6-J
SUMMER SEASON TEMPERATURE EFFECTS OF STORMWATER PONDS ON RECEIVING STREAMS

FINAL ENVIRONMENTAL IMPACT STATEMENT

Brightwater Regional Wastewater Treatment System

APPENDICES

Brightwater
King County TREATMENT SYSTEM

Final

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Summer Season Temperature Effects of Stormwater Ponds on Receiving Streams

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King County
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King County has prepared a Draft Environmental Impact Statement (Draft EIS) and Final Environmental Impact Statement (Final EIS) on the Brightwater Regional Wastewater Treatment System. The Final EIS is intended to provide decision-makers, regulatory agencies, and the public with information regarding the probable significant adverse impacts of the Brightwater proposal and identify alternatives and reasonable mitigation measures.

King County Executive Ron Sims has identified a preferred alternative, which is outlined in the Final EIS. This preferred alternative is for public information only, and is not intended in any way to prejudge the County's final decision, which will be made following the issuance of the Final EIS with accompanying technical appendices, comments on the Draft EIS and responses from King County, and additional supporting information. After issuance of the Final EIS, the King County Executive will select final locations for a treatment plant, marine outfall, and associated conveyances.

The County Executive authorized the preparation of a set of Technical Reports, in support of the Final EIS. These reports represent a substantial volume of additional investigation on the identified Brightwater alternatives, as appropriate, to identify probable significant adverse environmental impacts as required by the State Environmental Policy Act (SEPA). The collection of pertinent information and evaluation of impacts and mitigation measures on the Brightwater proposal is an ongoing process. The Final EIS incorporates this updated information and additional analysis of the probable significant adverse environmental impacts of the Brightwater alternatives, along with identification of reasonable mitigation measures. Additional evaluation will continue as part of meeting federal, state, and local permitting requirements.

Thus, the readers of this Technical Report should take into account the preliminary nature of the data contained herein, as well as the fact that new information relating to Brightwater may become available as the permit process gets underway. It is released at this time as part of King County's commitment to share information with the public as it is being developed.

1 INTRODUCTION

1.1 Objective

The objective of this appendix is to present a review of research showing the effects that stormwater detention and water quality treatment ponds may have on downstream temperatures during the summer season. In addition, the environmental effects of elevated temperatures in urban streams are documented.

1.2 Background

Temperature in streams is important because it determines the kinds of aquatic life that can live in that environment. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have preferred temperature ranges that they have adapted to in the streams and lakes where they live in the various climatological zones around the world (Michaud, 1991). When temperatures change drastically over a short time, or get too far above or below natural ranges, high mortality or reproductive failure can result.

There are several sources of natural variation in stream temperature within a region. A stream's initial temperature is determined by its origin, which can include surface runoff, a glacier, a lowland lake, groundwater seepage, or springs (Michaud, 1991). The primary influence in modifying that temperature is the seasonal variation in air temperature. Stream velocity also plays a major role: a parcel of water in a slower moving stream is exposed to sunlight longer and thus tends to absorb more solar radiation. Stream temperature is also affected by factors such as riparian shading, watershed land characteristics (for example, steep forested hills versus flat and sparsely vegetated land), and stream width and depth.

Urbanization has had a negative impacton the aquatic environments of streams. Paving over the landscape for homes, buildings, and roads, and removing trees from stream banks to make way for development can change the character of the watershed and raise average summer stream temperatures to dangerous levels. The chief mechanism is the change in flow rates due to the increase in impervious areas: stormwater runoff increases in volume and peak flow, while conversely there is a decrease in rainfall infiltration. The large peak flows and resulting damage to the stream channel alter the natural diurnal fluctuations in stream temperature. The reduction of rainfall infiltration also decreases the amount of cooler groundwater that enters the stream and provides baseflow.

Community awareness of the problem has grown since passage of the federal Clean Water Act and ensuing studies highlighting the effects of urbanization. Many communities have built stormwater detention and water quality treatment ponds to mitigate the impact. Stormwater ponds are very adaptable, have a proven ability to attenuate design storm flows, and are effective in removing various urban pollutants. They are generally acceptable to the community and in fact are considered a best management practice (BMP) to mitigate the impacts of urban stormwater runoff (Schueler and Galli, 1995). However, over the past 10 years it has been recognized that the stormwater ponds themselves have environmental impacts. One of the primary negative impacts is downstream warming of the receiving streams, which is the subject of this study.

