An Innovative and Cost Effective Approach to Wastewater and Sludge Treatment

Constructed Wetland Group

Reed Bed Systems for Biosolids Treatment

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Constructed Wetlands Group, Inc.

Reed Beds in Operation

Aiken, MN
Amity Township, PA
Amity Township, PA
Ancora State Hospital, Ancora, NJ
Appomattox, VA
Belgium, WI
Bethel, ME
Beverly, NJ
Birdsboro, PA
Blairsville, PA
Bowmanstown, PA
Brillion, WI
Burgettstown, PA
Caribou, ME
Central Carbon, PA
Culver, IN
Deer Lake, PA
Delano, MN
Denton, MD
Elizabethville, PA
Falls City, NE
Fleetwood, PA
Friendship, NY
Greencastle, IN
Green Lane, PA
Harrison Township, PA
Hawley Area Authority, PA
Indian Head, MD
Maiden Creek, PA
Marion, WI
Marlboro Developmental Ctr., Marlboro, NJ
Morysville, PA
Myerstown, PA
Mercersburg, PA
New Jersey School Of Conservation, Branchville, NJ
New Paris, IN
Northern Lancaster County Authority, Denver, PA
North Warren, PA
Oley, PA
Oneida Tribe of Wisconsin
Orbissonia Rockhill, PA
Orwigsburg, PA
Penn Yan, NY
Pine River, MN
Red Cliff Band of Chippewa, WI
Robeson, PA
Robesonia Wernersville, PA
Royersford, PA
Saint Michael, MN
Salem, MO
Schuylkill County MUA, Gordon, PA
Shade Gap, PA
Sherwood, WI
Shickshinny, PA
Susquehanna, PA
Union Township (Belleville), PA
U.S. Parks Service, Sandy Hook, NJ
Wanatah, IN
Washburn, WI
Washington Township, NJ
West Monmouth MUA, NJ
Winter Harbor, ME
Woodbine, NJ
Womelsdorf, PA
On-Site Water and Wastewater Treatment

An effective, cost-saving approach to dewatering sludge
History of Reed Beds

- Original research and seminal work conducted by the Max-Plank Institute, Ustersbach, Germany.
- Research began in the late 1950’s - early 1960’s.
Dr. Kaethe Seidel

- A pioneer in the study of the sewage treatment plant
- Dr. Seidel’s experiments showed the ability to metabolize and uptake various organic as well as inorganic substances
Metabolizing Plants

- Macrophytes grown hydroponically, and plants such as
  - Phragmites (common reed),
  - Scirpus (soft stemmed bulrush),
  - Juncus (bulrush), and
  - Typha (cattail)
Design Considerations for Reed Bed Biosolid Treatment

- **Volume** of sludge
- **Sludge characteristics**
  - including use of polymers
  - flocculent such as alum
- **Climatic** conditions
- **Volatile solids** concentration of waste activated sludge
- **Stabilization** process (aerobic vs. anaerobic)
Design Considerations  continued

- Most aerobic biosolids systems have further stabilization of WAS
- Efficacy of system dramatically diminished when volatile solids are consistently above 70 percent
- Provide biosolids retention to comply with seasonal application cycles
  - winter application intervals may be 3-4 weeks
- Land availability
Sludge Quality

- Metal concentration
- Oil and grease content
- pH
Biodynamics and Mechanisms of the Reed Bed Process

- Based on previously discussed design considerations
  - application rates will vary from 20 to 50 gal./sq. ft./yr.
- Application rates and intervals will depend on (est. 12-22 applications a year)
  - severity of winter as it relates to freeze and thaw conditions
  - amount of precipitation
Root System Phragmites (common reed)

- Extensive root structure creates an environment for diverse and active micro flora
  - microorganisms continually help to degrade the volatile solids
    - reduction in volatile solids documented as low as 20 percent
- Root structure enhances hydraulic conductivity and drainage of supernatant and water from the biosolids
Root System Phragmites continued

