spring and summer depending on if they are warm or cool season grasses.

Planting, like seeding, also allows managers to establish a diverse group of species and control their placement within the basin. This method is labor intensive and does not guarantee good establishment of species. Plants can be lost if not applied at the proper time and conditions, or by wildlife grazing. Transplants of perennials or grass plugs are believed to perform best when installed in the spring or early fall.

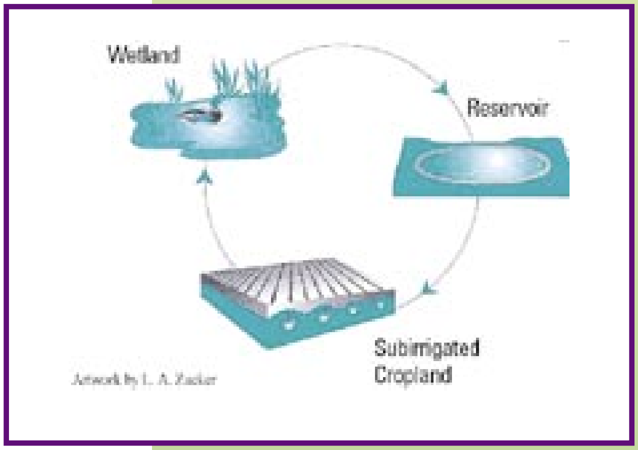
Many nursery companies can supply seeds/plants and give information on best water level and soil saturation conditions for particular species, most appropriate time to plant for your area, and other specific questions you may have. Seeds or plants purchased from local nurseries may be more accustomed to local climate and conditions in your area. Also, native species are well suited to local conditions and are excellent selections for seeding and planting. Ask your local Extension agent, consult OSU Extension Bulletin 865 (for Ohio) or consult a local nursery about which species are native to your area. Local companies or nurseries may also be able to suggest a "pre-mixed" combination of seed or plants for your basin type and/or proposed conditions and uses.

## Vegetation Management and Site Maintenance, Including Management Situations Encountered in the WRSIS Constructed Wetlands

Constructed treatment basins, especially constructed wetlands, should not be treated as ponds. Typical pond maintenance practices such as mowing should not occur on or within 50 feet of the basins in which wetland vegetation and wildlife habitat are being established. Weed management in the constructed basin should not include herbicide or algaecide usage. Exceptions may arise that may require minimal direct application/spot treatment within the basin area. Such an exception may include species that pose a significant threat to local area uses or undesirable species that do not respond to non-chemical management efforts. Vegetation should be managed for optimal vegetation growth and cover during the growing season using water level variation. Adjustment in the water level during different times of the year can aid in establishing and maintaining desired hydrophytic species in various water levels in the basin, while deterring upland species.

## Background on Example Basins

Experiences and management decisions from three treatment wetlands built within Wetland Reservoir Subirrigation Systems (WRSIS) in northwest Ohio are included in the discussion below. The WRSIS project has been designed to improve both water quality and crop yield by creating a system that collects surface run-off and subsurface drainage waters from agricultural fields into a wetland and then into a storage reservoir for on-site water needs such as subsurface irrigation. In addition to treatment, the WRSIS constructed wetlands provide wildlife habitat and flood water storage.




Conceptual diagram for the Wetland Reservoir Subirrigation System or "WRSIS" project.

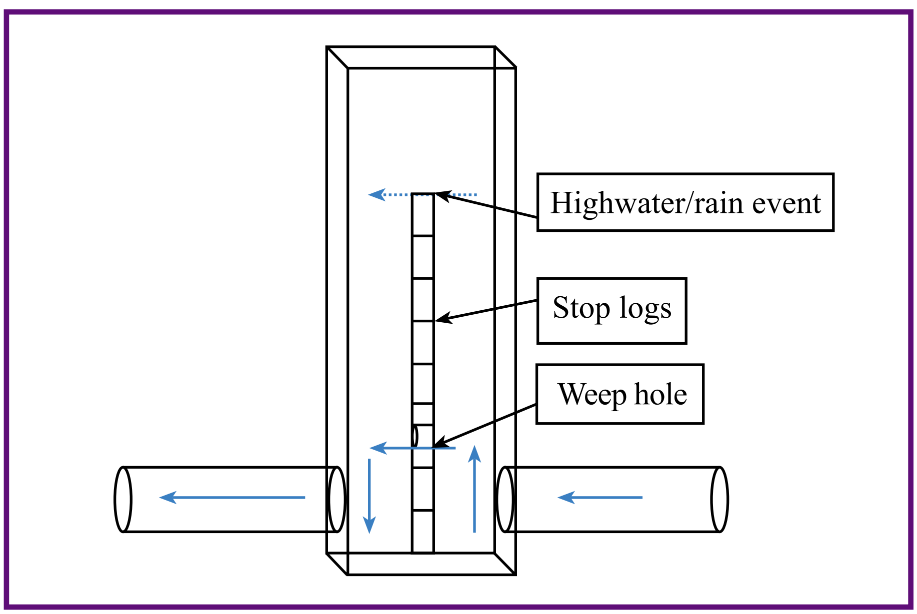
## Vegetation Establishment and Management Using Water Level Control

