This is a guidance document with sample specification language intended to be inserted into project specifications on this subject as appropriate to the agency's environmental goals. Certain provisions, where indicated, are required for U.S. federal agency projects. Sample specification language is numbered to clearly distinguish it from advisory or discussion material. Each sample is preceded by identification of the typical location in a specification section where it would appear using the SectionFormat™ of the Construction Specifications Institute; the six digit section number cited is per CSI Masterformat™ 2004 and the five digit section number cited parenthetically is per CSI Masterformat™ 1995.

SECTION 32 71 00 (SECTION 02670) - CONSTRUCTED WETLANDS

SPECIFIER NOTE:

resource management: Constructed wetlands address the management of the earth's fresh water resources. They attempt to address water quality issues with a broad view of the hydrologic cycle that involves less embodied energy and less chemicals than standard water treatment processes. Because they utilize natural systems to process wastewater, they also contribute to carbon sinking and may contribute to local habitats and wildlife corridors.
The amount of land required for constructed wetlands will vary depending on the desired level of treatment and the complexity of the system. Simple, exterior wetland systems may require 10-20 times more square footage than greenhouse systems.

toxicity/IEQ: Constructed wetlands treat water both mechanically and biologically - not chemically. Water can be treated to advanced tertiary standards and can process metals, fats, greases, oils, gasoline, and some industrial toxins. The U.S. EPA maintains a Constructed Treatment Wetland System Description and Performance Database which contains system descriptions and performance data for a large number of pilot, and full-scale wetland systems treating a variety of sources, including municipal wastewater, stormwater runoff, industrial wastewater, and agricultural runoff. While the emphasis is on constructed wetlands, natural wetlands are also included in the database. Refer to http://firehole.humboldt.edu/wetland/twdb.html
The Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources: rivers, lakes, reservoirs, springs, and ground water wells. For additional information, refer to the EPA Office of Ground Water and Drinking Water http://www.epa.gov/safewater/index.html Also, regional, state, and local governing agencies adopt their own standards to regulate water treatment. Minimum general standards for wastewater treatment: Secondary wastewater - BOD_5 < 30 mg/l and TSS < 30 mg/l; Advanced secondary wastewater - BOD_5 < 15 mg/l and TSS < 30 mg/l; Advanced tertiary wastewater - BOD_5 < 10 mg/l and TSS < 15 mg/l; pathogen removal required for beneficial public use - fecal coliform < 200/100 ml.

performance: Constructed wetlands reduce pressure on local municipal water treatment facilities. A constructed wetland is a system engineered and constructed for treatment of graywater, blackwater, and/or stormwater to levels which meet Federal, State and Local discharge requirements. They can be interior (greenhouse wetlands) or exterior. Constructed wetlands may serve individual facilities or whole municipalities. They can process metals, fats, greases, oils, gasoline, and some industrial toxins. They also produce usable byproducts such as nursery and water garden plants, compost, and methane gas.
Constructed wetlands may also produce potable water; however, local regulatory requirements for monitoring and acceptance of water treated by constructed wetlands may be challenging.
Maintenance requirements will vary with size - approximately 1/2 hr/day for 5,000 g.p.d. system to monitor computers and to trim and harvest plants and organisms. Blackwater treatment systems generally require a licensed wastewater operator.

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes engineering, fabricating, furnishing, and installing:
   1. Constructed wetlands for storm water treatment.

SPECIFIER NOTE:
Surface Flow systems may also be called Free Surface systems. Subsurface Flow systems may also be called Submerged Base systems.

      a. Surface Flow Wetlands
      b. Sub-Surface Flow Wetlands
   2. Constructed wetlands for wastewater treatment (black water).
      a. Surface Flow Wetlands
      b. Sub-Surface Flow Wetlands

B. Related Sections:
   1. Section 01 57 19.13 (01354)- Environmental Management.
   2. Section 32 90 00 (02900) – Planting.
   3. Division 22 (15) – Plumbing sections.