1.3 Water Quality Standards

The State of Washington recognizes that salmonids and trout are cold-water fish adapted to the cold-water streams of the Pacific Northwest, and that it is vital to their survival to keep those streams from overheating. Therefore the state has set a water quality standard for stream temperature, which varies by stream classification. Little Bear Creek, downstream from the proposed Route 9 treatment plant site, is a Class AA stream; this means that its water quality is extraordinary and must meet or exceed the requirements of the designated uses. One of those designated uses is the migration, rearing, and spawning of salmon and other fish. The temperature standard for Class AA streams reads as follows:

> *Temperature shall not exceed 16.0°C (60.8°F) (freshwater)… due to human activities. When natural conditions exceed 18.0°C (64.4°F) (freshwater)… no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C.* (WAC 173-201A).

2 REVIEW OF RESEARCH

Various studies have long concluded that urban streams tend to be warmer on average than undisturbed streams in the same region and with similar topography (Schueler and Galli, 1995). As yet, however, little research exists on the environmental impact of stormwater ponds, particularly in relation to temperature. This is likely because their potential adverse downstream effects were only recently recognized. Many studies have looked at the relation of urbanization to elevated stream temperatures, but few of these dealt specifically with stormwater pond releases.

2.1 Analytical Techniques and Research Methodologies

Schueler and Galli (1995) developed a method of analyzing the warming of stream temperatures due to urbanization in comparison to undeveloped streams within the same region. The method uses the “Delta-T” value, defined as the change in stream temperatures in an urban watershed as compared to a similar stream in an undeveloped watershed (referred to as a reference stream baseline). Schueler and Galli showed that an increase in Delta-T for urbanized streams is a direct function of the amount of impervious areas in a watershed. In Schueler and Galli's study, the summer mean Delta-T for a highly developed watershed headwater stream in Maryland was shown to be 8.6°F (Schueler and Galli, 1995). The maximum instantaneous Delta-T for the same stream was reported as 16.2°F.

Schueler and Galli (1995) summarized the environmental impacts of stormwater ponds, concluding that ponds tend to amplify the thermal warming of downstream temperatures in urban streams, primarily in the summer months. They measured the effect ponds have on a particular stream’s temperature, and called this measurement the “pond Delta-T,” which is the change in stream temperature measured upstream and downstream of a pond. These results are discussed in Section 2.2.

The Water Environment Research Foundation (WERF) is currently completing a study documenting the thermal effects of stormwater in urban watersheds, including the effect of ponds on stream temperatures (Thibert, 2003). The study involves monitoring an urban drain improvement project in Michigan to examine optimal design considerations for mitigating the impact of stormwater that has warmed after flowing across urban areas. The study also addresses the effects on the aquatic environment and BMP design techniques and methods to mitigate the negative impacts on streams. The results are not yet available, but should be released by the end of 2003.

2.2 Factors Affecting Temperature in Ponds

Several factors influence how ponds can affect the downstream temperature. Pond storage volume, wet pool depth, outfall design, and bankside plantings are some of the most important factors (Schueler and Galli, 1995). The size and flow of the receiving stream is another factor. The type of pond construction can also be a factor; a few of the types of stormwater pond are "wet ponds" (those with permanent wet pool systems), dry extended-duration ponds, infiltration ponds, and stormwater wetlands. Probably the most common type is a detention pond with a permanent wet pool, also known as a combination water quality/detention pond. Schueler and Galli (1995) showed that a wet pond’s impact on

Delta-T values correlates directly with the volume of the pond's permanent pool in relation to the size of the watershed.

Since urban stormwater ponds are typically sited in smaller headwater streams, their impacts tend to be exaggerated in comparison with larger regional ponds or impoundments, which are generally sited along larger streams or rivers. Thus a large wet pond in a small stream is particularly liable to raise downstream temperatures in the summer. The shallow wet pool can heat up quickly between summer rainfalls and then, when a storm comes, discharge a pulse of warm water into the stream. In general, the shallower the pond, the warmer the pool will become.

Although wet ponds are likely to have the most dramatic effects, Schueler and Galli (1995) concluded that no pond system configuration was exempt from raising downstream temperatures. One pond studied was an extended-duration dry pond, which, the data showed, had a moderate elevating effect on stream temperatures during storm events. Schueler and Galli attributed this to a lack of riparian cover near the pond outlet and to the absorption of thermal energy from the riprapped outlet channel, released into the water as it flowed over the rocks. (Schueler and Galli, 1995) observed an average of 1 to 3°F of Delta-T values for each 100 feet of riprapped outfall channel. Rock-lined outlet channels with little or no riparian cover for shading can heat up during dry periods and then, as the stormwater flows across the rocks, heat up the water and raise temperatures downstream.

