Outfall Mixing Zone Study Plan

Cosmo Specialty Fibers

Cosmopolis Pulp Mill - Outfall 001

Cosmopolis, Washington

NPDES Permit No. WA 0000809

November 20, 2017

1. Introduction

This Study Plan presents the specific approach for conducting an Outfall Mixing Zone Study of the Cosmo Specialty Fibers - Cosmopolis Mill 001 in Grays Harbor (Figure 1-1). This Study Plan includes the project background information, a detailed study approach, methodology for field measurements and dilution modeling, quality assurance and quality control methods, and the plan for reporting.

Figure 1-1. Overview of Cosmo Specialty Fibers Outfall 001 Site in Grays Harbor

1.1 Project Basis

Cosmo Specialty Fibers (CSF) operates the Cosmopolis Pulp Mill under their National Pollutant Discharge Elimination System (NPDES) Permit No. WA0000809, issued by the Washington Department of Ecology (Ecology). The current NPDES Permit (issued December 1, 2015) includes requirements in Section S13 for developing and conducting this Outfall Mixing Zone Study.

The NPDES Permit has the following requirements in Section S13.A (Note: the complete permit language is provided in Appendix A to this Study Plan):

1) submit a Plan of Study to Ecology by November 30, 2017, for review and approval;

2) determine dilution factors under critical receiving water conditions – as defined in WAC 173-201A-020, Tables VI-3 and VII-1 and Appendix 6 Guidance for Conducting Mixing Zone Analyses in Ecology's Permit Writer's Manual;

3) measure dilution factors in the field applying approved protocols (defined in S13.C or other approved methods) or by modeling if Ecology agrees that sufficient ambient field data are available (under critical conditions) and the outfall diffuser condition is documented by inspection;

4) apply dilution models consistent with the Guidance for Conducting Mixing Zone Analyses in Ecology's Permit Writer's Manual; and use models if critical condition scenarios to be examined are quite different from the conditions during a field tracer study;

5) conduct validation and calibration of models using field tracer study (if needed, consistent with Section 1.6.2 in the Guidance for Conducting Mixing Zone Analyses in Ecology's Permit Writer's Manual); and

6) apply dilutions at the acute and chronic mixing zone boundaries in accordance with Ecology's Permit Writer's Manual.

The CSF NPDES Permit also defines the reporting requirements in Section S13.B, as follows:

1) Outfall (or Effluent) Mixing Study Report must be submitted to Ecology within 12 months of Ecology's notification to CSF of the approval of the final Study Plan; and submit a hard copy and electronic pdf file of the report;

2) CSF needs to submit available background receiving water chemistry data as an attachment to the report; and

3) CSF needs to include the latitude and longitude of the outfall diffuser and the mixing zone boundary corners.

Section 13.C of the CSF NPDES Permit lists references for tracer study protocols and modeling guidance manuals to be used in the performance of this study. This Outfall Mixing Zone Study Plan for CSF Outfall 001 has been prepared and submitted to Ecology in accordance with the requirements of Section S13 of the CSF NPDES permit. Following review and final approval of this Study Plan by Ecology, CSF and their consultants will proceed with preparations to conduct the field tracer study under seasonal critical conditions, perform the field study measurements, complete data analyses and dilution modeling, and to prepare a study report for submittal to Ecology by the deadline. The study report deadline to submit to Ecology will be within 12 months of Ecology's notification to CSF of the approval of the final Study Plan.

1.2 Background on Discharge Characteristics and Mixing Zones

Outfall Characteristics

Cosmo Specialty Fibers (CSF) operates the Cosmopolis Pulp Mill, located in Cosmopolis, Washington (refer to Figure 1-1). The CSF facility is a sulfite pulp mill that produces dissolving pulp of acetate, viscose, and ether grades for commercial sale. The CSF mill provides primary and secondary treatment, as well as multiple-staged disinfection, to an average dry weather flow of approximately 19 million gallons per day (mgd), and a maximum flow of approximately 24 mgd. Treated and disinfected wastewaters are conveyed to the aeration stabilization basins (referred to as the Westport Ponds) for aeration and flow equalization prior to discharge via Outfall 001. These four ponds are designated A, B, C, and D. Discharges from Pond D to Outfall 001 are controlled by inflows to the ponds and discharge pH restrictions.

