Evaluating a Constructed Floodplain Wetland for Nutrient Removal Efficiencies

Biological Systems Engineering

Virginia Tech Invent the Future

A. Ludwig,[1] W.C. Hession[2]

[1]Graduate Assistant, [2] Associate Professor, BSE Department, Virginia Tech, Blacksburg, Virginia

Abstract

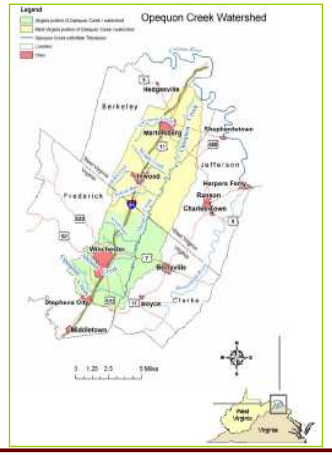
As part of a basin-scale nutrient reduction project, a floodplain wetland will be designed and implemented in the upper Opequon Creek watershed in Northern Virginia, USA. The goal of the project is to implement innovative best management practices (BMPs) to reduce non-point source nitrogen and phosphorus loads from the urban and agricultural lands in the basin[1]. The floodplain wetland will be designed to capture event flows from Opequon Creek that carry sediments and nutrients, treat the flow in the wetland, and return the treated flow back to the Creek. Retention time, water depth, and wetland volume will be adjusted for maximum available biological treatment. Various depth zones through the wetland allow for high- and low-flow patterns and a compilation of native wetland plant species. Water quality and discharge characteristics will be monitored at stations at the floodplain wetland inlet and outlet using automatic samplers. Comparisons of inflows and outflows will provide an estimate of nutrient reduction efficiencies of the floodplain wetland BMPs. Additional floodplain wetlands will be implemented within the watershed based on lessons learned on this first BMP installation.

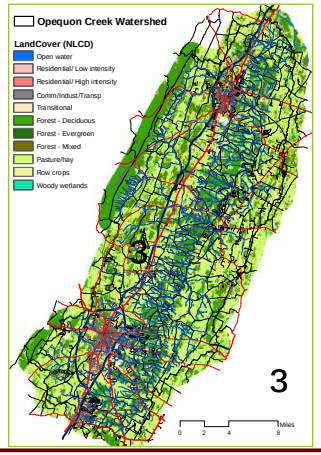
Objectives

- Construct and maintain a floodplain wetland in the Opequon Creek floodplain to mitigate urban and agricultural non-point source pollution;
- Evaluate the surface and subsurface hydrology of the floodplain wetland for flow retention during establishment and after;
- Evaluate the efficiency of the floodplain wetland at removing non-point nutrient pollutants of nitrogen and phosphorus through plant uptake and sediment binding.

Study Location

Opequon Creek begins southwest of Winchester, VA and flows north through West Virginia to the Potomac River. Land use is rapidly changing from agricultural areas of crops, pasture, livestock, orchards, and woodlands, to industrial and residential centers.



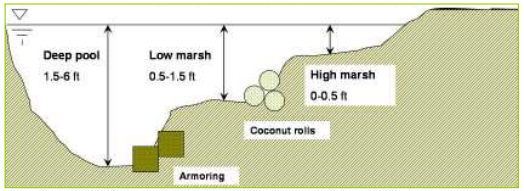


Methods

The floodplain wetland is designed to treat nutrients and other pollutants during storm flow conditions when most of these pollutants enter the stream. Construction involves grading to create a low area in the floodplain with an inlet to draw water from Opequon Creek at high flows and an outlet to return treated flows to the main channel. The design was created using the guidelines reported by the Virginia Department of Conservation and Recreation in 1999[2]:

- Maximize wetland volume in allocated area to maximize hydraulic loading;
- Vary depths within design to favor a heterogeneous culture of flood tolerant species;
  - High Marsh – 0.5 ft and 50% of surface area
  - Low Marsh – 1.5 ft and 40% of surface area
  - Deep Pools – 4 ft and 10% of surface area
- Vegetated grass swales forming inlet and outlet structures, allowing flows to enter floodplain wetland at a predetermined stage.

