DEVELOPING A VEGETATIVE COVER USING SHRUB WILLOW (*SALIX* SPP.) IN NEW YORK STATE

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DEVELOPING A VEGETATIVE COVER USING SHRUB WILLOW (*SALIX* SPP.) IN NEW YORK STATE

By,

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Introduction

Throughout the world, open land adjacent to industrial operations has been used to store byproducts of manufacturing and production processes. To minimize impacts on human health and the environment, these sites have traditionally been capped with clay or geomembrane materials to create a barrier to prevent the percolation of precipitation through the material and into the environment. Over the past two decades, the US EPA and others have experimented with vegetative covers, also known as evapotranspiration (ET) covers, as an alternative approach to address concerns at these sites while simultaneously providing a range of additional benefits (Figure 1, see sidebar *Evapotranspiration Cover Using Shrub Willow*).

The purpose of this environmental application is to highlight the steps that are required to develop a plant-based solution to protect human health and the environment at a former industrial site. The project example used is the development of a willow vegetative cover on a former industrial site in New York State that was used to store the byproducts of soda ash production. The Solvay Company used an area on the west side of Onondaga Lake in Onondaga County in central New York State to store the byproducts of soda ash (Na_2CO_3) production for over a century (1884–1986). For every unit of soda ash produced, about 0.9 units of waste byproduct material consisting of a mixture of calcium and magnesium salts were generated and stored in settling basins that cover an area of over 600 acres (Kuzovkina and Volk 2009). Leaching of calcium and chloride salts into groundwater and nearby surface waters is the main environmental concern that must be managed.

Evapotranspiration Cover Using Shrub Willow

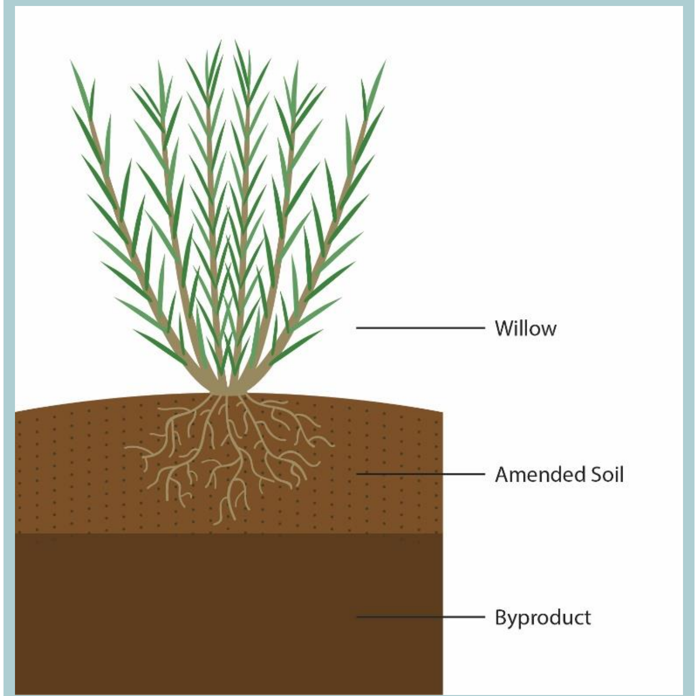

Figure 1. Diagram of a potential vegetative evapotranspiration cover using willow.

Rather than being designed to act as a physical barrier to water, vegetative covers are designed to *modify* the soil water storage, water runoff, evaporation, transpiration, and water infiltration at the site. The movement of water through the vegetative cover is reduced by the plants and the soil layers below them. The soil component provides support and nutrients for the plants in the system and also acts as a reservoir where water can be stored until it can be returned to the environment directly from the soil by evaporation or though the plants by transpiration.

Vegetative Evapotranspiration Covers

Vegetative covers have been developed and implemented over a number of years to protect human health and the environment and also provide an array of other benefits, such as providing wildlife habitat, aesthetic benefits, lower maintenance, and have fewer repairs than traditional caps (Kennen and Kirkwood 2015; Rock et al. 2012). Vegetative covers serve the same purpose as traditional caps but function differently.

