Appendix C
Chitosan Construction Stormwater Treatment

APPENDIX C
CHITOSAN ENHANCED SAND FILTRATION SYSTEM FOR CONSTRUCTION STORMWATER TREATMENT

The Draft EIS described a Cat-Floc 2953 Polymer treatment system proposed for construction stormwater treatment. The analysis included monitoring and compliance measures anticipated necessary by an Individual NPDES permit for construction discharge for this chemical treatment system (see **Appendix C** to the Draft EIS, pages 3-6 through 3-14). The stormwater treatment objective of Cat-Floc 2953 polymer use is sediment removal to comply with state water quality standards and Individual NPDES permit requirements prior to discharge to the Green River.

Since preparation of the Draft EIS, a second option for stormwater treatment during construction has been added to the proposal that would be equally feasible and effective. Chitosan enhanced sand filtration (CESF) is a polymer treatment system followed by sand filtration. CESF is a method of continuously testing and adjusting inflow stormwater to neutral pH, treating with controlled dosages of a natural polymer (chitosan, derived from crab shells), and pressurized sand filtration to remove suspended sediments and lower turbidity to required discharge levels. Like Cat-Floc 2953, chitosan polymer is a coagulant that disrupts the negative electrical charge keeping fine sediments apart and in water suspension. That disruption allows fines to combine, or agglomerate, into flocculent particles that gain enough mass and density for removal by sand filtration. If the CESF method is selected for use instead of Cat-Floc Polymer 2953, or in addition with Cat-Floc 2953 for pretreatment, a CESF treatment plan for the Tukwila South Project would be included in the Stormwater Pollution Prevention Plan (SWPPP) required by the Individual NPDES permit for construction discharge.

The CESF process mainly differs from the Cat-Floc 2953 Polymer treatment system by being a flow through continuous process that could discharge directly rather than to surface ponds for testing and batch release control, although provision for water storage is required as a contingency when continuous test results or maintenance do not allow release. Unlike Cat-Floc 2953 treatment, CESF is a contained continuous process with no reliance on surface ponds for treatment. The CESF system for construction stormwater treatment, along with proposed monitoring and compliance measures anticipated necessary by an Individual NPDES permit for such use, are described in this appendix.

Regulatory Status

The role of Ecology in evaluating and classifying emerging stormwater treatment technologies is outlined in the 2005 Stormwater Management Manual for Western Washington (Volume V, Chapter 12). Ecology has three sequential categories of approval for construction runoff chemical treatment technologies. The first category is a Pilot Use Designation which allows limited treatment and restricts discharge, with the goal of producing data to evaluate field applications of new technology. The second category is a Conditional Use Designation (CUD), which generally allows broader use but has strict monitoring requirements to ensure safe discharge. The CUD designation is for treatment technologies considered equivalent to approved technologies and likely to attain the third-category, General Use Designation (GUD) status. Ecology has not assigned a Use Designation status to Cat-Floc 2953. GUD status has fewer monitoring requirements and is granted to technologies that have demonstrated they will achieve Ecology's performance goals without adverse environmental impacts.

Ecology granted a Conditional Use Designation (CUD) for continuous CESF treatment and a General Use Designation (GUD) for batch release CESF treatment on February 26, 2004

(revised August 18, 2004). The CUD for continuous CESF expires on December 31, 2005. At that time, based on data obtained by monitoring under the CUD, Ecology will determine whether to (a) prohibit further testing and use, (b) extend continuous CESF under CUD status to gather additional data, or (c) designate GUD status and monitoring requirements for continuous as well as batch release CESF. An engineering report will be submitted to Ecology in August or September 2005, prior to expiration of the CUD, by Natural Site Solutions, LLC, the owner of the proprietary CESF process. The engineering report will summarize CESF monitoring results since August 2004.

CESF treatment to remove suspended sediments from construction runoff was analyzed using data from five construction projects in Washington State between 2001 to 2003 (Natural Site Solutions, LLC, CUD Engineering Summary, August 18, 2004). The 2004 analysis included 235 inflow and outflow samples. The combined samples were representative of approximately 600,000 gallons of treated stormwater. Inflow turbidity averaged 198 nephelometric turbidity units (NTU) and outflow turbidity averaged 4 NTU, for an average treatment efficiency of 97 percent turbidity reduction. These trial studies did not have the chitosan dosage limitation of 1 mg/L or the pretreatment requirement when inflow turbidity exceeded 600 NTU that are required under the August 2004 revised CUD. Analysis of turbidity results under the current CUD specifications will be provided in the final Engineering Report on CESF scheduled for fall 2005 evaluation by Ecology. Background turbidity in the Green River ranges between 1.3 and 96 NTU, with an average of 9.2 NTU and a median of 2.9 NTU, so the discharge turbidity using CESF treatment at other sites is below the average background turbidity in the Green River, and well within the 5 NTU change over background allowed under the state water quality standards (WAC 173-201A).