1.2 DEFINITIONS

A. Definitions pertaining to sustainable development: As defined in ASTM E2114.

1.3 SUBMITTALS

A. Shop Drawings: Not less than 10 days before the Pre-construction meeting, prepare and submit Shop Drawings for the Constructed Wetlands.
   1. Identify primary contact for Constructed Wetlands installation.
   2. Indicate system type (surface flow or sub-surface flow), installation process and schedule. Indicate approach to water introduction to system.
   3. Detail Drawings. Indicate components of system, including: structure cells, liners, flow control structures, soil, aggregate, pipe, vegetation, pumps and related equipment. Identify manufacturer of each component. Indicate connections to related plumbing and landscaping work.
   4. Soil Analysis. Site-specific information on the hydraulic conductivity and permeability of the site soils shall be made through field data collection. Laboratory soil analyses shall include clay content and type of clay, percent organic matter, and mineral content.
   5. Plant List. Indicate type, establishment period, size, quantity of each type. Indicate water tolerance limits for each type as applicable during establishment period and after establishment period. Include picture of each type of plant.

SPECIFIER NOTE:
Detailed water balances can be prepared with site-specific monitoring data collected during pilot- or full-scale operation of the wetland. If large seasonal variation is expected, monthly data is essential.

B. Water Balance: Submit with Shop Drawings. Include equation and back up data. Calculate water budgets for daily, monthly, and yearly intervals; expressed as:

   $S = Q + R + I - O - E T$

   Where:
   S = net change in storage
   Q = surface flow, including wastewater or stormwater inflow,
   R = contribution from rainfall
   I = net infiltration (infiltration less exfiltration)
   O = surface outflow
   ET= loss due to evapotranspiration

SPECIFIER NOTE:

USGBC LEED includes a prerequisite that NPDES applies to all projects. Per EPA construction general permit, provisions of NPDES Phase I and Phase II would only apply to sites greater than 1 acre.
On November 23, 2009, the U.S. Environmental Protection Agency (EPA) issued effluent limitations guidelines and new source performance standards to control the discharge of pollutants from construction sites. The agency believes this rule, which takes effect in February 2010 and will be phased in over four years, will significantly improve the quality of water nationwide. It requires construction site owners and operators that disturb one or more acres to use best management practices to ensure that soil disturbed during construction activity does not pollute nearby water bodies. In addition, owners and operators of sites that impact 10 or more acres of land at one time will be required to monitor discharges and ensure they comply with specific limits on discharges to minimize the impact on nearby water bodies. This is the first time that EPA has imposed national monitoring requirements and enforceable numeric limitations on construction site stormwater discharges.
Refer to: http://www.epa.gov/waterscience/guide/construction

C. Comply with applicable regulations.
   1. Obtain a general construction storm water CWA Section 402 (NPDES) permit for projects 1 acre or more in size. Submit copy of permit and Storm Water Pollution Prevention Plan.

D. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:

SPECIFIER NOTE:
Specifying local materials may help minimize transportation impacts; however it may not have a significant impact on reducing the overall embodied energy of a building material because of efficiencies of scale in some modes of transportation.
Green building rating systems frequently include credit for local materials. Transportation impacts include: fossil fuel consumption, air pollution, and labor.
USGBC-LEED™ v3 includes credits for materials extracted/harvested and manufactured within a 500 mile radius from the project site. Green Globes US also provides points for materials that are locally manufactured.

   1. Local/Regional Materials:
      a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
      b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
      c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
      d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.