Outfall 001 is a buried pipeline that extends approximately 1,200 feet from Pond D to the north into the South Channel of Grays Harbor. This 6-foot diameter wood stave outfall pipe ends with a 200-foot-long diffuser section located in the deepest portion of the South Channel, and the south and north ends of the diffuser are marked by dolphin piles in the channel (Refer to Figure 1-2). The diffuser section is buried below the pipe crown and consists of 21, 12-inch ID risers with 90-degree elbows and 12-inch diffuser ports that discharge alternating east and west of the diffuser pipe. The water depths over the Outfall 001 diffuser ports ranges from approximately 7 feet at Mean Lower Low Water (MLLW) to 12.4 feet at Mean Tide Level (MTL) to 17 feet at Mean High High Water (MHHW). The most recent 2017 dive inspection identified damaged diffuser risers and some pipe banding that requires repair, and CSF has applied to the US Army Corps of Engineers to perform maintenance on the outfall pipe and diffuser under the Nationwide #3 permit. As-built drawings of the CSF Outfall 001 outfall and diffuser are included in Appendix B.

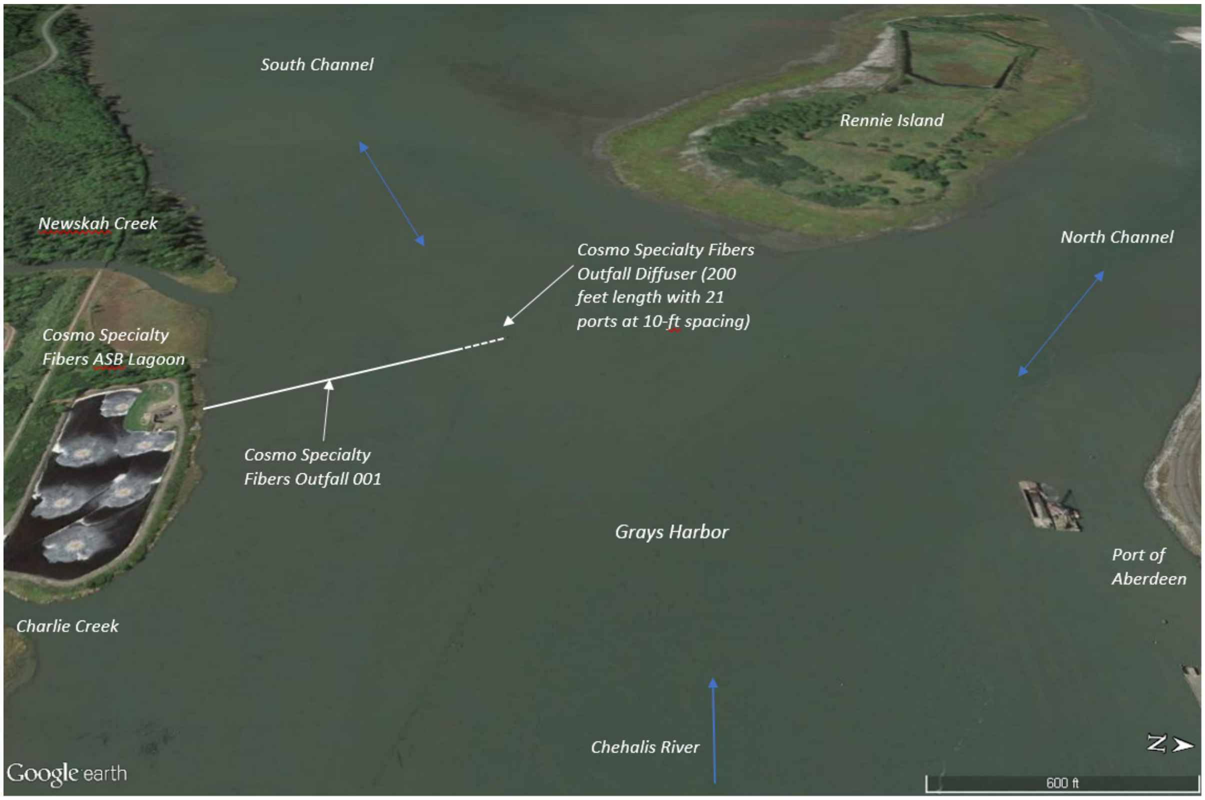

Figure 1-2. Location of Cosmo Specialty Fibers Outfall 001 and Diffuser in the South Channel of Grays Harbor

Mixing Zones and Dilution Factors

Section S1.B of the CSF NPDES Permit defines the Outfall 001 mixing zone authorizations, and these include an acute mixing zone, a chronic mixing zone, and a fecal coliform extended mixing zone. The fecal coliform extended mixing zone was developed by Ecology in accordance with the rules of WAC 173-201A-400(12) to balance the mill's use of sodium hypochlorite for disinfection with available ambient mixing characteristics. The former mill owner (Weyerhaeuser) demonstrated through extensive microbiological testing that bacteria present in the mill effluent are bacteria associated with wood fibers (*Klebsiella*) not human fecal coliform, but the bacteria test procedures required by the Clean Water Act cannot distinguish human fecal coliform bacteria from *Klebsiella* bacteria. The CSF mill discharge is administratively treated in the NPDES Permit as if the bacteria discharge were fecal coliform.

The acute and chronic mixing zone boundaries for Outfall 001 are depicted in Figure 1-3, and the fecal coliform extended mixing zone boundaries are depicted in Figure 1-4. The NPDES Permit defines the acute and chronic mixing zones for Outfall 001 in Section S1.B, as follows:

"S1.B. Outfall 001 Mixing Zone Authorization

The following paragraphs define the maximum boundaries of the mixing zones:

Outfall 001 Chronic Mixing Zone
The mixing zone is a circle with radius of 207 feet (63 meters) measured from the center of each discharge port. The mixing zone extends from the discharge ports to the top of the water surface. The concentration of pollutants at the edge of the chronic zone must meet chronic aquatic life criteria and human health criteria.

Outfall 001 Acute Mixing Zone
The acute mixing zone is a circle with radius of 20.7 feet (6.3 meters) measured from the center of each discharge port. The mixing zone extends from the discharge ports to the top of the water surface. The concentration of pollutants at the edge of the acute zone must meet acute aquatic life criteria.

Outfall 001 Fecal Coliform Extended Mixing Zone
The extended mixing zone is 4,300 feet (1300 meters) upstream and downstream of the diffuser with a width of 400 feet (123 meters) at the farthest downstream point of the extended mixing zone."

