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EEOS660
Neponset River Wetland Restoration Assessment 2
Geological Aspects of Neponset Restoration :
Dam Management and Downstream Effects

The Neponset River

The Neponset River Watershed comprises ca 117 mi^2, running 30 miles northeast from its origin at the Neponset Reservoir in Foxborough, MA to Boston Harbor in Quincy, MA (Kennedy et al., 1995). The river winds through Foxborough, Sharon, Walpole, Norwood, Canton, Dedham, Milton and Boston, respectively, while its watershed includes Dover, Medfield,, Quincy, Randolph, Stoughton and Westwood (Milone and MacBroom, 2006). Overall, the basin contains 12 dams, including several mills and reservoirs. It is borded to the north and west by the Charles River basin, the east by the South Shore coastal drainage system and on the south by the Taunton River basin (Foot-Smieth and Katuska, 2000).

Geologic Setting

In coastal New England, the primary underlying bedrock (Piedmont) is derived from Appalachian mountain building events dating to 480 mya during the construction of Pangaea (Kaye, 1982). Later tectonic and glaciation events over the intervening millenia led to the creation of high-grade metamorphic rocks which still dominate the Boston area. In Quincy, rocks are classified as PzZc (Proterozoic Z to earliest Paleozoic; Kaye, 1982). They are mostly metaclastic argillite and quartzite, with some clastic conglomerates and sandstone (Garrells and MacKenzie, 1972).

The Upper River Valley includes both igneous and sedimentary rock formations. Igneous rocks are slightly more common and vary in age from 210 my (Triassic) to more than 600 my (Precambrian). It is thought that the sedimentary rocks are younger, ranging from 290-320 my (Pennsylvanian) (Yuan, 2014). A number of faults run northeast within the Neponset River Valley, mostly likely cut before the Devonian (410 mya). Bedrock groundwater flow is generally restricted to these faultlines, as the rock types themselves are impermeable.

Superficial deposition occured primarily during the late Pleistocene (100 kya), when glacial erosion promoted the formation of deltas, outwash plains, eskers (ridges) and kames (terraces). Glacial moraines and till are common in the upland areas of the Valley (Kennedy et al., 1995). A buried bedrock valley exists below the surface watershed, with tributaries below the Ponkapoag and Purgatory Brooks. Glacially deposited stratefied sand and gravel are present in numerous geologic formations throughout the valley, while the distribution of clays and silts suggest that several lakes existed post-glaciation throughout the region (DEQ). Rock groups identified within the watershed by the USGS include clastics, meta-agillite, mudstones, Alkali-feldspar granites, metavolcanic rock, subaluminous granite and alkaline basalt. In coastal New England, geologic uplift, fluvial and glacial erosion of the Piedmont strata, coastal vegetative productivity and concurrent fluctuations of local sea level have resulted in the buildup of several layers of organic sediments (peat) with increased inorganic contributions at depth (Wigand et al., 2014).

New England soils are characterized as either spodosols (northern New England) or inceptisols (southern New England; Mott, 1967). Spodosols are fairly acidic, with a thick humus layer rich in aluminum and iron. These soils are typically infertile with light-colored E horizons overlying a reddish-brown horizon. Inceptisols have very little horizon development and are often found overlying young, resistant parent material. It is likely that both of these soil types have contributed to sediment delivery in New England river basins, and in particular, the Neponset River basin.

A basic topographic analysis of the region demonstrates several important features of the lower Neponset River Valley. Heavy urbanization of the gently south-sloping northern rivery valley contrasts with the largely forested, protected, steeper north-facing slopes (< 700 ft) of the Blue Hills Reservation. Several small ponds and lakes outside the I-95 belt serve as temporary reservoirs within the watershed (Willet Pond, Reservoir Pond, Ponkapoag Pond, Massapoag Pond, the Neponset Reservoir and several smaller water bodies).

The river supports several important fish species including the American shad (*Alosa sapidissima*), river herring (*A. pseudoharengus*), blueback herring (*A. aestivalis*) and rainbow smelt (*Osmerus mordax*).