Vegetative covers can also produce biomass that can be harvested as renewable biomass, enhance biodiversity, and decrease carbon and energy footprints (see sidebar, *Using Shrub Willow and Poplar as a Vegetative Cover*). These covers are now a green remediation best practice that the US EPA encourages where it is effective (EPA 2008), especially in regions where overall evapotranspiration potential at a site exceeds incoming precipitation. As of 2011, there were over 223 projects in the US employing vegetative landfill covers (EPA 2016), but their application in more humid regions of the country is less common because precipitation can be greater than potential evapotranspiration from vegetated covers.

Development in Stages

Vegetative cover systems must be developed in phases to account for the specific conditions and waste materials at a site. The phased approach means testing each component, such as cultivars of plants or mixes of soil amendments, incrementally to ensure the overall success of the vegetative system and to allow issues to be addressed as the system is developed and scaled up. This phased approach is effective because it allows the development of a vegetative cover system that is specifically designed to match plants with the unique attributes of the site (Westphal and Isebrands 2001). By not committing to a large-scale planting too early in the process, system-wide failures are avoided. While the development of the system over many years is sometimes perceived as being too slow, costs are spread out over time and the end result is usually more effective and successful than when systems are deployed rapidly over large areas.

Solvay Reclamation Site

At the Solvay site, several collective miles of French drains and other measures have been installed around the perimeter to capture and treat leachate to prevent these salts from entering the groundwater. The remaining waste byproduct on site is not a typical mineral soil and its characteristics pose challenges for growing plants. The waste byproduct across this site ranges from 40 to 65 feet deep. It is a white powdery material when dry, and a sticky material when very wet. The pH of the substrate is alkaline, ranging from a pH of 8–10 in the top 15 inches to greater than 11 at depths of 24–40 inches and few plants grow at such a high pH. Conversely, the ideal pH range for willow is between 6.0 and 8.0. The substrate has a uniform texture, with over 70% of the material being silt-sized particles. Because of the uniform nature of the material and lack of organic matter, the substrate has very little soil structure, high salt concentrations, and low nutrient availability.

Using Shrub Willow and Poplar as a Vegetative Cover

Shrub willow (*Salix* spp.) and poplar (*Populus* spp.) have many characteristics that contribute to their effectiveness as covers applicable to locations across the US. Both can tolerate a range of soil conditions, have rapid juvenile growth rates, develop a large leaf area in a short period of time, and have leaves that emerge early in the spring and remain on the plants well into the fall. Poplar and willows have high transpiration rates and an extensive, fine root system for accessing water in the soil profile. Poplar has been used as a vegetative cover at other sites in the US. At the Solvay Site, poplar was not used because it did not perform as well in early trials and is also highly susceptible to a lethal disease (*Septoria musiva*) in this region of the country. When selecting poplar or willow for a vegetative cover please check with your county Extension office or local conservation district for the best species for your region. Using a phased approach, small tests of any recommended cultivars, should occur first before large scale planting to ensure they will be successful.

Figure 2. Greenhouse trials to screen a large number of willow cultivars (left) and different types of organic amendments (right).

Determining if Willow Can Grow

The first challenge was to determine if shrub willow could grow at the Solvay site and what amendments might be needed to ensure successful and rapid growth of willow. If high willow survival and growth rates could not be achieved at the site, then the plants would not transpire enough water for effective water management, and a vegetative cover would fail. To determine if willow could grow at the site, a research group from the State University of New York College of Environmental Science and Forestry (SUNY ESF) conducted a series of greenhouse studies to test if shrub willow cultivars could be successful in the Solvay soil and if different types of organic amendments would impact the response of the plants (Figure 2).