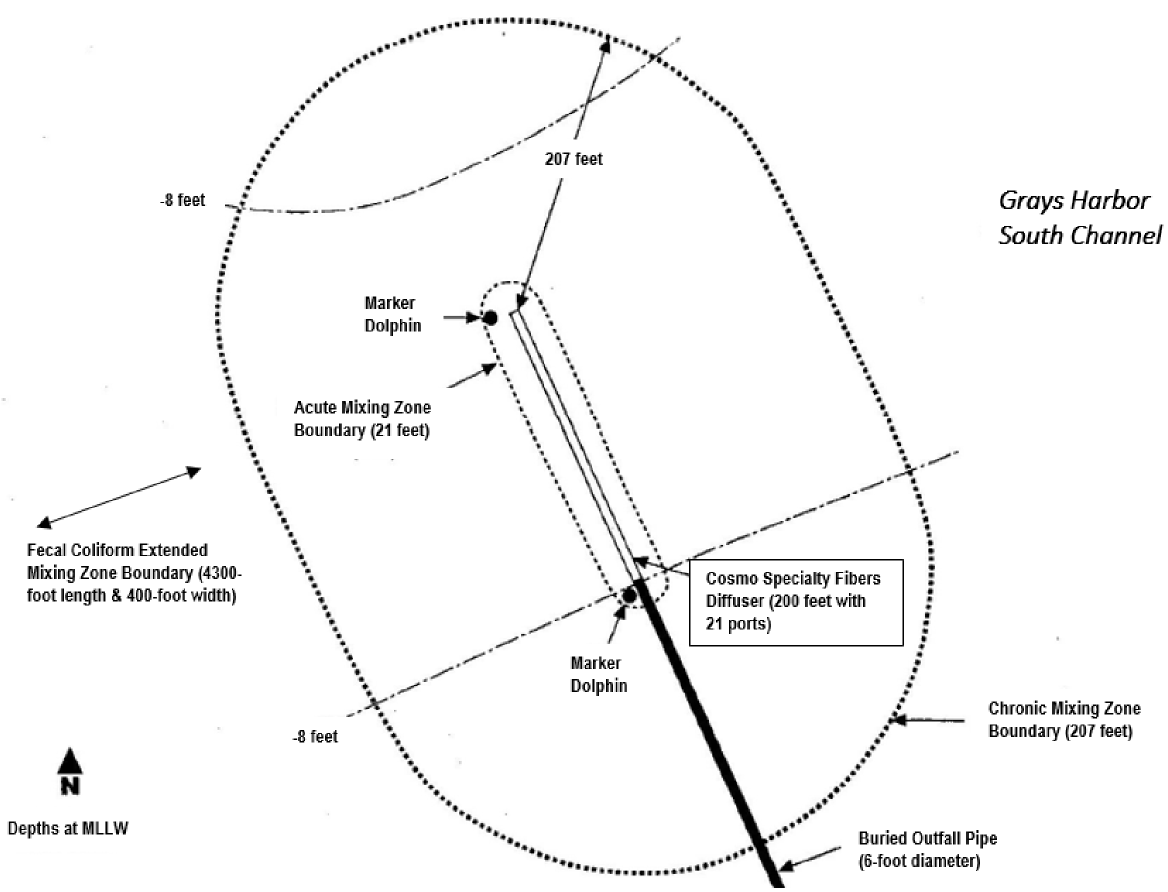

Figure 1-3. Schematic Diagram of Cosmo Specialty Fibers Outfall 001 Diffuser in the South Channel of Grays Harbor and Acute and Chronic Mixing Zone Boundaries