- Voracious demand for water by the plants results in uptake and release of water by the leaf structure (evapotranspiration)
- Mature monoculture of reeds can effectively assimilate up to the equivalent of 40 inches of annual precipitation
- Mature plants can transfer oxygen to its root system even against the pressure of six feet of water
Physical Characteristics of Phragmites

- Rhizome and emergent stalk has a system of **nodes**
- When nodes are engulfed by **biosolids**, they form adventitious secondary root system
- Secondary root system provides enhanced attachment sites for **microorganisms** and aids in dewatering
Propagation of Phragmites

- Phragmites are one of the world’s most opportunistic plant species
  - Found in over 40 states
  - Can survive in up to six feet of standing water for long periods of time
  - Can also be found in desert climates
- Phragmites is native in many of the states in which it is found
  - Phragmites has been documented historically in almost all mid-western states
Propagation Issues

- Phragmites is viewed as an invasive species
  - It has been shown that Phragmites propagates almost exclusively by vegetative means
  - Scientists have proven in the laboratory that 30 - 70% of the seeds produced are viable
  - However, conditions necessary for germination of the seed make it extremely difficult to propagate via seed.
Safeguards to Prevent Inadvertent Spread of Phragmites

- Special care of harvested plant material
- Use of rigid structural barriers (concrete and treated timber)
- Ultimate disposal of the biosolids together with the plant material should be carefully monitored
Advantages of the Reed Bed System

- Although there are significant capital costs in new construction, there are minimal operation and maintenance costs.
- Existing drying beds can be inexpensively converted to accommodate reed beds.
- Requires no removal of biosolids for six to ten years.
- Final bi-product may meet Class A limitations for final disposal.
More Advantages

- Significant volume and volatile solids reduction
- Long term dewatering and biosolids degradation
Construction of the Reed Beds

- Typically Reed Beds are constructed with concrete side walls.
Construction of Reed Beds (continued)

- PVC liner is used to make the beds impermeable
Construction of Reed Beds (continued)

- Perforated underdrain system usually connected to the head of the plant
Construction of Reed Beds (continued)

- Less than two feet of gravel and sand required
- 3.5 - 4 feet wall of freeboard or cement
- Biosolids distribution system
- Eight foot tongue and groove pretreated side panels
The Process

Wastewater Treatment Plant
The Process

Clearing the Site
The Process

Clearing and Preparing the Site
The Process

Clearing and Preparing the Site
The Process

Preparing the Site
Adding Watering System and Walls
The Process

Adding Walls
The Process

Adding Walls
The Process

Adding Walls
The Process

Adding Entrance/Exit
The Process

At Entrance/Exit
The Process

Watering System
The Process

Inspecting and Preparing for PVC Liner
The Process

Laying Out PVC Liner
The Process

Installing PVC Liner
The Process

Installing PVC Liner
The Process

Installing PVC Liner
The Process

Adding Gavel Layer over PVC Liner
The Process

Adding Sand Layer over Gravel Layer
The Process

Planting of Rhizomes in Sand
The Process

Watering Rhizomes
The Process

Watering Rhizomes
The Process

Flooding Bed
The Process

Early Phragmites/Reed Growth
The Process

Grown Mature Phragmites
The Process

Grown Mature Phragmites
The Process

Grown Mature Phragmites
The Process

Grown Mature Phragmites
The Process

Harvesting Phragmites/Reeds
The Process

Harvested Reed Piles – Ready for Mulching or Baling
The Process

Harvested Reed Piles – Mulched
The Process

Seasonal Burning of Unneeded Phragmites/Reeds
The Process

Dormant Winter Tubular Reeds Allow Air Flow
The Process

Solids Prior to Screening of Rhizomes – with Topsoil Consistency
The Process

Removal of Solids Built-up over 8 to 10 years
The Process

Removal of Solids After 8 to 10 years
The Process

Applying to Agricultural Land – Consistency of Nutrient-Rich Topsoil
The Process

Reworking the Bed Bottom
The Process

Flooding for New Season
The Process

New Season Growth
The Process

Grown Mature Phragmites
Preparing for Planting

- Spacing of rhizomes 12 inches apart
- Watering new roots
Preparing for Planting

