Constructed Wetlands for Stormwater Treatment in Alaska

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Introduction

Anchorage, Alaska, is situated at 61° latitude, at the very northernmost extension of the Pacific Ocean. Centered on a broad peninsula between the Chugach Mountains and the marine waters of Knik and Turnagain Arms, the city receives 15-20 inches per year of precipitation, roughly half of which falls as snow. Anchorage is home to 260,000 people, with a convenient road network of over 3000 miles. The Municipality of Anchorage and State of Alaska Department of Transportation and Public Facilities expect to receive an NPDES permit for municipal storm water discharge from the USEPA by early 1998. The Municipality has been using wet pond sedimentation basins for BMP treatment of stormwater runoff and snowmelt for over a decade. Suspended solids are the primary contaminant of concern in Anchorage, based on the sensitivity of local salmon-bearing streams to increased sediment loadings and contaminants associated with sediments. Sediments are also particularly relevant in Anchorage storm water and melt water runoff, as a result of sanding of city streets to improve winter traction. These sedimentation basins have been documented as achieving removal of suspended solids as high as 80% during storm events.

Sedimentation treatment is also required by municipal design criteria as part of snow disposal site development. Snow is collected from city streets after snowfalls and stored in designated snow disposal areas, where the large piles of collected snow will gradually melt through the course of the summer. Recent anecdotal observations suggest that the rate of runoff from snow disposal sites is not conducive to mobilizing a significant mass of sediment. While consistent through the long warm days of the early summer, the flow emanating from the snowmelt is never turbulent and forceful. As a result, course sediment is typically left behind as the water emanates from the snow disposal site.

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The sedimentation basins have not been effective in reducing turbidity of runoff to the same extent as course sediment, since fine particles require extremely quiescent conditions for settling. The basins may even contribute to elevated turbidity in the freshwater receiving streams during non-storm conditions, as inorganic turbidity introduced during stormflows is retained in the water column for a long time after cessation of stormwater discharge. Additionally, subdrains discharging groundwater base flow into certain portions of the storm drain system carry iron leached from natural sources in soils. Upon introduction to the ponds, ferric precipitates and iron bacteria proliferate, coloring the water column at several pond locations.

In response to the need to reduce turbidity in sedimentation basin discharges, the Municipality is experimenting with a constructed wetland approach to augment the treatment of stormwater discharge from several storm drain systems. The largest project undertaken to date is a basin/wetland complex on a 14 acre site that will be used to treat discharge from over 1000 acres of residential, commercial, and industrial drainage upgradient from the site as well as treatment of drainage from an adjacent 17 acre snow disposal site. The configuration of the site and the contributing drainage area is shown in Figure 1.