Decisions for water level manipulation for vegetation establishment in the treatment basin should consider water requirements needed to meet any other site functions such as wildlife habitat. Treatment basins should not maintain high water level throughout the growing season that results in pond-like conditions. The pond-like condition will support only those species that can tolerate high water levels, and this may result in an undesirable monoculture and potentially reduce vegetative cover, risking increased erosion and reduced treatment efficiency. A fluctuating water level, with the average water level set where it can best encourage good vegetation establishment and growth based on known flooding tolerances of either available or selected species, along with basin design to create varying water levels, should result in a diverse number of species with many types of growth habits (submersed, emergent, floating, rooted floating, mudflat). This diversity is considered best to support site functions, such as water quality improvements, as well as wildlife habitat.

A combination of basin design and water level control should be used to create various water levels within the basin. There should be some deep (30 cm+) water areas in the basin. This is especially important if the local sources contain submersed or floating species. Examples of common submersed species are pondweeds *(Potamogeton sp.)* and of floating species are duckweeds *(Lemna sp.)*. The constructed basin should also have areas with water depth and soil saturation levels from shallowly submersed (<15 cm) to moist soil. For example, work on the WRSIS wetlands has shown local seed banks contain many wet meadow and mudflat species, which germinate and grow best with intermittently wet and saturated conditions respectively. A shelf was constructed just below the water line on the east side of one basin to create saturated, but not submersed, conditions to help establish the mudflat/wet meadow species in the seed bank while maintaining a permanent deep basin that supports submersed and floating species. This diversity in water level and vegetation type supports many different wildlife types, as well as good vegetative cover, which increases water treatment.

To encourage germination and establishment of emergent and mudflat species, a water level "drawdown" can be used. A water level drawdown exposes soil containing seeds and creates more suitable germination conditions by allowing oxygen and light to reach available seeds. The best drawdown time in Northern Ohio has been found to be mid-May. Drawdowns are accomplished by lowering the weir in the control structure, but still maintaining a low water level. Drawdown depth should result in a water level that maintains areas of shallow standing water (11–12 inches or 30 cm) in the deepest portion of the basin. Drawdown done in this fashion should result in moist areas on the basin sides and still maintain a water pool for floating and submersed species, amphibians, and fish, if present. When seedlings reach about 5 inches in height, the water level can be slowly raised, making sure that some of the vegetation remains exposed.

The water level throughout the growing season should be kept at a level that does not stress vegetation and also




Conceptual diagram of a water control structure. The central portion of the diagram shows stacked stop-logs with gasket seals that control water level and storage capacity. The weephole establishes the designed average water level, and also allows slow water release after precipitation events.

allows area in the basin for additional rainwater and field runoff during rain events. There is no "ideal design"—the water level in each basin will depend on basin side slope and design, dominant vegetation species, and site goals. For example, the water level on a WRSIS constructed wetland has been kept a little less than an inch (2 cm) below the shelf. This water level and basin design encourages emergent wet meadow and mudflat species, and discourages upland species while also maintaining deeper water areas within the center of the basin for wildlife use and water treatment. This level is allowed to fluctuate with rainfall events, but not to maintain higher water levels for more than 7–10 days. This slow removal of excess rainwater and runoff was accomplished by installing a board with a "weephole." The weephole board is set at the desired water elevation with a diameter that will allow excess water to slowly be removed from the wetland.

The water level can be dropped in late August to expose higher elevation areas (shelves, hummocks). This period of exposure will allow the soil to dry and organic matter to break down. The water level can be raised again in late October if waterfowl habitat is a site goal.

## Mowing, Herbicides, and Pesticides

Mowing is a common practice for farm ponds, but because goals of treatment basins can often include wetland acreage and wildlife habitat, mowing should not occur within 50 feet of the basin. But, mowing may be required on the buffer or within the wetland periodically (~3 years) to control aggressive plant density (after July) or to create a narrow walking path to equipment or important locations.