SPECIFIER NOTE:
The Food, Conservation, and Energy Act of 2008 (also known as the 2008 U.S. Farm Bill) largely continues programs of the Farm Security and Rural Investment Act of 2002 (2002 Farm Bill) http://www.usda.gov/farmbill/ Section 9002 requires each Federal Agency to develop a procurement program which will assure that items composed of biobased products will be purchased to the maximum extent practicable and which is consistent with applicable provisions of Federal procurement law. USDA designates biobased products for preferred Federal procurement and recommends biobased content levels for each designated product.
USGBC-LEED™ v3, for example, includes credits for use of rapidly renewable materials, which USGBC describes as plants harvested within a ten-year cycle.
Green Globes – US, provides credit for integration of materials from renewable sources that have been selected based on life-cycle assessment.

2. Biobased materials:
   a. Indicate type of biobased material in product.
   b. Indicate the percentage of biobased content per unit of product.
   c. Indicate relative dollar value of biobased content product to total dollar value of product included in project.

E. Operations & Maintenance Plan.

F. Reports for Field Quality Control: Submit test reports and inspection reports to **[Owner] [Architect].**
1. System Inspections.
2. Pressure Test.
3. Water Quality Tests.

1.4 QUALITY ASSURANCE

A. Design, furnish, and install a biologically and hydrologically functional system, reviewed and approved by regulatory agencies having jurisdiction.

SPECIFIER NOTE:
The EPA provides information and guidance on constructed wetlands; refer to http://www.epa.gov/owow/wetlands/watersheds/cwetlands.html
Following are examples.

B. Comply with the U.S. Environmental Protection Agency's Guiding Principles For Constructed Treatment Wetlands: Providing For Water Quality And Wildlife Habitat, EPA 843-b-00-003; http://www.epa.gov/owow/wetlands/constructed/

C. Comply with the U.S. Environmental Protection Agency's Constructed Wetlands Treatment of Municipal Wastewaters, EPA/625/R-99/010; http://www.epa.gov/owow/wetlands/pdf/hand.pdf

D. Pre-Construction Meeting: After award of Contract and prior to the commencement of the Work of this Section, schedule and conduct meeting to discuss the Work of this Section and to coordinate with related Work. Convene pre-construction meeting to comply with requirements of Division 01 (1) and as follows:
1. Notify all attendees at least two weeks prior to the conference.
2. Require attendance of parties directly affecting Work of this Section, including, but not limited to:
   a. Owner,
   b. Contractor,
   c. Architect,
   d. Civil Engineer,
   e. System Designer/ Installer,
   f. Plumbing Installers.
3. Review methods and procedures related to installation and operation of Work of this Section, including coordination with related Work.
4. Document proceedings, including corrective measures or actions required, and furnish copy of record to each participant.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate the Work with installation of associated plumbing systems specified under other sections as the Work of this Section proceeds.

1.6 OPERATIONS AND MAINTENANCE

A. Develop an Operation and Maintenance Plan:

1. Identify the Constructed Wetlands Manager.
2. Include procedures and schedule for operations and maintenance.
3. Identify procedures for reporting results of Operations and Maintenance.
4. Identify procedures for implementing corrective action as required.
5. Update plan as necessary to reflect specific system characteristics learned during actual operation.

B. Operations: Identify procedures to accomplish the following:

SPECIFIER NOTE:
An application schedule should be selected that is both convenient and relatively continuous. Short, high-flow discharges to a wetland are more likely to erode or damage established vegetation than lower velocity, more continuous flows. Schedule discharges to or from the wetland, recycling/redirecting flows, or rotating between cells, if such are part of the design.

1. Provide ample opportunity for contact of the water with the microbial community and with the litter and sediment.
   a. Indicate setting of water depth control structures.
   b. Indicate depth of sediment accumulation before removal is required.
   c. Indicate operating range of water levels, including acceptable ranges of fluctuation.
   d. Indicate the supplemental water source to be used to ensure adequate water levels during establishment and operation wastewater application schedule, if this is part of the system design.
2. Assure that flows reach all parts of the wetland.
3. Assure a healthy environment for microbes and a vigorous growth of vegetation.