Human history of the River Valley

Precolumbian indigenous communities extensively inhabited the Neponset region, including the Massachuset and Wampanoag (Massasoit) nations (Swanton, 1953). Small scale forest management (fire) and controlled damming may have taken place, resulting in alternating patterns of upstream erosion and downstream sedimentation, and upstream sediment accumulation and downstream subsidence (Galvin, 1985). In 1635, grist, flour, gun powder and paper making mills were located on the Neponset, while in 1673, a lumber mill was located near modern-day Mattapan. A chocolate mill was added in 1765, while the paper mill was rebuilt in 1773, later becoming the Tileston and Hollingsworth Paper Mill in 1836. At this point, ship-building and commercial shipping represented the major industrial activities along the river. In the 1800's several railroad bridges were constructed, while the Baker Chocolate Mills expanded to 7 mills along the river. Meanwhile, the MDC (Metropolitan District Commission) was created in 1893 to perserve downstream marsh (controlling 232 acres). The mid to late 20th century saw decreased industrial activity along the river, as the railroad company stopped operations (1959), the chocolate factory moved to Delaware (1964) and the MDC continued to expand parkland within the marshes.

Current geologic restoration

The Neponset River has experienced some measure of damming for at least 350 years. Modern geologic restoration of the Neponset focuses on effective management of the two currently existing dams of the lower Neponset River: The Tileston and Hollingsworth Dam and the Baker Dam, including a braided river section between the two dams. The upstream dam, the Tileston and Hollingsworth Dam, was rebuilt in the 1960's after Hurricanes Connie and Diane. It includes a large pair of levers that can control the water height of the resulting reservoir, which is typically 12 ft. deep and 180 ft. long. The Bay State Paper Company closed in 2005, and the buildings around the dam have long since been razed or abandoned. Currently, the dam is managed by the MDC (Metro District Commision). The MDC controls the flow twice a year (spring/fall), and is able to divert excess floodwaters from the Charles through the Mother Brook (the first canal ever built in the US in 1640). Almost three miles downstream, as previously mentioned, the MDC also manages the Baker Dam, built by the Walter Baker Chocolate Company mills and rebuilt in 1955 after a major flood breached the existing structure. The dam currently exists as an upstream concrete structure (6 ft tall) and a lower section consisting of several small walls 2 ft in height. Several small blockages exist from the Baker Dam upstream to the T & H dam including the former impoundment of the old Jenkins Dam, a utility stream crossing built by the MRWA (Mass Rural Water Association) and an old abandoned rock dam. These represent significant impediments to normal flow, affecting downstream sediment transport and anadromous fish transport.

The MDC took control of the dams after a great flood in 1955. Two dams were damaged by the floods and removed (the Mattapan and Jenkins dams). It was during this period that the T & H dam and the Baker dam were rebuild. Concurrently, the main channel was deepened, straightened and entrenched with concrete and dredge spoil material. These activities may have contributed to reduced hydrologic connectivity and downstream sediment starvation in the lower Neponset River.

The Neponset River is heavily urbanized, and particularly vulnerable to sediment contamination in several forms including runoff, atmospheric deposition, fossil fuel combustion and accidental spills. Impoundments along the river may lead to organic matter accumulation, microbial-driven anoxia and heavy metal accumulation.

The upper section of the Neponset River is characterized by a modest descent (24 ft/miles) and several riffle-run-pool series, where shallow surface flow is followed by a deeper downstream reservoir. In two of these upstream reservoirs (Neponset Reservoir and Crackrock Pond, treated wastewater inputs from the Foxborough Company result in severe eutrophication and heavy metal contamination. As well, upstream impoundments often exhibit excess turbidity, degraded sediment quality, bioaccumulation of several heavy metals (Cd, Cr, Cu and Zn) and signs of eutriphication (excess total phosphorus and total kjeldahl nitrogen). Nearby, the Foxborough Park Raceway contributes stone dust though a culvert system, resulting in excessive turbidity and sedimentation. Continuing downstream, treated wastewater from a roofing company and an electroplating operation contribute to water contamination. Downstream, the School Meadow Brook and the Meadow Brook exhibit relatively high coliform concentrations, possibly due to broken sewer lines. Further, the Traphole Brook (Sharon, Walpole and Norwood) exhibits fairly high turbidity due to drainage over loose subsoils. The lower, estuarine section of the Neponset River is tidally influenced below the Baker Dam, and structurally supported by adjacent salt marshes. The East Branch of the Neponset (Canton) was found to exhibit acutely degraded conditions, including high water temperatures and poor sediment quality.