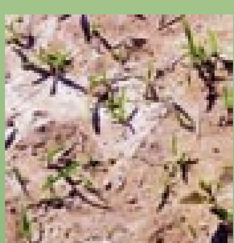
Herbicides, pesticides, and algaecides should not be applied to the treatment basin or surrounding areas unless weedy species are posing threats to nearby fields or downstream locations. Insects are a common part of constructed basins and should not be sprayed for unless viewed as a serious risk to on-site activities or health. As for mosquitoes, research suggests that mosquito populations are significantly reduced if the basin or wetland has large areas shaded by vegetation or trees and if water consistently moves through the system. Calm or stagnant water encourages egg laying and allows larvae to develop. Wetlands that are "healthy" also have many predators such as dragonflies, predacious beetles, frogs, waterfowl, and many others that reduce mosquito populations.

## Nuisance Vegetation or Upland Species

Very aggressive species such as purple loosestrife, cattails, and thistles may reduce the treatment basin abilities to perform functions and can be potential threats to the basin or surrounding area. Therefore, an important part of your overall management plan should include the removal or control of these aggressive species. Purple loosestrife *(Lythrum salicaria)* if present as a seedling, should be removed with its root ball by digging. If blooming (June–September), the upper portions of the plant should be tightly bagged, and the lower portions removed by digging—remove all parts of the roots. Cattails, *Typha*, may become nuisance species as they tend to grow very aggressively. Mechanical control has proven effective by cutting cattails in patches 3–4 inches (7.5–10 cm) below the water surface to remove air supply. This may have the best results if completed in late spring or early summer. Crop-related nuisance species, such as thistles *(Cirsium sp.)* may necessitate herbicide application or other management methods. More information is included in the WRSIS experiences below. A list of current labeled aquatic herbicides can be found through your local county Extension office in fact sheet ANR-4-98 "Chemical Control of Aquatic Weeds."

## Experiences Related to Management from the WRSIS Constructed Wetlands

### Excessive Algal Growth



Seedlings growing through a dried algal mat.

The WRSIS basins receive nutrient-rich runoff from agricultural fields that results in increased algal growth. This growth occasionally becomes problematic, especially during drawdown events, where patches may need to be physically removed from the edges before the water level is drawn down. Algal mats remaining before drawdown can blanket the exposed soil and prevent oxygen and light from reaching seeds in the soil, discouraging germination.

### Herbicide Applications

Typical crop field practices at WRSIS locations involve the use of herbicides such as Roundup® (Glyphosate), 2-4 D, Banvel® (Dicamba) and fungicide-treated corn seed starting in April. It is understood that herbicides will be incorporated into the drainage and runoff that serves as a water supply to the wetland. Applications to the crop fields are expected, but the application equipment must never be cleaned near or in the wetland. The WRSIS wetlands were designed and placed to treat water coming off row crop fields adjacent to the basin and included in this water are residues from herbicides and fertilizers applied to the crops during a normal field season.

Direct application of herbicides to buffer areas or in the basin is strongly discouraged. But, for example, at one WRSIS location it was decided that Canadian thistles were becoming a risk to the farmer and neighbors' fields near the constructed wetland, so spot-applied herbicides were applied in the fall (October) for reducing stands of thistles. The herbicide application type and timing was chosen to minimize damage to surrounding vegetation and reduce wetland exposure to chemicals. If it is believed that herbicide application is necessary, current information on safe application and acceptable herbicides for species of interest can be obtained by contacting your local Extension agent.

#### Weedy Woody and Tall Species

Woody species desirability on WRSIS or similar basins may depend on each site's goals and limitations. One constructed WRSIS wetland is in proximity to an airport that has specific limitations on the height of vegetation around runways. If species extend beyond this height requirement, they are trimmed to a level below the height requirement based on the speed of growth. Trees can be thinned if woody vegetation growth becomes too dense or too tall, or if species are problematic with water use or seed production. If required, methods used for removal should minimize disturbance of the soil and other vegetation.

#### Poor Vegetation Coverage

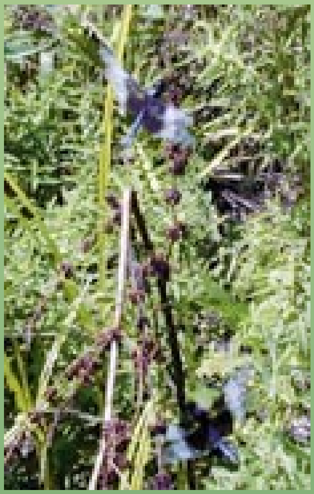
Vegetation coverage was sparse moving from spring to summer during some of the studied growing seasons at WRSIS constructed wetlands. Drawdowns, discussed above, have had some success in increasing diversity and encouraging the growth of hydrophytic plants known to be in the seed bank, such as barnyard grass, which was able to provide both coverage and wildlife habitat.