Over 30 different willow cultivars and three different sources of organic amendments were initially tested. Each organic amendment was a waste product from either a local industry (e.g., pharmaceutical manufacturer, brewery) or biosolids from a wastewater treatment plant. Results showed that amendments improved the survival and growth of willow overall and that many cultivars grew well in the amended Solvay material (Kuzovkina and Volk 2009; Farber 2006).

Selecting the Best Cultivars and Organic Amendment Mixtures

The next step was to select the best performing cultivars and organic mixtures and test them on the site in small field trials that were a few acres in size (Figure 3). The conditions during the field trial, including periods of drought, winter cold, and desiccation, revealed that six of the first ten cultivars tested in the field were not suitable for the site (Rodzkin and Volk 2017). These small trials emphasized that a phased approach allowed the willow cover system to be improved before large-scale implementation occurred. For the successful cultivars, biomass after three years of growth was as good as what has been recorded in trials on nearby marginal agricultural sites (Figure 4; Rodzkin and Volk 2017). These trials were monitored closely for six years to provide the data needed to calibrate a water-budget model that was being developed for the site (Brown 2007; Mirck and Volk 2010).

Figure 3. The first set of willow trials at the site as part of the development of a willow vegetative cover. The best ten cultivars from greenhouse screening trials were used but only a subset of the willows were successful in the field. The photo on the left illustrates that only a subset of blocks and strips with different cultivars were successful. Growth after three years for successful cultivars was excellent (right), and biomass production was as good as that found on nearby marginal agricultural land.

Figure 4. Three-year-old willow being harvested at the Solvay site. Shrub willow resprouts in the spring and grows rapidly so that it continues to function as a vegetative cover. Since the planting date is staggered across the site, only about one-third of the area is harvested at a time. Biomass from these operations is used to generate renewable heat and power in the region.

Field Testing the Design

Initial trials at the Solvay site planted in 2004 provided the foundation for the design of the vegetative cover system that was tested on ten acres in 2008. Initially, there were challenges for effectively and efficiently mixing organic amendments into larger areas when mixing heads on excavators were used. This was resolved by using tractors and large disks to incorporate the organic material. Between 2011 and 2017, an additional 115 acres of willow vegetative cover was planted at the Solvay site. There is the potential to expand this system across several hundred more acres at the site and at other locations where water movement through former industrial sites needs to be managed.

Benefits of the Willow Cover

The benefits of the willow vegetative cover start with protecting human health and the environment and extend to other ecosystem services, such as carbon cycling and enhancing landscape diversity. Shrub willow grew well on the site, which also transpired between 493–771 mm of water over a single growing season (Mirck and Volk 2010). As a result, a water budget model for the site showed that very little water moved below the willow root zone and off site to impact ground and surface water (Brown 2007). The performance of the vegetative cover was similar to that of a traditional clay or geomembrane cover that is often installed. Studies have shown that the fossil fuel investment needed to prepare this site for planting and growing a willow vegetative cover is about one-tenth of the energy needed for a traditional geomembrane cover. CO_2 emissions associated with establishing a willow vegetative cover are about one-sixth of those of a traditional cover because there is much less fossil fuel invested in the willow cover and because willow takes up CO_2 from the atmosphere as it grows.

Willow also helps to develop wildlife habitat for a wide range of species. There are more birds and small mammals that make use of the willow compared to the adjacent unplanted areas and more than 55 species of bees use the willow in the early spring as sources of nectar and pollen. In addition, the characteristics of willow harvested from the Solvay site are found to have no difference in wood composition compared to willow grown on nearby agricultural sites (Timothy Volk, unpublished data), which has provided confidence to renewable energy producers who are planning to use the material to generate electricity and heat.

Conclusion

The development and deployment of a willow vegetative cover at the Solvay site was successful in part because of the phased approach that was used, which will be effective for developing similar systems using willow or poplar at other sites. Each of the sites will have its own set of unique characteristics that need to be investigated before designing and implementing a vegetative cover. These incremental steps are important for these plant-based systems to be successful across a range of sites. Once vegetative systems are properly developed and implemented, they can protect human health and the environment as well as provide a wide range of other benefits.

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