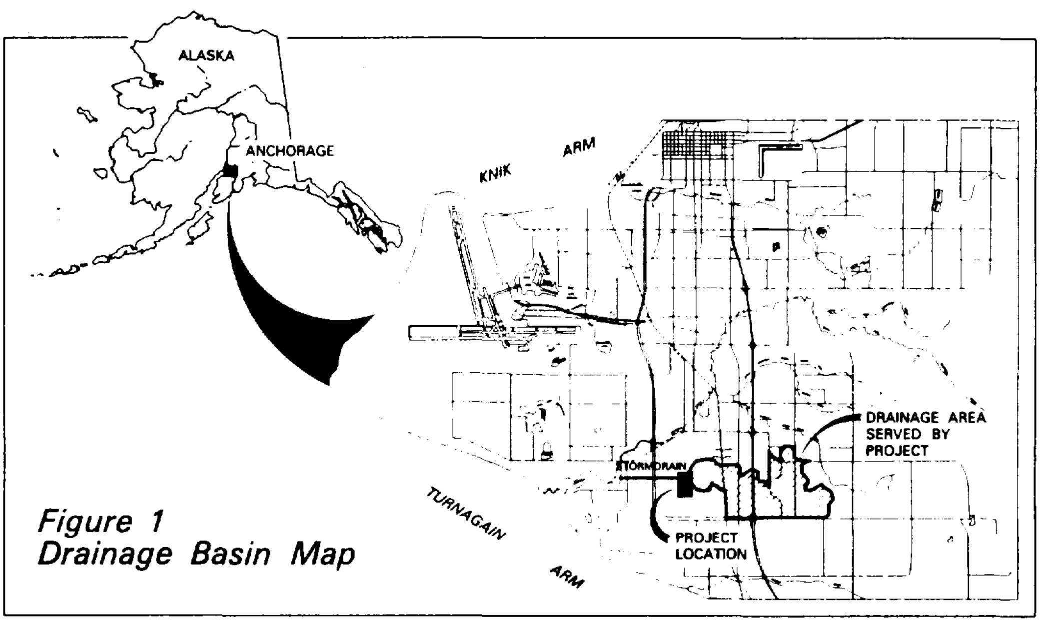

Figure 1
Drainage Basin Map

Site Design Layout

Figure 2 shows the proposed layout of the site. Snow disposal will take place on the southern 17 acres, and has been graded to deliver runoff to the existing wetland area on the northeast corner of the snow disposal site. This natural heath wetland area is being retained as a preliminary filter for the average 100 gpm snowmelt discharge anticipated from the snow disposal site.