## Summary

Hydrophytic plants, or plant species that have special adaptations for growth in wet areas, are very important in wetlands, ponds, and sedimentation basins designed for water treatment and/or wildlife habitat. Site designers and managers of treatment basins can greatly improve the potential success of their projects by evaluation of available hydrophytic vegetation and potential problem species prior to basin design and development. Managers should consider effort involved and cost of management, as well as revegetation strategies prior to designing and building a wetland or pond. If hydrophytic species are limited or not available from the seed bank and local sources, managers should consider planting or seeding (occasionally salvage soil application) to provide appropriate hydrophytic species to the basin.

## Sources of Additional Information for Each Section

- Introduction: (Hammer 1997; Reddy et al. 1989; Reddy and Patrick 1986; Riemer 1984; Zhu and Sikora 1995). National List of Plant Species that Occur in Wetlands is located in Reed 1998.
- Construction considerations: (USDA-NRCS [SCS] 1992).
- Vegetation availability, establishment, and revegetation:
  - Seed bank methods: (Forcella et al. 1992; Galatowitsch and van der Valk 1998; van der Valk and Davis 1978). General seed bank information is located in Leck et al. 1989 or Rosburg 2001.
  - A wetland plant identification manual "Midwestern wetland flora" is free for download from USDA.
  - Seeding and planting: (Wild Ones 1997).
  - Species suggestions: Information on best water or soil saturation level for listed species is located in Galatowitsch and van der Valk 1998, Hammer 1997, and Payne 1992. Information on germination or propagation requirements and wildlife uses for many wetland species can be found in Middleton 1999. Native plant information for Ohio is provided in OSU Extension Bulletin 865, "The Native Plants of Ohio."
- Management and site maintenance: These guidelines include considerations for management and design suggested in Galatowitsch and van der Valk 1998; Luckeydoo 1999, 2002; Payne 1992; USDA-NRCS (SCS) 1992; and Weller 1994. Conceptual diagram of WRSIS included in Zucker and Brown 1998. WRSIS water table management information is located in Allred et al. 2000. Additional information on site maintenance was found in Hartman 1998. Drawdown suggestions are based on results from Meeks 1969. Suggestions for mechanical control of *Typha* were found in Garbisch 1994, and Sale and Wetzel 1983. Mosquito reduction information found in Joy and Clay 2002, and Mogi and Mototmura 1996. Mosquito predator information supplied in memo from John Rockenbaugh, Union Soil and Water Conservation District.



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# Appendix: Seed Bank Methodology

## Manual Sieving Method for Seed Bank Estimation

This methodology involves the collection of soil from the sites, then physical separation using "chemicals" available from your local drug or grocery store. This method is faster and requires less equipment than the germination method of seed bank examination.

Soil collection should occur along straight lines that cross the area planned for the basin. Enough soil should be collected to equal 200 $cm^3$. For other wetland basins in which this has been completed, about 15 cores with 5 cm diameter to 15 cm deep (Forcella et al., 1992) or 30 cores with 2.5 cm diameter to 15 cm deep (Luckeydoo, unpublished). Allow the soil to "air dry" for 10 or more days. Published methods suggest that all of the collected soil should be used, at 40 g per sample, for mechanical separation method, but as many samples of the 200 $cm^3$ should be completed as time allows to give a better estimate of how many and of which species are available in the seed bank.

**Equipment needed:** 2 small pails, measuring cup with millimeter markings, squirt sports bottle to apply rinse water, small food scale to measure soil and chemical amounts, water source, Calgon® (your choice of pleasing scents), baking soda, Epsom salts, plastic cups with bottom removed and nylon hose stretched and secured over the bottom equal to the number of samples planned to separate.