C. Maintenance: Identify procedures to accomplish the following:
1. Hydrology: Periodic inspection of water flow and levels. Verification that water is moving through all parts of the wetland, that buildup of debris has not blocked flow paths, and that stagnant areas have not developed.
   a. In Sub-Surface Flow wetlands, verification that surface flow is not developing.
2. Structures: Inspection of dikes, spillways, and water control structures for damage, erosion, or blockage periodically and immediately after an unusual flow event such as a severe storm, rapid ice break up, and similar events.
   a. Cleaning and maintenance of inlet and outlet structures, valving, and monitoring devices.
3. Vegetation: Inspection periodically to verify water levels are appropriate to plant age and type. Inspection periodically to verify that invasive species are not present.
   a. Water depth may be increased during the cold months to increase retention time and to protect against freezing.
   b. Maintain vegetative cover on dikes.
4. Herbicides: Not permitted.
   a. The control of mosquitoes with insecticides, oils, and bacterial agents such as Bti *(Bacillus thuringiensis isroelensis)* is not permitted.

PART 2 PRODUCTS

SPECIFIER NOTE:
EO 13423 includes requirements for Federal Agencies to use “sustainable environmental practices, including acquisition of biobased, environmentally preferable, energy-efficient, water-efficient, and recycled-content products”

Specifically, for USDA-designated biobased products, Federal agencies must use products meeting or exceeding USDA's biobased content recommendations; and for other products, biobased products made from rapidly renewable resources and certified sustainable wood products.

EO 13423 directs Federal Agencies "… beginning in FY 2008, reduce water consumption intensity, relative to the baseline of … year 2007 … by 2 percent annually through the end of fiscal year 2015 or 16 percent by the end of fiscal year 2015"

Specifically, under the Sustainable Building requirements per Guiding Principle #3 Protect and Conserve Water, EO 13423 directs Federal agencies to "Employ strategies that in aggregate use a minimum of 20 percent less potable water than the indoor water use baseline calculated for the building, after meeting the Energy Policy Act of 1992 fixture performance requirements." And, to "Use water efficient landscape and irrigation strategies, including water reuse and recycling, to reduce outdoor potable water consumption by a minimum of 50 percent over that consumed by conventional means (plant species and plant densities)."

Executive Order 13514; *Federal Leadership in Environmental, Energy, and Economic Performance*; was signed on October 5, 2009. http://www.ofee.gov/execorders.asp It expands upon the environmental performance requirements of EO 13423.
http://www1.eere.energy.gov/femp/regulations/printable_versions/eo13423.html

EO 13514 sets numerous federal requirements in several areas, including sustainable buildings and communities. Federal agencies must implement high performance sustainable federal building design, construction, operation and management, maintenance, and deconstruction, including:

- Ensuring all new Federal buildings, entering the design phase in 2020 or later, are designed to achieve zero net energy by 2030.
- Ensuring all new construction, major renovations, or repair or alteration of Federal buildings comply with the Guiding Principles of Federal Leadership in High Performance and Sustainable Buildings http://www1.eere.energy.gov/femp/pdfs/mouhighperfsustainfedfacs.pdf
- Ensuring at least 15% of existing agency buildings and leases (above 5,000 gross square feet) meet the Guiding Principles by fiscal year 2015 and that the agency makes annual progress towards 100% compliance across its building inventory.

Additionally, EO 13514 Federal requirements for water stewardship, including:

- Reducing potable water consumption intensity 2% annually through fiscal year 2020, or 26% by the end of fiscal year 2020, relative to a fiscal year 2007 baseline.
- Reducing agency industrial, landscaping, and agricultural water consumption 2% annually, or 20% by the end of fiscal year 2020, relative to a fiscal year 2010 baseline.
- Identifying, promoting, and implementing water reuse strategies consistent with state law that reduce potable water consumption.

2.1 WETLANDS COMPONENTS

A. Structures Cells:

SPECIFIER NOTE:
Wetlands can be constructed by excavating basins, by building up earth embankments (dikes), or by a combination of the two.