A 2000 restoration plan for the lower Neponset prepared by the Wetlands Restoration and Banking Program (Foot-Smieth and Katuska, 2000) set a 2010 goal of 130 acres of restoration, defined as reestablishing former wetlands and returning functional environmental services to existing wetlands. Proposed methods included removing culverts, plugging ditches, replacing hydric soils, removing fill, stabilizing stream banks, removing physical pollution and reducing contamination sources of sediment degradation. Specific proposed projects include hydrologic restoration of the Sharon White Cedar Swamp near Lake Massapoag, the largest natural lake in watershed. Existing challenges to the health of the swamp include ditching and reduced groundwater levels. Plans include groundwater restoration and the proper mitigation of stormwater runoff from surrounding residential neighborhoods. Other targeted areas include the Fowl Meadow, whose wetlands have been drained or filled for airports, roads and groundwater withdrawal, and Gulliver's Creek near the mouth of the river. The surrounding salt marshes are severely degraded due to heavy ditching, dredge soil disposal, stormwater pollutant accumulation and *Phragmites* invasion (Foot-Smieth and Katuska, 2000). Overall, the plan calls for restoration of specific sites in five areas: improved water quality (68 sites), restored salt marshes (16 sites, 900 acres), improved habitat (76 sites), greater flood storage (84 sites), reduced invasive species (39 sites), healthier cold water fisheries (5 sites) and improved groundwater recharge (69 sites).

Historic and ongoing urban and industrial discharge have been found to have significantly affected both water quality and benthic sediments along the lower Neponset River Valley as well. Specifically, the USACE (Army Corp. of Engineers) and USGS have both documented many contaminants including PCBs (poly-chlorinated biphenols), PHCs (polyaromatic hydrocarbons) and heavy metals (Pb, Cu, Zn, Cr; Shafer, 2009). Over several decades, many projects have attempted to restore the riverway with respect to the aforementioned contaminants. These projects have included stormwater, wastewater and hazardous waste management, as well as sediment quality assessments (Kennedy et al., 1995).

Proposed restoration efforts have included specific consideration of the two dams, and generally involve channel restoration and improved fish passage, dam breaching and sediment removal, and improved management of hydrologic inputs to reduce sediment contamination.

One particular study details the sediment and water quality characteristics of the two main hydrologic impediments in the lower Neponset River (T & H and Baker dams as well as the braided river section between them (Breault et al., 2004). With respect to effective dam management, a proper assessment of the sediment contamination is necessary due to the often substantial accumulation of sediments in the still waters behind dams.

The results of the study demonstrated that the water depth behind the T & H dam were the deepest in the Neponset River (mean = 8.8 ft, max = 15 ft), while the Baker dam impoundment was slightly shallower (mean = 7.3, max = 9.3). Sediment thickness was greater behind the T & H dam (9.7 ft) than near the Baker Dam (7.6 ft) and was thicker than the braided channel sediments (5.8 ft). A wide range of sediment sizes were found in the lower Neponset, ranging from silt to boulders. T & H sediments were generally dominated by silts and clays, while the braided river section consisted of silt overlain by loam. Further downstream, sandy clays again appear to dominate (Breault et al., 2004).

Sediment samples taken from both modern and older marshes revealed heavy metal contamination, particularly behind the Baker dam (Breault et al., 2004). As well, PAHs and PCBs were present in significant concentration, with the Baker impoundment sediments exhibiting the greatest concentrations of PCBs (possible due to a nearby railroad bridge) and T & H sediments revealed the greatest concentrations of DDT and PCBs.

Geological implications of dam removal included a comparative summary of sediment quality up and downstream from the dams (Breault et al., 2004). Downstream sediment quality was generally better than above the Baker dam, possibly due to the trapping of contaminated sediments behind the dams. As well, the lower dam experiences greater amounts of tidal flushing, helping to wash out contaminated sediments. The release of the dam might transport these contaminated sediments downstream, perhaps affecting the lower estuarine marshes and Boston harbor nearshore environments. Alternatively, the removal of sediments may be the most effective, but also the most costly (Breault et al., 2004).