**Method:** This method has been modified from Regnier and Scott (2001). Add 40 grams of soil (weigh using small scale) and 200 ml (volume determined with measuring cup) water into the first pail. Add 10 grams Calgon and 5 grams baking soda to the pail and break up any big clumps using your fingers. Add 26 grams Epsom salt to the pail and stir for 2 minutes, separating soil clumps as much as possible. After stirring, use the squirt bottle to rinse materials off the sides back into the bowl of the pail. Allow the soil and water in the pail to separate into two layers (about 5 minutes). Pour the water and floating material through the nylon stocking-bottomed cup into the second pail, trying not to allow the remaining soil into the stocking. It may be necessary to rub the bottom of the stocking or squirt extra water though the stocking-bottomed cup to help move sample water through into the second pail. The water in the second pail should be poured back into the first pail containing soil. Stir up the contents of the first pail for a second time for 2 minutes. After stirring, use the squirt bottle to rinse materials off of the sides back into the bowl of the bucket. Allow the soil and water in the bucket to separate into two layers (about 5 minutes). Pour the water and floating material through the stocking-bottomed cup into the second bucket, trying not to get much of the soil into the hose. Again, it may be necessary to rub the bottom of the hose with your finger or squirt extra water though the cup to help move sample water through into the second bucket. Label the cups with the site and date and then allow the contents of the cups to dry for a few days.

After materials in the cups have dried, and using good lighting, tweezers and a magnifying glass, sort through each cup that includes collected seeds, removing seeds with tweezers and placing into a container for identification. After seeds have been separated from soil, the potential ability to germinate or "viability" of the seeds can be determined by applying gentle pressure with tweezers. If the seed does not crush, it is very likely able to germinate. This test is referred to as the "squeeze test" discussed in Malone, 1967.

Identification of seed species may be made with the help of identification manuals such as R. J. Delorit's Illustrated Taxonomy Manual of Weed Seeds available for $20 (including postage) from the North Central Weed Science Society, 1508 West University Ave., Champaign, IL 61821-3133 or with The Seed Identification Manual written by Alexander C. Martin and William D. Barkley ISBN 1-930665-03-2 available through http://www.blackburnpress.com (973-228-7077).

## Germination Seed Bank Study

Seed bank contents can also be estimated using a germination technique modified from van der Valk and Davis (1978). The basin can be sampled by collection of soil cores to about 3–5 inches deep with a pail type auger at three locations along each of three straight lines across the location and placed into plastic bags. At each sampling point three cores should be taken. Successful results have occurred when soil was collected in early spring (Luckeydoo 1999).

If soil is collected in the spring, the germination study should be set up as soon as possible. If collected in the fall, the plastic bags full of soil should be kept in a cool place until spring and then the germination study should be conducted.

**Equipment:** two plastic wading pools, available water source, small (17 x 12.5 x 5.5 centimeters) germination trays (from your local nursery) or identical plastic bowls with small drainage holes in the bottom, sand, and newspapers or coffee filters.

**Methodology:** First, large organic matter such as roots, tubers, and corn stalks should be removed by hand and each sampling point's soil should then be mixed. The soil is then spread at a thickness of 1 centimeter into trays/bowls already containing 1 inch of sand and a coffee filter or 3 layers of newspaper placed over the holes in the bottom. Each soil sample bag should be divided into 4 portions: 1 for the saturated condition, 1 for the flooded condition, and the remaining 2 as a control in each of the water conditions.

Equipment set-up for a germination seed bank study.

Two of the soil trays will be grown in a plastic pool simulating a mudflat or lightly saturated condition, and the other two soil trays will be placed in a wading pool that resembles a flooded or submersed condition. Water should be added along the sides of the pool, never directly into the trays. Just enough water should be added to the mudflat pool to moisten the soil from underneath; there should not be standing water over the soil in the mudflat trays. The "flooded" pool should have standing water at approximately 2–3 inches above the top of the trays containing soil.

The water should be maintained at these approximate levels through the duration of the study which continues until late fall. Plant counts and identification of the plants germinated should occur at least weekly over the sampling period. Mature plants should be removed from the tray when identified. Notes should be taken on how many of each species are removed. If trays are labeled, one could compare species that germinate in the replicated sample points.

For example, each sample point in a basin had two replicates per treatment type; with a total of 36 trays for the entire site (9 points x 2 replicates x 2 treatments). These seed bank trays were created in May and maintained in the greenhouse in wading pools with above-mentioned conditions until November. Algae became a problem and were removed by hand every other day, being careful not to disturb the sediments in the tray below. Also, some species, when mature enough for identification and then removal, had very fibrous root systems that were hard to remove without destroying the trays. Such troublesome species were clipped to the soil line after identification and not counted in future counts.

There are online resources for weed and wetland species identification and seedling identification, such as Extension services: (http://www.oardc.ohio-state.edu/weedguide/listall.asp), http://www.weeds.iastate.edu/weed-id/sld001.html, http://www.extension.umn.edu/distribution/cropsystems/DC0776.html, http://screc.unl.edu/IPMManual/weeds.htm, and a searchable "Plants Database" http://plants.usda.gov/.