1. Dikes: Constructed of soils with adequate fine-grained material that will compact into a relatively stable and impervious embankment; high enough to contain the expected volume plus ample freeboard to accommodate occasional high flows as well as the buildup of litter and sediment over time.
   a. Slope dikes no steeper than 2:1
   b. Protect slopes with riprap or erosion control fabric.
   c. If multiple cells are used, divider dikes may be used to separate cells and to produce the desired length-to-width ratios.
2. Spillway: Provide an emergency spillway.

B. Liners:

1. Constructed wetlands shall be sealed to avoid possible contamination of groundwater and also to prevent groundwater from infiltrating into the wetland.

SPECIFIER NOTE:
Soils that contain more than 15% clay are generally suitable.
Bentonite, as well as other clays, provide adsorption/ reaction sites and contribute alkalinity.

2. Where on-site soils or clay provide an adequate seal, compaction of these materials may be sufficient to line the wetland.
   a. On-site soils may be used if they can be compacted to permeability of <108 ft/sec (<10-6 cm/sec).
3. Synthetic liners: Asphalt liners are not permitted. Synthetic liners may be fabricated from synthetic butyl rubber or 0.5 to 10.0 mil high density polyethylene.
   a. If the site soils contain angular stones, place sand bedding or geotextile cushions under the liner to prevent punctures.
   b. Cover the liner with 3 - 4 inches of soil to prevent the roots of the vegetation from penetrating the liner.

C. Flow Control Structures:

SPECIFIER NOTE:
Flow control structures should be simple and easy to adjust. They should allow flexibility so that processes can be optimized initially and adjusted later in response to system changes. Multiple inlets must be fully and independently adjustable to ensure an even distribution of flow. Structures should be sized to handle maximum design flows and should be located for easy access and to minimize short-circuiting.
If the wetland will be accessible to the public, or located in an isolated area where it will be vulnerable to vandalism, inlet and outlet structures should be enclosed in lockable concrete structures or manholes to avoid damage or tampering with water level settings. Structures must be protected against damage by animals. Measures include installing covers or wire mesh over openings, and enclosing controls, gauges and monitoring devices in pipes or boxes.

1. Inlets: Unless otherwise indicated, provide inlets above the water surface of the wetland 12 - 24 inches. Provide coarse rock sized 3 - 6 inches (8 - 16 cm) in the entry zone to promote rapid infiltration and prevents ponding and algal growth.
   a. Provide a flow splitter will be needed for parallel cells.
2. Outlets:
   a. At Surface Flow wetlands, outlets may be a weir, spillway, or adjustable riser pipe. Weirs and spillways shall be designed to pass the maximum probable flow. Spillways shall consist of wide cuts in the dike with side slopes no steeper than 2:1 and lined with non-biodegradable erosion control fabric. If high flows are expected, coarse riprap shall be used.
   b. At Sub-Surface Flow wetlands, outlets may include subsurface manifold, and weir boxes or similar gated structures.

SPECIFIER NOTE:
If pipes are used, small diameter (<12 inch) pipes shall be avoided because they clog with litter.

   c. Pipes smaller than 12 inches diameter are not permitted.

   d. The final discharge point from the wetland system shall be placed high enough above the receiving water that a rise in the water level in the receiving water will not interfere with the flow of water through the wetland.

D. Soil: The soil shall provide enough organic matter to fuel plant growth and microbial activity, particularly during startup. Dense soils, such as clays and shales, are not permitted.

SPECIFIER NOTE:
Soil properties that should be considered in selecting soils include cation exchange capacity (CEC), pH, electrical conductivity (EC), texture, and soil organic matter.

1. pH: between 6.5 and 8.5.

2. EC: less than 4 mmho/cm.
3. CEC: greater than 15 meq/l00 g of soil.
4. Provide a reducing substrate to promote the removal of nitrate and ammonia.