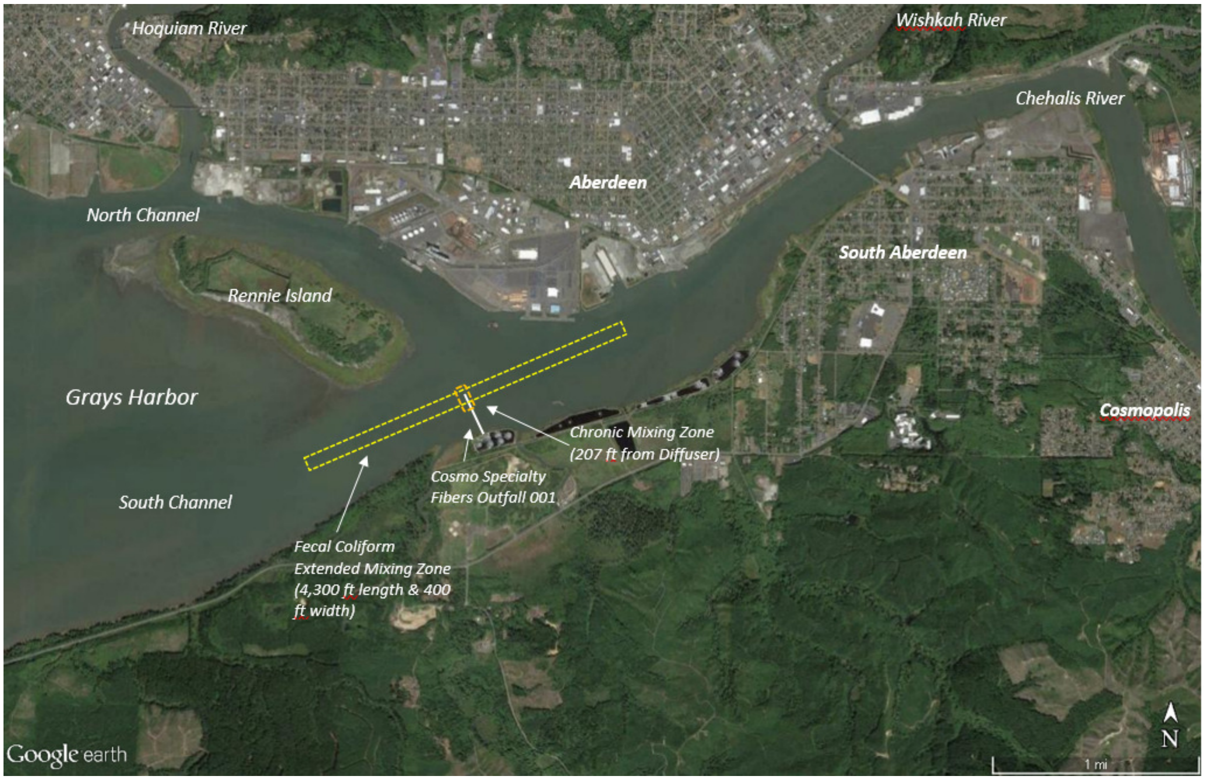

Figure 1-4. Location of Cosmo Specialty Fibers Outfall 001 in the South Channel of Grays Harbor and Chronic and Extended Mixing Zone Boundaries

The NPDES Permit includes the dilution factors at the acute, chronic, and extended mixing zone boundaries that were applied in the NPDES Permit development, and these dilution factors (DF) are as follows:

Acute Aquatic Life Criteria - Acute DF = 9
Chronic Aquatic Life Criteria - Chronic DF = 74
Human Health Criteria – Carcinogen DF = 74
Human Health Criteria - Non-carcinogen DF = 9
Fecal coliform, Shellfish Harvest DF = 250

The acute, chronic, and human health dilution factors were develop using the model UDKHDEN (now DKHW in Visual Plumes) and the farfield model RDIFF in the *Outfall Dilution Study for Weyerhaeuser Cosmopolis Mill Outfall* (CH2M HILL and Weyerhaeuser Environmental Sciences & Technology, 1993) and the *Addendum to Outfall Dilution Study Report* (CH2M HILL and Weyerhaeuser Environmental Sciences & Technology, 1994). The fecal coliform extended mixing zone dimensions and dilution factors were developed by Ecology using the model DKHW in Visual Plumes. Ambient currents and density stratification inputs for modeling were based on field measurements collected at the outfall site in 1993. Additional field measurements were collected in 2003 by CH2M HILL and in 2016 by Washington Department of Health, and these are reviewed in the following section.

Discharge Site Characteristics and Studies

The CSF Outfall 001 is located at the eastern end of the Grays Harbor estuary where the estuary splits into north and south channels (refer to Figures 1-1 and 1-2).

