

Sustainable Watershed Planning and Design Using Bioengineered Solutions

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INTRODUCTION

Sustainable design practices and natural systems based solutions can result in restoration practices built into any design challenge. An interdisciplinary approach is essential to solving complex environmental problems. The approach involves the scientific interplay of restoring natural landscapes, reestablishing ecological functions, sound engineering concepts, dependence on self-repair and adaptation mechanisms (more than prescribed maintenance measures) and geologically viable long term solutions. The “sustainability” philosophy includes implementing the interdisciplinary approach to environmental problem solving and using hydrology as a connecting factor to establish the essential link for long term sustainable design. This often couples design approach with the need to teach and inform various nationwide Federal, State and private stakeholders in the concepts. We have found great interest and acceptance for the interdisciplinary approach to sustainable watershed planning and design.

CASE STUDIES OF SUSTAINABLE WATERSHED PLANNING AND DESIGN

Restoration Design of Herrick Hollow Creek, NY

This case study involved detailed fluvial geomorphologic and stream channel and floodplain engineering to restore Herrick Hollow Creek at the Richardson Hill Road Landfill Superfund Site. Herrick Hollow Creek, located in the Catskill Mountains in upstate New York, discharges into the Delaware River and Cannonsville Reservoir operated by the New York City Department of Environmental Protection (NYCDEP). Previous stream restoration measures failed multiple times and much of the fill material placed in the stream corridor had been washed downstream into the municipal drinking water reservoir. The situation was very tense due to the need for the NYCDEP to comply with US Environmental Protection Agency (USEPA) regulations limiting turbidity in the reservoir, and the NY Attorney General’s office was involved. We adopted a three phase approach including (a) immediate short-term field engineered remedies to reduce sediment mobility and stream channel incision; (b) stakeholder meeting to establish restoration goals and objectives; and (c) stream restoration design based on site-specific hydrologic data, stream hydraulic data, combined with data from multiple geomorphically similar “reference reaches” known to perform the prioritized habitat functions. After ecological performance was clearly linked to earth science parameters such as channel geometry and base flow, full geotechnical and hydraulic engineering analysis was conducted to validate and refine the treatment designs.

The interdisciplinary design and restoration master planning approach brought a level of stakeholder communication and engineering rigor to the project which served to maintain constructive interaction even in the face of severe weather and construction delays. Integrating the hydrology, fluvial geomorphology and floodplain ecological aspects received stakeholder support, and the consensus process allowed clear communication when change was needed. Supervision during various phases of construction, follow-up monitoring of the performance of the restoration and all work was conducted under the close scrutiny of multiple agencies was essential to ensure project success.



Figure 1: Herrick Hollow Creek Restoration (New York)
(Left) Interim In-stream Measures; (Right) Stream Bank, Floodplain and Riparian Zone
Restoration by Reestablishing Native Vegetation

Mill Creek River Restoration, OH

The City of Cincinnati, Office of Environmental Management was looking for a cost-effective, environmentally sensitive bank stabilization plan for a portion of Mill Creek to halt erosion threatening to uncover waste materials contained in the Center Hill Landfill. The eroding bank was approximately 27 feet high and 600 feet long with clay strata overlain by highly permeable, loosely compacted sandy and gravelly soils mixed with landfill materials creating a zone of intense seepage at the interface. Both leachate and solid waste were entering the river due to ongoing bank erosion of this highly urbanized river. The site is immediately above a concrete lined flood control channel and within the limits of a US Army Corps of Engineers flood control project area. A detailed field investigation of site geomorphic and hydrologic parameters, existing geotechnical data was performed.

The next steps were to identify appropriate measures, provide construction documents, and overseeing the bidding and construction process. Bioengineering treatments were selected because of their ability to aid stabilization, assist in leachate extraction, and enhance wildlife habitat, water quality, and aesthetics. The bioengineering design featured the use of live poles integrated into a riprap toe, brush layers, geogrid lifts, live staking, and a brush fascine. An innovative design for incorporating vegetation into a leachate collection system used phreatophytic (highly water consuming) species to intercept and extract leachate from a gravel collection trench. Vegetation and geosynthetic materials function to stabilize the over-steepened bank, with trees and shrubs adding shade along the stream corridor. The chosen treatments were highly resilient to flashy peak flows, urban floatable debris, and potential future hydrologic impacts due to increasing development within the watershed.