A total of 30 acute whole effluent aquatic toxicity tests were performed on chitosan treated water samples from the same five test sites. The tests used Rainbow Trout, Fathead Minnow, and *Daphnia magna*. Ecology's Chemical Treatment Review Committee concluded that the chitosan polymer is non-toxic to humans and other mammals. However, chitosan acetate did exhibit toxicity to rainbow trout at higher doses, and was therefore restricted to a maximum dose rate of 1 mg/L as a conservative measure by Ecology to ensure there would be no toxicity in the discharge under the current CUD.

The Ecology-approved Quality Assurance Project Plan (QAPP) dated January 12, 2004 for the CESF system must be followed when CESF is proposed for use at a construction site (or the current approved version at the time of use). The QAPP includes a procedure for residual chitosan analysis, determining when bioassay testing is required, pretreatment for influent turbidity greater than 600 NTU, optimal pH range guidelines, optimal sand filter operation, and monitoring requirements for inflow and outflow turbidity, flow, pH, and residual chitosan. The QAPP requires temporary containment capability to accommodate equipment failure, which can include pre-approved discharge to sanitary sewer if available or contingency discharge to an infiltration area with suitable capacity. The Tukwila South Project would have containment capability in the south pond (as described in **Appendix C** to the Draft EIS).

CESF Operations

Under either the Cat-Floc 2953 or CESF treatment system, most of the coarse sediment would be removed by temporary construction traps. Although it is not anticipated to be necessary, Cat-Floc 2953 or chitosan could be included in the SWPPP for pretreatment of stormwater in the sediment traps. As described in **Appendix C** to the Draft EIS, water from these traps would be pumped to CESF treatment and release to the Green River after monitoring. General

system requirements anticipated necessary for CESF use are summarized in Table C-1. Treated runoff could be pumped into the south pond if additional treatment or treatment system maintenance, such as sand filter backflushing, is needed. The system would have a storage volume exceeding the 1.5 times the 10-year 24-hour runoff volume required by Ecology (BMP C250), as explained in Section 3.1 of **Appendix C** to the Draft EIS.

The conditions applicable to flow through CESF treatment under the current CUD include the following four primary conditions:

1. Implementation of the Approved Quality Assurance and Preparation Plan (QAPP)

The QAPP details monitoring and reporting requirements for CESF systems. The implementation, monitoring and reporting associated with the use of CESF on this project would be consistent with this and all Ecology conditions under the Individual NPDES permit for construction discharge that is obtained for the project.

2. Water quality influent and effluent monitoring

Each CESF treatment system must include continuous inflow and outflow monitoring of pH and turbidity. The CESF monitoring system is designed to automatically terminate discharge in the event that discharge water quality requirements are not met. Anticipated monitoring requirements for CESF are summarized in Table C-2.

The CUD requires dosing system calibration at the time of system startup and every four hours during operation to ensure that the dose rate is at or below 1.0 mg/L. Discharge from the sand filter must contain less than 0.1 mg/L residual chitosan acetate polymer, determined by at least two samples during each operating period. Results of each test would be documented in the treatment system daily log and kept onsite. The CUD requires that a residual chitosan contingency plan be developed to contain stormwater in the event that chitosan residual is detected above 0.1 mg/L, so that maintenance, repair and testing can proceed. The CUD requires that source control measures be implemented to control influent turbidities to less than 600 NTU. Implementation and maintenance of traditional BMPs would reasonably control inflow turbidity to less than 600 NTU. In the unlikely event that inflow turbidity exceeded 600 NTU, it would be managed by pretreatment using chitosan or Cat-Floc 2953 in the sediment traps or the south pond, and by BMPs described in Section 3.1 of **Appendix C** to the Draft EIS.

3. Inflow turbidity control

The 600 NTU maximum inflow turbidity limit is required because field experience shows slow degradation of system operating efficiency as inflow turbidity approached 1,000 NTU. Lower inflow turbidity increased CESF system efficiency and reduced the need to halt operations for sand filter backwashing maintenance.

4. Certified CESF system operators

Minimum operator qualifications include at least 40 hours of training and knowledge of stormwater testing, equipment operation and troubleshooting.