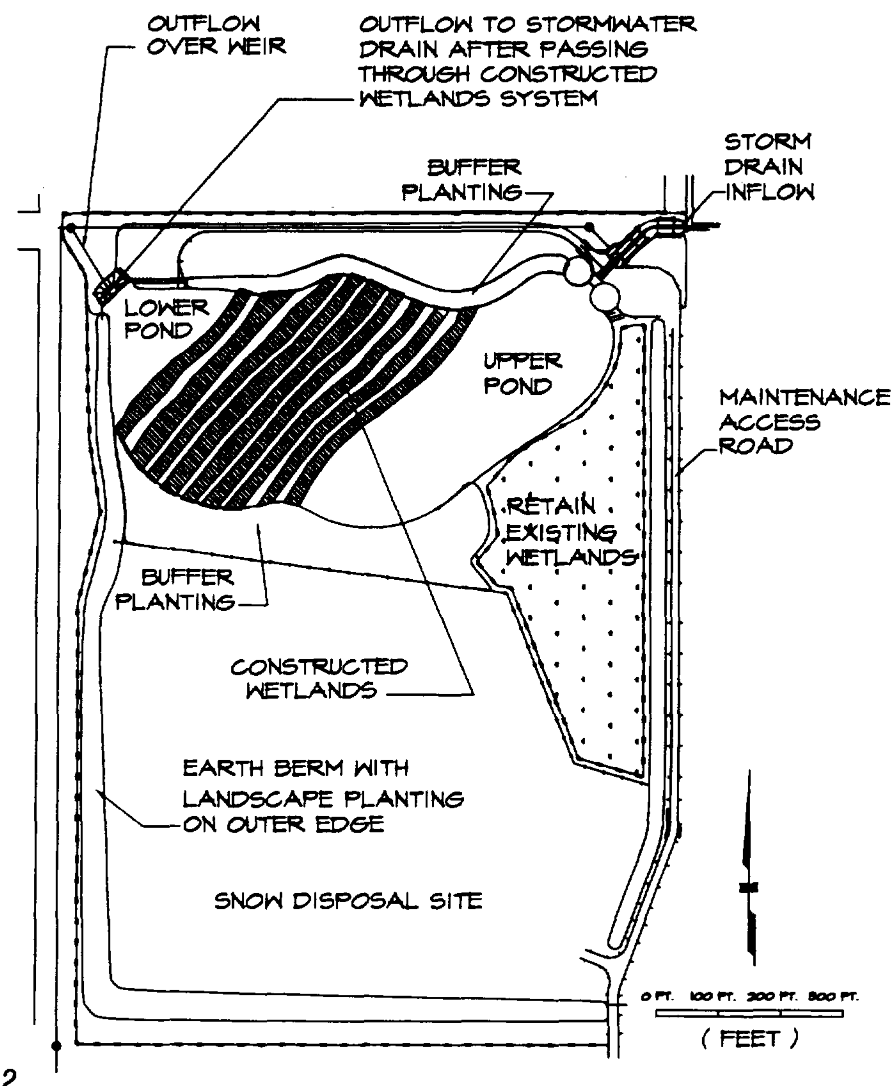

Figure 2
Site Design Layout

The discharge from the natural wetland seeps into a two-acre pond excavated on the northeast corner of the overall site, where it is joined by discharge from the upgradient storm drain system. A base flow of less than 1 cfs is expected from subdrains and wetlands contributing to the storm drain system upstream from the ponds. Peak flows are expected up to 82 cfs for the two-year, six hour design storm.

A bypass is provided to divert water for pond maintenance and mitigate impacts on the sedimentation pond and wetland system from flows in excess of the design storm.

The pond discharges across a wetland complex to the west. The wetland complex is designed as a series of rows of "high marsh" composed of native heath vegetation, including *Potentilla, Salix, Ledum, Rosa, and Myrica*, interspersed with "low marsh" composed of emergent plants including *Carex, Scirpus,* and *Juncus*. The overall slope of the marsh complex is 0.5%, with the upper edge of the wetland carefully graded to control the water elevation in the pond, and distribute flow across the full 400' wetland width. The series of alternating high and low marsh areas provides hydraulic control to ensure that all of the storm water receives repeated filtering, and that the potential for short-circuiting is minimized. The broad flow path also serves to minimize surcharging due to flooding. Hydraulic modelling suggests that rises in stage during high flows will be limited to less than 0.5 feet.

The water discharges from the wetland into a smaller lower pond, which has its water level controlled by a sheet pile effluent weir. The weir spills into a storm drain conduit, which redirects the discharge to a large diameter storm drain and ultimately to a lake lined with residences.

Design Loading

The basin surface area was established to provide for a hydraulic loading rate on the upper wet pond based on the peak flow which may occur from the fully-developed contributing drainage area during a 2-year 6-hour storm event (82 cfs). Applying this peak design flow and stokes law for a 20-micron particle, the sedimentation basin would theoretically remove 100% of particles larger than 20 microns in effective diameter at a hydraulic loading of approximately 2200 cm/d (8.5 x 10^{-4} fps). As suggested above, the ponds are less effective at removing smaller particles, due to turbulence from a variety of sources.

Constructed wetlands are intended to augment the treatment of storm water flow by providing filtering of inorganic turbidity. Our review of existing literature did not provide any specific guidance for design of surface loading rates for constructed wetlands for stormwater. Bingham(1994) reviewed effectiveness data reported by Strecker *et al.* (1992) and others, but noted that no widely accepted design criteria methods, or even rules of thumb have been established. WPCF(1990) suggests steady state loading rates of 0.4 to 4 cm/d (1.5 x 10^{-6} fps) surface flow treatment wetlands used for municipal wastewater, with somewhat higher loading rates for subsurface flow, up to 20 cm/d (7.6. x 10^{-6} fps). The area of constructed wetland for biofiltration is constrained by the site conditions. Our design configuration provides for approximately 4 acres. We expect that this area of wetland to be constructed will result in a higher maximum hydraulic loading of 1340 cm/d (5.1. x 10^{-4} fps) distributed over the wetland for the 2-year storm. The actual peak rate will be reduced somewhat due to routing of the inflow through the upper pond cell. Average hydraulic loading of the wetland will be much reduced, on the order of 10 cm/d (3.8.

x 10^{-6} fps) for typical conditions of less than 0.7 cfs of combined storm drain and snowmelt inflow.