The regulatory community, local citizens groups, and municipal engineers were all extremely pleased with the design and its performance. Additionally, our design offered a savings of 30% over a different bioengineering design by others, while being favored for ecological integrity and stability. Accurate cost estimating and thorough construction supervision helped achieve the financial goals. After more than five years of highly effective performance, the community opted to expand the treated area to cover two miles of riverbank upstream and downstream of this site, incorporating a public greenway to allow recreational access to what has become a stable, beautiful, and biologically diverse riparian corridor.

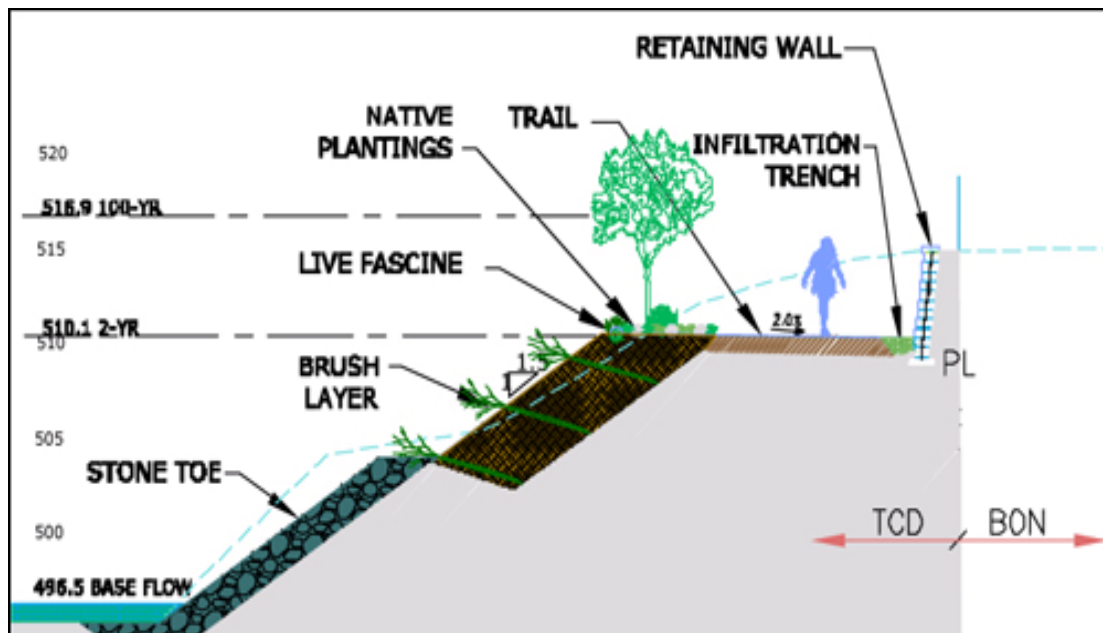


Figure 2: Mill Creek Stream and Bank Restoration Schematic (Ohio)

Alewife Brook Restoration - Cambridge Storm water Wetland

As part of a massive sewer segregation project designed to eliminate Combined Sewer Overflows (CSO's) to the Alewife Brook as part of the Boston Harbor Cleanup, the City of Cambridge needed to construct a stormwater management basin. The most feasible alternative was to construct the basin on land owned by the state, an idea at first rejected by the owner agency. Located within the 100-year floodplain in the Alewife Brook Reservation, an urban wild, the site currently serves as habitat for a diverse wildlife population and as a recreational area laced with informal hiking and bike trails. The challenge was to design a constructed wetland and detention basin that met the technical requirements for detention and treatment while simultaneously meeting the habitat and recreational functions envisioned for the area in the Massachusetts Department of Conservation and Recreation (DCR) master plan for the Alewife Brook Reservation. The solution was to design a stormwater management facility as a multi-functional wetland that serves the combined objectives of stormwater detention, water quality improvement, wildlife habitat enhancement, and recreation/education.

The tasks included formulation of alternatives, participation in public meetings and outreach, Massachusetts Environmental Policy Act (MEPA) and other permitting support, preparation of responses to comments, completion of a wildlife inventory, and bioengineered design of the detention basin as a stormwater wetland park. The stormwater wetland was designed to minimize flooding of the Alewife Brook by retaining up to 10.3 acre-feet of stormwater to shave peak flows to the Alewife Brook during major storm events. The stormwater wetland provides treatment of the stormwater "first flush" via sediment removal, biological filtration, and thermal regulation while providing recreational trails, enhanced wildlife habitat and wetlands, and an educational feature promoting stormwater management best practices. A new entrance to the reservation was designed to improve public access and the park's amenities including an amphitheater/outdoor classroom, boardwalks, overlooks, benches, and interpretive signage highlighting the historical, ecological, and hydrological features of the site.