Construction stormwater pH must be in the range of 6.5 to 8.5 for chitosan to be effective, which is generally within the range that construction runoff would be expected to occur. Where construction involves concrete work affecting stormwater runoff, pH greater than 8.5 can occur. The preferred method for pH reduction in the CESF system is in-line treatment with carbon dioxide (CO_2) prior to chitosan addition and filtration. An inline monitoring feedback system sets

carbon dioxide dosage based on inflow pH. Construction activities do not cause reductions in pH and treatment to remove acidity by the CESF facility is not expected to be required.

Conclusions

Under Alternatives 1 and 2, use of either the Cat-Floc 2953 Polymer system or the Chitosan Enhanced Sand Filter System (CESF) would be equally effective in removing sediment from construction phase stormwater runoff before discharge to the Green River. The turbidity in discharge from either system would be within background in the Green River, and well within turbidity discharge limits defined by state water quality standards (WAC 173-201A). There is no toxicity risk from either chemical treatment system when used under the restrictions required by Ecology for issuance of the Individual NPDES permit for construction discharge. The CESF system would require less space for treatment than the Cat-Floc 2953 system, because it is a continuous flow contained treatment process rather than a pond-based treatment system. Both systems would have the same minimum stormwater storage requirement by Ecology, which is exceeded by the proposed Tukwila South system capacity under Alternatives 1 and 2.

If CESF is selected as the treatment option for construction stormwater, then mitigation to avoid construction impacts would be the same as described in the Draft EIS for the Cat-Floc 2953 polymer system, except that system and monitoring requirements for CESF would be substituted in the Individual NPDES permit for construction discharge.

Under the No Action Alternative, CESF would not be used for construction stormwater treatment. The conclusions in the Draft EIS for construction impacts on water quality are unchanged.

Table C-1
SUMMARY OF REQUIREMENTS FOR CONSTRUCTION RUNOFF TREATMENT
BY CHITOSAN ENHANCED SAND FILTRATION (CESF)

Requirement	Description	Comment
Notification	Included in (1) State Environmental Protection Act evaluation (EIS for Tukwila South Project), (2) Notice of Intent for Individual NPDES permit for construction discharge, and (2) in Stormwater Pollution Prevention Plan (SWPPP).	
Authorization	Ecology presumptively assumes the Permittee meets the conditions of the Individual NPDES permit for construction discharge if Best Management Practices for Chemical Treatment from its 2005 Manual[1] are followed. Formal authorization and effluent discharge limitations are included in the Individual NPDES permit.	The SWPPP must be submitted to and signed by Ecology to meet the written authorization requirement for chemical treatment. Local authority (City of Tukwila) must also grant written approval for chemical treatment.
Discharge Limits	Turbidity, chitosan dosing limits (and other parameters) are established by the Individual NPDES permit for construction discharge.	
Best Design	Utilize most efficient treatment process design to minimize chitosan dosing requirements.	Substantiate in the SWPPP
Operator Training	Contractor must be trained for at least 40 hours on treatment system by experienced personnel or have equivalent experience.	Training and experience requirements included in SWPPP.
Storage	Provide storage sufficient to hold 1.5 times the runoff volume from the 10-year 24-hour design storm.	The Tukwila South system storage would exceed the permit storage requirement of about 1.928 million CF (see Section 3.1 of **Appendix C** to the Draft EIS).
Monitoring	Treatment, compliance (established before discharge) and bioassay monitoring.	See Table C-2
Reporting	Daily log of field measurements, continuous influent and effluent pH and turbidity, and immediate notification if bioassays show toxicity. Otherwise, reporting per Individual NPDES requirements.	See Table C-2
Removed Sediment	Sediment removed by the system must be disposed once per season or as required.	Removed sediment management included in SWPPP.

[1] Stormwater Management Manual for Western Washington, February 2005.

Table C-2
CHITOSAN ENHANCED SAND FILTRATION (CESF)
CONDITIONAL USE DESIGNATION MONITORING REQUIREMENTS

Element	Monitoring Rate	Inflow	Treated Stream	Outflow
pH	Continuous	√		√
Turbidity	Continuous	√		√
Acute Bioassays (fathead minnow and *Daphnia magna*)	First 5 batches, periodic thereafter, as approved by Ecology; immediate notification required if toxicity discovered.			√
pH Adjustment (type and quantity of chemical used)	Daily if used		√	
Dosing with Chitosan	Continuous Record		√	
Residual Chitosan	Twice each Process Period			√
Stormwater Volume (Treated and Discharged)	Daily			√