Construction Sequencing

The proposed South Anchorage Snow Disposal and Sedimentation Basin site is currently under construction. A carefully composed construction sequence has been specified to allow completion of the project in the fall of 1998. First, the site was rimmed with silt fence to delineate the construction boundary and protect adjacent remaining natural wetlands. Next, the subgrade for the constructed wetland area was excavated to a base of existing mineral soils between the proposed upper and lower pond locations. Site work on the snow disposal area was also completed prior to the onset of winter so as to ensure availability of the site for snow disposal in the winter of 1997/98. Additional fencing is used to delineate boundaries for contractor operations and the owner's beneficial use of the site for snow disposal.

Access to the pond locations and other areas of heath wetland was prohibited until frost was sufficient to allow movement of heavy equipment with minimal damage to wetland vegetation. The ponds are slated for excavated in winter, and will be the source area for much of the transplanted wetland plant material. The contract specifications call for the contractor to monitor the depth of frost penetration and to encourage frost penetration with site management techniques including compacting and removing snow.

High marsh areas will be formed in late winter using frozen blocks of peat extracted from the proposed pond areas. This winter wetlands construction technique was pioneered by Anchorage Water and Wastewater Utility (AWWU), as described by Barber-Wiltse (1997). This project differs from the AWWU project in that the intent here is to transplant the peat blocks from one location to a new configuration on a prepared subgrade, rather than return the peat blocks to an original position. The alternating series of peat blocks and low marsh is shown in Figure 3 below.

Low marsh wetland will be constructed with imported topsoil and planted plugs of aquatic emergent plants in the spring, while the ponds and wetland areas are being flooded with snowmelt from the watershed. Plantings must be placed by hand, as the Department of the Army wetlands permit prohibits use of heavy equipment from April 15 to July 1, the nesting period for wildfowl using Anchorage wetlands. Upland locations will be planted in the summer, providing completion of the facility by the fall of 1998.

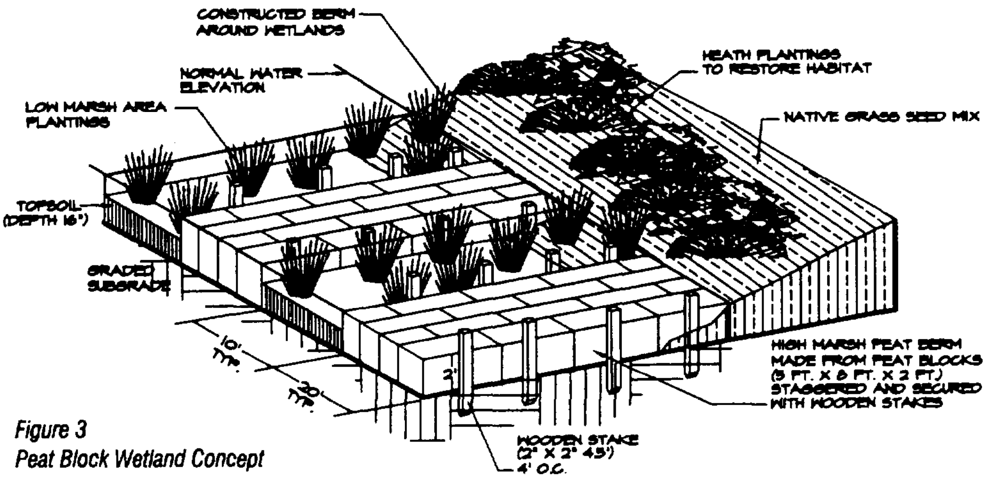

Figure 3
Peat Block Wetland Concept

Monitoring Treatment Performance And Wetland Viability

Permitting agencies are requiring monitoring of treatment performance as well as the long-term viability of the vegetation of the basin/wetlands complex. As little is documented concerning quantifiable effectiveness of BMP's such as the pond/wetland complex for storm water treatment, the actual performance efficiency will only be known after a period of operation. The Municipality is committed to performance monitoring of the treatment process, in addition to monitoring of the flora of the wetland complex as the plant community establishes itself and evolves in response to the constructed wetland hydrologic regime.

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