SPECIFIER NOTE:
Constructed wetlands receiving water high in nutrients, such as domestic and agricultural wastewaters may use sand or gravel. Sands and gravels dry out quickly and may need to be irrigated to maintain water levels while the vegetation is becoming established.

E. Aggregate: Aggregate used to construct the system shall be defined by their ability to pass a given sieve size as indicated on the approved Shop Drawings.
   1. Use aggregate that are suitable for use in concrete.

F. PVC pipe: ASTM D2241 SDR 26 or D1785 sch 40.

G. Septic Tanks: Not applicable.

H. Pumping stations:
   1. Design capacity: **[85] [xxx] gpm**
   2. Rated TDH at design capacity**: [21] [xxx] ft**
   3. Electric service: **[480 volt / 3 phase] [xxx]**
   4. Discharge size: **[2] [xxx]** inches

I. Dosing Tank: Provide with locking basin cover, spice box, mercy float switch assembly, pump control panel with run time meter, trip counter, and check valve assemblies, and breakaway flanges with slide rails. All components shall be made of non-corrosive materials. Audio and visual alarms shall be connected to separate power circuits to be activated with pump failure or high water alarm.

J. Plants: Non-invasive species appropriate to wetland type and as indicated on approved Shop Drawings.

SPECIFIER NOTE:
Following are examples. Edit as appropriate for project.

Table 1. Emergent plants for constructed wetlands (adapted from Schueler 1992 and Thunhorst 1993).

Recommended Species	Maximum Water Depth*	Notes
Arrow arum *Peltandra virginica*	12 inches	Full sun to partial shade. High wildlife value. Foliage and rootstocks are not eaten by geese or muskrats. Slow grower. pH: 5.0-6.5.
Arrowhead/duck potato *Sagittaria latifolia*	12 inches	Aggressive colonizer. Mallards and muskrats can rapidly consume tubers. Loses much water through transpiration.
Common three-square bulrush *Scirpus pungens*	6 inches	Fast colonizer. Can tolerate periods of dryness. High metal removal. High waterfowl and songbird value.
Softstem bulrush *Scirpus validus*	12 inches	Aggressive colonizer. Full sun. High pollutant removal. Provides food and cover for many species. of birds. pH: 6.5-8.5.
Blue flag iris *Iris versicolor*	3 - 6 inches	Attractive flowers. Can tolerate partial shade but requires full sun to flower. Prefers acidic soil. Tolerant of high nutrient levels.
Broad-leaved cattail** *Typha latifolia*	12-18 inches	Aggressive. Tubers eaten by muskrat and beaver. High pollutant treatment, pH: 3.0-8.5.
Narrow-leaved cattail** *Typha angustifolio*	12 inches	Aggressive. Tubers eaten by muskrat and beaver. Tolerates brackish water. pH : 3.7-8.5.
Reed canary grass *Phalaris arundinocea*	6 inches	Grows on exposed areas and in shallow water. Good ground cover for berms.
Lizard's tail *Saururus cernuus*	6 inches	Rapid grower. Shade tolerant. Low wildlife value except for wood ducks.
Pickerelweed *Pontedaria cordata*	12 inches	Full sun to partial shade. Moderate wildlife value. Nectar for butterflies. pH: 6.0-8.0.
Common reed** *Phragmites australis*	3 inches	Highly invasive; considered a pest species in many states. Poor wildlife value. pH: 3.7-8.0.

Recommended Species	Maximum Water Depth*	Notes
Soft rush *Juncus effusus*	3 inches	Tolerates wet or dry conditions. Food for birds. Often grows in tussocks or hummocks.
Spikerush *Eleocharis palustris*	3 inches	Tolerates partial shade.
Sedges *Carex* spp.	3 inches	Many wetland and several upland species. High wildlife value for waterfowl and songbirds.
Spatterdock *Nuphar luteum*	5 ft, 2 ft minimum	Tolerant of fluctuating water levels. Moderate food value for wildlife, high cover value. Tolerates acidic water (to pH 5.0).
Sweet flag *Acorus calamus*	3 inches	Produces distinctive flowers. Not a rapid colonizer. Tolerates acidic conditions. Tolerant of dry periods and partial shade. Low wildlife value.
Wild rice *Zizania aquatica*	12 inches	Requires full sun. High wildlife value (seeds, plant parts, and rootstocks are food for birds). Eaten by muskrats. Annual, nonpersistent. Does not reproduce vegetatively.