Such a cost-benefit analysis was recently performed for the Commonwealth of Massachusetts Riverways Program by Milone and MacBroom, Inc., an environmental firm (Milone and MacBroom, 2006). The goals of this restoration assessment were to restore habitat quality of the Neponset River, and improve anadromous fish access along the dammed lower river (shad, alewife, blueback herring, rainbow smelt and the American eel). Secondary considerations included the remediation of contaminated sediments, maintainance of flood control, long-term dam safety and public considerations including access, historical and cultural preservation and aesthetically pleasing public spaces. A 2005 remediation assessment by the Johnson Company and the Mass Riverways Program outlined several possible avenues for restoration including in-situ treatment, stabilization, sediment capping, removal and off-site disposal, bioengineering and natural attenuation (Milone and MacBroom, 2006). Potential PCB-sediment waste could be carried to a landfill, incinerated or treated at a waste facility.

However, 28 alternative techniques were considered, with particular focus on the two dams and intervening river impediments. Such techniques included the installation of fish ladders, rock ramps, bypass channels, full dam removal and channel relocation. Several sediment management techniques were also considered. Each alternative was ranked by the potential for efficient fish passage and by the number of river miles potentially restored and available to fish through the implemented action (Milone and MacBroom, 2006).

Options for a fish ladder included choosing a particular bank, while sediments could be fully dredged (or left in place) in the event that the entire dam is removed. Further, containment walls might be placed on either bank, with a cap over contaminated sediments to reduce downstream tranport of polluted material. In the event of rock ramp construction, full or partial impoundment of the surrounding dammed waters is possible (given either movable flashboards or a concrete weir, respectively), or the ramp could be build with a relatively gently slope (4%) to allow greater fish transport with little hydrologic impediment.

The assessment detmined that full dam removal is the most favorable option to improve both fish passage and upstream habiertat restoration (a rock ramp would only accomplish the former; Milone and MacBroom, 2006). A bypass channel would create new habitat, but would also incur greater costs due to the presence of the nearby commuter-rail line. A hypothetical budget for potential restoration efforts was created, given a specific cost of "no action" (which included dam replacement, operations and maintainance costs totally \$7.25 million). The least costly plan included the removal of the Baker dam with on-site sediment stabilization with a containment wall on the right bank with a sediment cap, as well as a partial dam removal at T & H with a containment wall (costs = \$3.2 million). A secondary option included the full removal of Baker dam, the partial removal of T & H dam, with an adjacent rock ramp (\$1.9 million). Overall, these techniques should not affect the total hydrological input of the lower Neponset, but would reduce potential surface elevations under 100-year flood conditions. With sediment capping and containment wall stabilization, erosion and transport of contaminated sediments to downstream marshes should decrease over time. As well, the removal of the dams should improve fish passage, ameliorate downstream water quality conditions and diversify downstream wetland habitats. All of the other project goals (increased public access, historical preservation, aesthetics) should all be either improved or unaffected by the proposed plans (Milone and MacBroom, 2006).

Overall, it appears that geologic restoration of the Neponset River basin should seek to address the well-documented contamination of upstream sediments and the hydrologic impediments impounding such sediments and reducing downstream water quality. Using several dam and river management techniques (including rock ramps, sediment caps, cement weirs and containment walls), proper restoration should ameliorate water quality and local wildlife habitat through careful planning and consistent assessment and management.

As Margaret Mead once said, "Never doubt that a small group of thoughtful, committed containment walls and sediment caps can change the world; indeed, it's the only thing that ever has."

Alternatively, you could go with Edward Abby and the Monkey Wrench Gang: "One man alone can be pretty dumb sometimes, but for real bona fide stupidity, there ain't nothing can beat teamwork." So sayeth the ACOE. Amen.

"These temple-destroyers, devotees of ravaging commercialism, seem to have a perfect contempt for Nature, and instead of lifting their eyes to the God of the mountains, lift them to the Almighty Dollar.

Dam Hetch Hetchy! As well dam for water-tanks the people's cathedrals and churches, for no holier temple has ever been consecrated by the heart of man." — John Muir, from *The Yosemite* (1912)

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