2.3 Effects on Receiving Waters and Aquatic Life

Schueler and Galli (1995) measured pond Delta-T values for four types of urban detention pond in Maryland from April to September 1989. The effects on downstream mean water temperatures (pond Delta-T) ranged from 2.5 to 9.5°F. The low value corresponded to a dry infiltration-type pond, and the high value corresponded to a typical wet pond with a mean 6-foot depth of water storage in the permanent pool. As part of the study, Schueler and Galli also tracked continuous temperature readings from the inflow and outflow of the wet pond from July 1 through July 3, 1999. The results show diurnal variations with the temperature readings, and both sets of readings tracked each other except that the inflow temperatures were approximately 10°F less than the outflow temperatures. This means that the water entering the pond during the period of observation was heated an average of an additional 10°F.

A warmed stream will eventually cool off to its previous temperature, as shown by longitudinal profiles of stream temperatures. In an urban stream, however, a parcel of water as it flows is typically subjected to more heat inputs from parking lots, streets, businesses, and industrial plants. Cooling is retarded in urban streams that have little riparian shading or cool groundwater inflows, and that is why studies have shown that the increase in stream temperature is directly related to the extent of impervious surfaces in a watershed. Stormwater ponds that discharge warm water to an already thermally stressed stream during a rain event can further aggravate the problem.

The impact of stream warming can be important for the cold-water streams in the Puget Sound region. Water temperature plays an important role in aquatic life productivity because it directly affects the rates of chemical and biological processes (May, 1996).

Stream temperature affects the rates of detrital processing, respiration, and bacterial growth, as well as the timing of reproduction and spawning (Schueler and Galli, 1995). For anadromous species of fish, the critical life stages affected by stream temperatures are the incubation and rearing stages. For trout, the entire life cycle is influenced by stream temperatures. Salmonids are especially sensitive because their optimal temperature range for growth is very narrow (approximately 54 to 57°F). An increase in temperature can reduce the dissolved oxygen levels in the water column and especially in the streambed where the salmonids are developing. Low dissolved oxygen concentrations can be lethal to aquatic life.

3 MITIGATION TECHNIQUES

To protect the aquatic environment from further harm due to thermal stresses, development practices and BMP designs need to be modified to preserve natural temperature regimes in rivers and streams. With regard to stormwater pond systems, several changes can be incorporated into the design to reduce the potential for discharges to impact the temperature of the receiving water bodies.

The negative impacts associated with elevated temperatures from stormwater ponds during the summertime can be reduced by varying the design of the pond systems and the outfall channels, as well as by generally protecting riparian vegetation within stream channels. The first step, however, is to reduce the amount of surface runoff from impervious surfaces by using low-impact development techniques and maximizing infiltration where possible. Infiltration of stormwater can help to recharge the near-surface groundwater systems, which can then return cooler temperature baseflows to the streams. Reduced runoff also minimizes the volume of potentially heated stormwater discharge. Reducing runoff volumes should be the primary focus of mitigating thermal pollution from stormwater systems.

Once stormwater runoff volumes have been reduced, other options are available to reduce the impact of stormwater ponds. Where possible, infiltration ponds are preferable as opposed to detention ponds. As an alternative, when the soil types preclude the use of infiltration basins, the physical design of the stormwater pond can be modified so that ponds are oriented in a north-south direction with a narrow water surface. Trees should be planted as close to the pond as pond stability constraints allow. These measures help to reduce the solar radiation input to the pond. The banks of the stormwater discharge channel should also be vegetated. Maximizing the shading of both the pond water surface and the discharge channel can be an effective way of reducing the heating effects of stormwater ponds.

Reducing the exposed surfaces of pond discharge channels and avoiding rock lining will help to avoid heating the stormwater discharge after release from a pond. Where shading of the pond discharge cannot be provided, consideration should be given to piping the discharge to the stream. If possible, a baseflow bypass channel or pipe past the stormwater pond should be constructed. The bypassed baseflow can be combined with the discharged stormwater to help mitigate the elevated temperatures of the stormwater pond discharges.

Flow from the dewatering systems for building foundations can be a source of cool water to combine with the pond discharge. This can help reduce the overall temperature increase due to discharges from a project site.

These are some of the techniques that are available to help reduce the impact from stormwater ponds. As Brightwater moves into the design phase, it is recommended that these techniques be closely reviewed for incorporation into the project's stormwater management treatment system.

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