Grays Harbor is a complex estuarine system with extensive mudflats and substantial seasonal freshwater inflows. The estuary receives direct inflow from the Chehalis, Elk, Hoquiam, Humptulips, Johns, and Wishkah Rivers, as well as many creeks. The circulation patterns in Grays Harbor are complex flows driven by freshwater inflows, tides and marine water inflows, meteorological influences, and local bathymetry. The average tidal range at the entrance to Grays Harbor is approximately 10 feet, and this range increases slightly at Aberdeen on the north channel, and then decreases up the Chehalis River to Montesano, where the tidal influence ends. The local bathymetry is complex and involves large areas of tidal mudflats that are submerged and exposed over each tidal cycle. Freshwater inflows vary seasonally and are highest in the winter months and lowest in July and August. During periods of high river flows the average residence time in Grays Harbor is reduced, and as freshwater inflows decrease during dry season the residence time in the harbor increases. The ambient currents and water column density stratification at the CSF outfall site in the South Channel of Grays Harbor are determined by ebb and flood tidal currents, freshwater discharges into Grays Harbor (primarily from the Chehalis, Hoquiam, and Wishkah Rivers), and surface wind influences. (CH2M HILL, 2002).

Historical oceanographic studies of Grays Harbor were performed by Beverage and Swecker (1969), and by Loehr and Collias (1981) to document currents and water quality conditions. In the 1970's, a water quality model was developed for Grays Harbor under a U.S. Environmental Protection Agency contract (Battelle, 1974). The Washington Department of Ecology (Ecology) Environmental Assessment Program, Long-term Marine Water Quality Monitoring has performed routine water quality monitoring at stations in Grays Harbor since 1975, and one routine station (GYS008) is in the South Channel approximately 1.8 miles west of Outfall 001 and another station (GYS004) is in the Chehalis River approximately 1.9 miles east. The nearly monthly water quality profiles at Station GYS008 provide measurements of temperature, salinity, density, dissolved oxygen, pH, and light transmission. These seasonal water column profiles have been reviewed to provide input to selecting the critical water column density stratification seasonal period for the field tracer study of the CSF Outfall 001.

Significant additional field data collections and modeling efforts have been conducted to evaluate Grays Harbor and specifically the CSF Outfall 001 discharge. In response to Ecology requirements for NPDES permit development, extensive field measurements (including a two-day tracer study) and dilution modeling under critical discharge conditions were developed for Outfall 001. These studies are documented in the *Outfall Dilution Study for Weyerhaeuser Cosmopolis Mill Outfall* (CH2M HILL and Weyerhaeuser Environmental Sciences & Technology, 1993) and the *Addendum to Outfall Dilution Study Report* (CH2M HILL and Weyerhaeuser Environmental Sciences & Technology, 1994).

In 2000, Ecology published the *Grays Harbor Fecal Coliform Total Maximum Daily Load Study* (Ecology, 2000), which include fecal coliform source sampling around Grays Harbor and water quality modeling. A series of subsequent studies were developed by CH2M HILL working with Weyerhaeuser Company, including the *Grays Harbor TMDL Modeling Review TM* (CH2M HILL, 2001), the *Grays Harbor Hydrodynamic and Water Quality Modeling Report* (CH2M HILL, 2002), and the *Farfield Tracer Study of Cosmopolis Mill Outfall 001* (CH2M HILL, 2003). In 2013, CH2M HILL working for CSF developed an updated version of the hydrodynamic model and performed modeling to assess plume transport from Outfall 001 to the Department of Health Sanitary Line (west end of

South Channel) under the influence of large ebb tides and high river flows. These modeling results are documented in the *Grays Harbor Hydrodynamic and Water Quality Modeling Report: Investigations of Bacteria Transport Under Low Frequency Events* (CH2M HILL, 2013).

The 2003 *Farfield Tracer Study* provides significant field measurements that are useful to this Outfall 001 Mixing Zone Study. The 2003 *Farfield Tracer Study* was performed to measure and document current speeds, wastewater plume transport distance and travel time under peak ebb tide and high Chehalis River flow conditions in the wet season. Current meters were used to record continuous current speed and directions as well as water temperature, salinity, and depths at the CSF Outfall 001, western mid-point of the South Channel, and at the western end of the South Channel. These extensive current measurements and water column profiles recorded during the 2003 *Farfield Tracer Study* provides data for the wet season water column stratification for modeling Outfall 001.