* These depths can be tolerated, but plant growth and survival may decline under permanent inundation at these depths.
** Not recommended for stormwater wetlands because they are highly invasive, but can be used in treatment wetlands if approved by regulatory agencies

K. Erosion control: As specified in Divisions 31 – 33 (2) and as follows:
1. Mulch for seeding may consist of straw, chaff clover, alfalfa, peppermint, soy bean hay, or wood cellulose fiber mulch.
2. Compost blankets, berms, and socks as specified in Section 31 25 73 (02635) - Stormwater Management By Compost

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions under which system will be installed, with Designer/Installer present, for compliance with requirements.

B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wetlands system in accordance with approved Shop Drawings, as indicated, and in accordance with applicable regulations.

B. Planting:
1. Plants assigned to each cell shall be planted in random distribution by type on **[18] [xxx]** inch spacings.
2. The effluent level in the gravel bed shall be within one to three inches of the surface at the time of planting and be maintained at that level at all times for the duration of the initial growing season.

SPECIFIER NOTE:
Temporary anchoring may be needed if the substrate is soft, the plants are buoyant, or erosion could disturb the existing system.

3. Provide temporary anchoring as necessary.

4. Establishment: Maintain water level as appropriate to plant types and wetlands type (surface flow or sub-surface flow).

3.3 PROTECTION

A. Provide mechanical protection as needed to prevent animals from damaging newly established plants.

SPECIFIER NOTE:
Canada geese cause significant depredation by grazing on young shoots and seedlings and by uprooting rhizomes and tubers. Deer and blackbirds can also damage newly established seedlings. Muskrats feed on the fleshy tubers of plants such as cattails and can quickly demolish a cattail wetland.

Muskrats and other burrowing animals can damage dikes and liners. If wire screening was not installed in the dikes, a thick layer of gravel, rock, or bentonite over trouble spots may inhibit burrowing. If damage continues, the animals may have to be trapped and removed for temporary relief until wire screen can be installed. Burrows can also be sealed by placing bentonite clay in the entryway and adding water to the bentonite to seal the opening.

Mosquitoes are common in natural wetlands and can be expected in constructed wetlands. However, in the mid- Atlantic states, mosquitoes are usually not a major problem in constructed wetlands. The best approach to avoiding mosquito problems in constructed wetlands is to create conditions in the wetland that are not attractive to mosquitoes or are not conducive to larval development. Open, stagnant water creates excellent mosquito breeding habitat, and stagnant, high nutrient water is ideal for larval development. Flowing water and a covered water surface minimize mosquito development. Control methods include unblocking flows to eliminate stagnant backwaters, shading the water surface (females avoid shaded water for egg laying) and dispersing floating mats of duckweed or other floating plants. Purple martins, swallows, and bats can eat thousands of adult mosquitoes every day, so providing purple martin houses, swallow perches, and bat boxes will reduce the number of mosquitoes. Mosquitofish *(Gambusia)* can be introduced to prey on mosquito larvae. The green sunfish *(Lepornis cyanellus),* a native, hardy, and aggressive mosquito-eating fish, can be used in areas that are too cold for mosquitofish. Some control is provided by the larvae of insects. such as dragonflies, which prey on mosquito larvae.
Before beginning any involved control procedures, every aspect of the wetland system and the surrounding area should be carefully inspected. The inspection should include such minor components as old cans, discarded tires, undrainable depressions in wooded areas, hollow stumps, water control structures, open piping, and anywhere else that standing water can accumulate. Mosquito problems often originate from some small and frequently overlooked pocket of standing water rather than from the wetland as a whole.