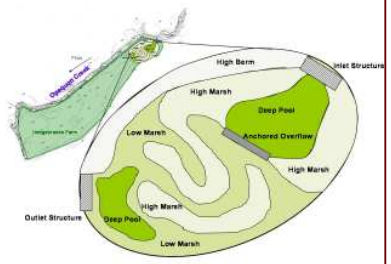
Design Details



Cross-sectional depth zones of a constructed floodplain wetland[2].

Floodplain wetland schematic showing important features[2]:

- deep pool fore bay for sediment deposition,
- winding low marsh through a high marsh acting as a thalweg of concentrated flow, and
- a final deep pool for additional sediment deposition.



Acknowledgements: *This project is a partnership with state and federal agencies and local watershed groups. Funding comes from the Chesapeake Bay Targeted Watershed Grants Program administered by the National Fish and Wildlife Foundation in cooperation with the Chesapeake Bay Program and the CSREES Mid-Atlantic Regional Water Quality Project.*

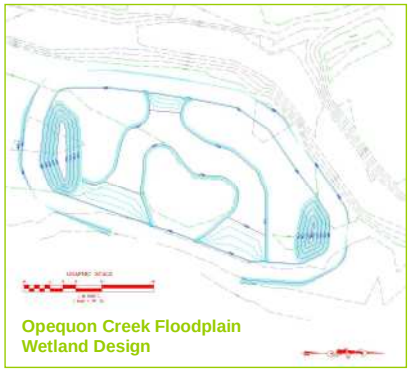
References:

[1]Heatwole, C, 2006. "Opequon Creek – Targeted Watershed Grants." Proposal to Chesapeake Bay Targeted Watersheds Grant Program, Virginia Tech, Blacksburg, Virginia, USA.

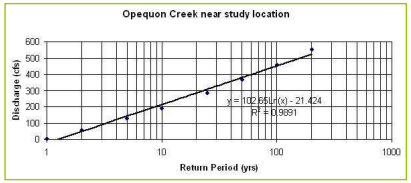
[2]Virginia Department of Conservation and Recreation, 1999. "Virginia Stormwater Management Handbook: First Edition." Commonwealth of Virginia, Richmond, Virginia, USA. Available at http://www.dcr.virginia.gov/sw/stormwat.htm. Accessed in August 2006.

[3]Virginia Department of Forestry, 2005. "Rain Gardens: A landscape tool to improve water quality." Virginia Department of Forestry, Virginia, USA.

Preliminary Plan



Opequon Creek Floodplain Wetland Design



The floodplain wetland design encompasses approximately 0.67 acres of bottomland currently in pasture. A United States Geological Survey gage station is located on Opequon Creek downstream from the study location. Stage readings from this gage were used to assemble a storm frequency curve using the Log-Pearson Type III analysis on six years of stage data. The wetland will be planted with native wetlands species and every effort will be made to assure existing riparian trees will be left on site.

Native Virginian wetland species [3]

Herbaceous
- Sweet flag
- Jack-in-the-pulpit
- Swamp milkweed
- Common boneset
- Eastern mallow
- Yellow flag iris
- Cardinal flower
- VA blue bell
- Monkey flower
- Pickerel weed
- Lizard's tail

Ferns
- Sensitive fern

Grasses/Sedges/Weeds
- Blue joint reed grass
- Switch grass
- Indian grass

Completed floodplain wetland showing off-channel storage of stream flow.

Future Work

- Model hydrology of floodplain wetland to ensure favorable retention time (Winter, Spring 2007);
- Implement plan; construct and plant floodplain wetland (Spring 2007);
- Install automatic sampling stations to monitor flows at floodplain wetland inlet and outlet for hydraulic loading and nutrient removal efficiency (Spring 2007-2009);
- Install piezometers to monitor groundwater movement through the wetland (Spring 2007-2009).