In April 2016, the Washington Department of Health (DOH) conducted a farfield dye tracer study of the CSF Outfall 1 that was similar to the 2003 Farfield Tracer Study. The purpose of the 2016 study was to gather measurements to determine if the CSF discharge plume reached the DOH's commercial shellfish harvesting Sanitary Line in the western end of the South Channel in one major ebb tide, determine effluent minimum dilutions at the Sanitary Line and shellfish growing areas, and to document if a measurable plume enters the North Channel of Grays Harbor. This 2016 DOH study measured the same travel time and effluent minimum dilutions at the Sanitary Line as were measured in the 2003 study. The DOH study had some unexplained results that may be due to turbidity interferences with their instruments at low measurement values. The DOH study did not report water column stratification profile data.

Critical Seasonal Discharge Conditions

Appendix C - Guidance for Conducting Mixing Zone Analyses in Ecology's *Water Quality Program Permit Writer's Manual* (Ecology, 2015) states that discharges to tidally-influenced rivers where a saltwater wedge is present warrant consideration of critical conditions which are known to occur simultaneously (e.g. saltwater intrusion at depth, freshwater inflow on the surface, and tidal induced vertical mixing). Critical discharge conditions are those conditions that result in reduced dilution, and the factors affecting dilution include the depth of water, the density stratification in the water column, tidal and river currents, and the wastewater discharge rate. Density stratification is determined by the salinity and temperatures in the receiving water column, and the magnitude of stratified conditions in the water column change with ebb and flood tides. Density stratification affects how much the discharge plume may rise in the water column before reaching the surface, reaching neutral buoyancy, or trapping beneath a density stratification layer.

Based on reviews of these numerous past studies of Outfall 001 and the South Channel of Grays Harbor, and data collected by Ecology's Environmental Assessment Program - Long-term Marine Water Quality Monitoring, there are three seasonal periods with the greatest observed water column density stratification. These seasonal periods with the greatest water column density stratification are described as:

- Spring stratification due low salinity and temperature of freshwater runoff (April-May)
- Fall stratification due to surface water temperatures and freshwater runoff (October)
- Winter stratification due to low salinity and temperatures of freshwater runoff (January)

All three stratification periods will be evaluated in the development of the dilution modeling scenarios and the period selected for the field tracer study may be either Spring (April-May) or Fall

(October). The field tracer study will need to be performed during a neap tide week to represent lower tidal current exchange velocities and depth changes. The timing of the field tracer study will need to occur following the completion of the outfall diffuser repairs, which are dependent on the U.S. Army Corps permit approval and the Washington Department of Fish and Wildlife in-water construction work window in Grays Harbor (July 15 to February 14). The projected timing of the field tracer study is either April-May 2018 or October 2018, depending on the permit approvals and completion of outfall and diffuser repairs.

The methodology for field measurements at the Outfall 001 diffuser are presented in Section 2 of this Study Plan.

1.3 Project Objectives

The project objectives of the Outfall Mixing Zone Study of the CSF Outfall 001 diffuser are to address the requirements in Section S13.A of the CSF NPDES Permit, which require:

1) determining dilution factors under critical receiving water conditions – as defined in WAC 173-201A-020, Tables VI-3 and VII-1 and Appendix 6 Guidance for Conducting Mixing Zone Analyses in Ecology's Permit Writer's Manual;

2) measurements of dilution factors in the field applying approved protocols (defined in S13.C or other approved methods) or by modeling if Ecology agrees that sufficient ambient field data are available (for critical conditions) and the outfall diffuser condition is documented by inspection;

3) dilution modeling consistent with the Guidance for Conducting Mixing Zone Analyses in Ecology's Permit Writer's Manual;

4) validate and calibrate selected model using field tracer study (consistent with Section 1.6.2 in the Guidance for Conducting Mixing Zone Analyses in Ecology's Permit Writer's Manual); and

5) applying dilutions at the acute and chronic mixing zone boundaries in accordance with Ecology's Permit Writer's Manual.