This project was described in the Boston Globe as "*a far cry from the traditional treatment prescribed by engineers*". The stormwater wetland incorporated both conventional and bioengineered structures designed with a natural "look and feel" that won praise from stakeholder groups. The wetland increases base flows in the brook and enhances the health of adjacent natural wetlands via infiltration for groundwater recharge. In addition, the stormwater management park incorporates a site layout and plant species selected for synergistic relationships with existing ecological patterns and natural processes that provide a significant improvement over the existing degraded habitat. The City was delighted to save more than \$15 million dollars compared to the alternatives, and the DCR was pleased to have a cost-sharing partner to implement elements of its Master Plan, a win for those parties as well as the natural systems and local communities.

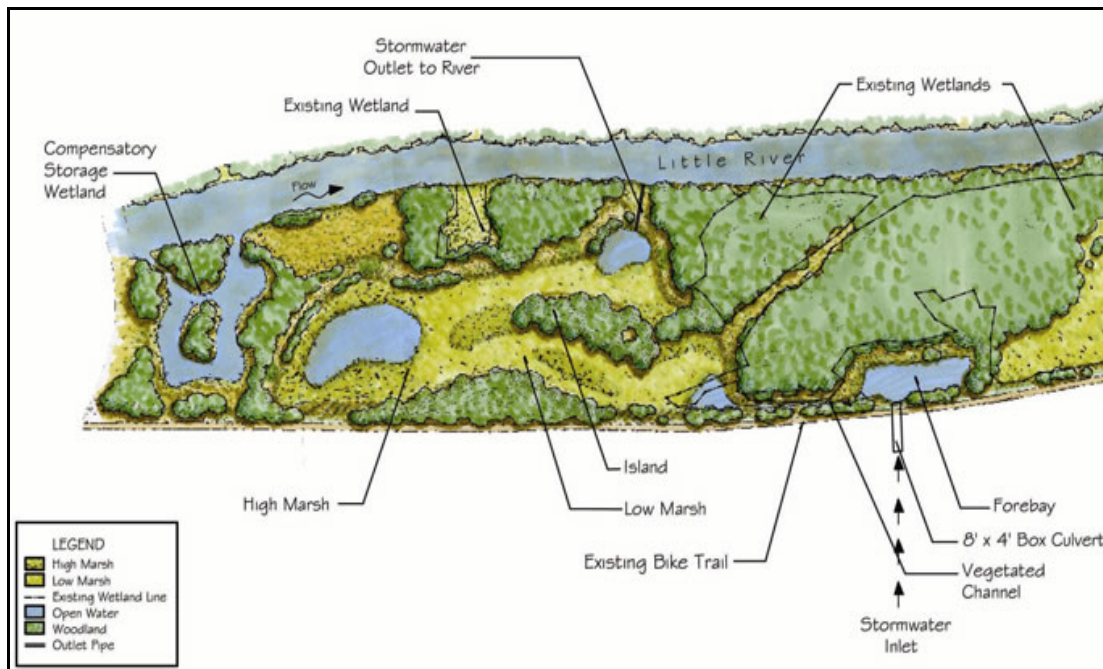


Figure 3: Cambridge Stormwater Wetland Restoration Schematic (Massachusetts)

CONCLUSION

Throughout our many years and significant amount of restoration work, it repeatedly demonstrates that utilizing the various integrated elements of the hydrological cycle, a full understanding of existing ecology, and a thorough engineering design using natural systems and materials are essential to retaining and enhancing ecological functions, the key to sustainable watershed master planning.

REFERENCES

- Bioengineering Group Inc. (2009). Project Description Sheet: Herrick Hollow Creek - Richardson Hill Road Landfill SFS, EPA Region 2 Superfund Site, Sidney Center, New York.
- Bioengineering Group Inc. (2009a). Project Description Sheet: Mill Creek at Center Hill Landfill, Cincinnati, Ohio.
- Bioengineering Group Inc. (2009b). Project Description Sheet: Cambridge Stormwater Wetland, Cambridge, Massachusetts.