1. Preventive methods may include planting through chicken wire fence fastened over the surface of the substrate to prevent animals from excavating tubers and rhizomes.

3.4 WATER INTRODUCTION

SPECIFIER NOTE:
Satisfactory establishment may take from several months to one or two full growing seasons. The plants may not begin to reach maturity and equilibrium until late in the second growing season.
A gradual rather than sudden increase in the concentration of the wastewater applied reduces shock to the vegetation. Alternatively, if plants are readily available and inexpensive, some die-off and replanting can be utilized in order to apply the wastewater sooner.
Water level management is key to maintaining wetland vegetation. Despite relatively broad depth tolerances, freshwater plants often sort by small variations in water depth, producing the apparent zonation of vegetation along the shores of marshes.
Most wetland species are adapted to daily or seasonal fluctuations in water level but most wetland plants can tolerate neither extended periods of flooding nor drying of their roots.
Water quality also affects the health and survival of wetland plants. High nutrient loads, high or low pHs, high dissolved solids concentrations, and buildup of heavy metals and other toxics can affect the vegetation in wetlands. Constant pollutant loads work against species diversity and favor pollution-tolerant species such as cattails.

A. Allow plantings to become well established before the wastewater is introduced into the system.

B. Verify that the water supplies enough nutrients to support plant growth. If not, a solution of commercial nutrient supplement may be added.

3.5 FIELD QUALITY CONTROL

A. General: Comply with requirements of agencies having jurisdiction and as specified herein.

B. System Inspection: System Designer/Installer shall inspect system installation and submit reports to Architect. Notify **[Architect] [Owner]** 48 hours in advance of the date and time of inspection.
1. Provide site inspection of system **[at Substantial Completion] [two weeks prior to Occupancy]**.
2. Provide site inspection of system immediately after storm event that may be severe enough to affect the system; provide inspection services for minimum **[12] [xxxx]** months after Final Completion.
3. Provide site inspection of system seasonally, and not less than once every three months; provide inspection services for minimum **[12] [xxxx]** months after Final Completion.

C. Pressure Test: Perform pressure test of the pressure distribution system prior to final cover. Confirm observation by local health department.

D. Water Quality: Comply with requirements of agencies having jurisdiction and as specified herein. Comply with ASTM D4840 for chain of custody of water samples. Coordinate with work specified in Section 01 57 19.13 (01354) – Environmental Management to provide water monitoring for influent and effluent of constructed wetlands.

SPECIFIER NOTE:
Monitoring criteria may include water quality (surface and ground water), sediment quality, temperature, hydrology (fluctuation, loading, variability and flow pattern monitoring by means of tracer studies), plant, benthic macroinvertebrate, fish tissue analyses, toxicity testing, seasonal vegetation mapping or physical sampling, habitat structure and diversity (including species richness), and wildlife use surveys (birds, amphibians, macro-invertebrates, and fish, if appropriate).
If the State has a wetlands biomonitoring program, it may be appropriate to incorporate your efforts into the program.
Volunteer monitoring groups, such as the Izaak Walton League or local schools, may be able to assist you with your monitoring efforts. Refer to http://www.iwla.org/

1. Provide data on the following immediately after plants are established and **[weekly] [monthly] [xxxx]** thereafter for minimum **[6] [12] [xxxx]** months:
   a. Biochemical oxygen demand (BOD_5).
   b. Total Suspended Solids (TSS).
   c. Fecal coliform.
   d. **[xxxx].**
2. Establish baseline water quality for constructed wetland system for both influent and effluent.
3. Provide comparison of test results with municipal water quality, and maintenance of system.
4. Water testing shall be performed by a laboratory in compliance with agencies having jurisdiction.

END OF SECTION