- Watering covered rhizomes
- Flooding of bed
Planting of Phragmites

- Planting season from mid April to November
- Vegetative root stock is planted on one foot centers
- Watering is required for a period of 4-8 weeks after planting depending on the season
- Application of biosolids within 4-6 weeks after planting
Operational Concerns & Common Problems

- Over loading or application of poorly digested biosolids
  - may cause plant stress or plant mortality
  - formation of anaerobic slime layers and potential for odor problems
  - diminished drainage resulting in significant downtime

- Immature reeds can be susceptible to nitrogen burn, heat stress, ammonia toxicity and damage by aphids
Solution to Common Problems

- Early recognition and prompt re-mediation
  - increased levels of DO in biosolids stabilization process
  - longer retention time
  - conservative application rates
  - avoidance of loading on hot sunny days (causes burn)
  - taking beds out of service for extended periods of time
Control of Biological Pests (Aphids)

 During the first year of plant growth, aphids can cause serious damage

 Aphids can be managed with chemical and biological controls
   During the first year it is often necessary to use systemic insecticides such as Cygon
   With established plants aphids can be controlled by the release of ladybugs
Harvesting of Reed Beds

- Harvesting is normally done in the winter when the biosolid layer is frozen
  - provides firm footing
  - plants are dormant
- Harvesting can be completed by several methods
  - use of sickle bar mower
  - weed trimmer with metal blade
  - burning
Why Do We Harvest the Reeds?

- Significant biomass (10-13 foot high plants) will dramatically add to the sludge blanket if not removed.

- Although metal uptake by plants is not significant, removal of the reeds helps to lower metal levels in the accumulated biosolids layer over time.
  - reeds have the greatest affinity for copper and zinc.
Harvesting continued

- Nine to twelve inches of plant stalk should be left after harvesting
- Remaining stalk is dead plant material, which will not renew itself
  - important conduit for air to the rhizome which promotes new growth the following season
  - creates hydraulic conductivity promoting drainage during the winter
Disposal of Harvested Material

- Disposal methods for reed stalks
  - composting on-site
  - chipping/mulching
  - burning
  - disposal to landfill
  - baling
Evacuation of Reed Beds

- Eventually biosolids will accumulate to 3 – 3.5 depths
- Beds are taken out of service for six months, beginning in the fall
- Allowing time for the biosolids to dry and degrade
- Following six month down time, water content becomes as low as 50%
- Beds can be walked upon, biosolids are friable
Evacuation continued

- Volatile solids are as low as 20 - 25%
- Metal values in the accumulated biosolids have consistently been lower or equivalent to the liquid that has been applied
- Pathogen and Helminth ova values at a number of facilities are well within Class A limits
Removal of the Biosolids

- Removal can be accomplished by excavation equipment set up outside the bed
- Use of floatation type vehicles within the bed
- Care should be taken to drag biosolids, avoiding disturbance of underlying sand and gravel layer
- Facilities often leave 3 or 4 inches of residual biosolids
Reeds after Evacuation

- Reeds will regenerate as a result of the undisturbed underlying root structure
- Beds need to be watered following biosolids removal
Disposal of Biosolids

- Land fill
- Beneficial Use
  - cover for solid waste land fill
  - used to stabilize mine land reclamation sites
- Agricultural application
  - provided that biosolids have been screened for vegetative matter
Costs

- Construction costs of reed beds will vary from $20.00 per square foot to $40.00 per square foot.
- Constructed Wetland Group, Inc. costs for reed beds will vary from $1.00 per square foot to $5.00 per square foot.
Scope of Services

- Technical support to engineer during feasibility and cost studies
- Provides design criteria and assistance during design phase
- Site inspection during construction
- Provide botanical material, planting supervision, and guarantee
- Create site specific written operation and maintenance guidelines
- Regular on site support during the first two years of start-up