This study has been designed to provide: 1) site-specific field measurements of the dilution performance of the CSF Outfall 001 during seasonal stratified conditions in Grays Harbor, 2) accurate field measurements of receiving water characteristics and dilutions to use to select and calibrate the dilution models, 3) direct measurements of the plume mixing and location in the defined CSF mixing zones, 4) dilution modeling results for CSF effluent discharges under seasonal stratification and tidal-current conditions, 5) an assessment of discharge compliance with water quality temperature standards and water quality chemical criteria, and 6) a technical study report that summarizes field and modeling results for CSF Outfall 001.

This study will be conducted using well planned, designed, implemented, and documented procedures to produce a technically-defensible study that:

- documents the dilution performance of the CSF Outfall 001,
- meets the requirements of Ecology's Guidance for Conducting Mixing Zone Analyses and the specific requirements in Section S13.A and S13.B of the CSF NPDES Permit, and
- achieves the objectives and activities defined in this Outfall Mixing Zone Study Plan (as approved by Ecology).

To meet these project objectives, this project will be implemented by experienced personnel; 1) to develop accurate and defensible field measurements of the outfall diffuser performance, mixing zone region, and oceanographic conditions for dilution modeling, and 2) to document the selection and application of an appropriate dilution model to represent the outfall diffuser. This Study Plan has been developed specifically to define the field measurements that are necessary for accurate dilution modeling and to provide the study results defined in the CSF NPDES Permit, as well as align with Ecology's Guidance for Conducting Mixing Zone Analyses.

1.4 Study Approach

The study approach for this Outfall Mixing Zone Study involves collecting site-specific oceanographic measurements of currents and water column stratification as well as simultaneous measurements of diffuser dilutions using a dye tracer study – during ebb and flood tidal conditions corresponding with a neap tidal period (lowest tidal elevation exchanges). These field-measured dilutions and physical oceanographic data will be used to develop accurate model predictions of discharge dilutions for the field-measured conditions and other critical seasonal conditions and effluent flows. The field-measured dilutions will also be used to compare and select the correct dilution model (Visual Plumes or CORMIX2) for application over the range of discharge conditions. Field-measured and model-predicted dilutions will be compared during the model selection process.

This study plan has been prepared and submitted for review and approval by Ecology. Following approval of the study plan by Ecology, CH2M and CSF will complete preparations for the field study. The field tracer study is planned to be performed in either April-May 2018 or October 2018 to meet the NPDES permit requirements. The field study will occur during 5-day period that is scheduled to correspond with a neap tidal period in either April-May 2018 or October 2018. The field study timing is dependent on receiving the Army Corps Nationwide #3 permit to allow outfall and diffuser repairs during the Washington Department of Fish and Wildlife in-water construction work window (July 15 to February 14). If the permit approval does not allow repair work completion before February 14, 2018, then the outfall repair work will need to take place after July 15, 2018 and the field study will need to occur in October 2018.

Prior to the field study, outfall diffuser repairs and an external inspection of the Outfall 001 diffuser will be completed to document the diffuser functional status. The field study will include simultaneous measurements of ambient current speed and direction, water depth, conductivity, and temperature using two current meters deployed on two separate anchored cable arrays deployed approximately 100 feet east and west of the diffuser mid-point. The field tracer study will consist of repeated water column vertical profile measurements of the tracer dye injected into the effluent, as well as simultaneous measurements of temperature, salinity, density, and turbidity in the water column. The tracer dye will be injected into the effluent and measured in the CSF Outfall 001 mixing zones during a 12-hour period that corresponds with ebb and flood tide conditions at the diffuser site. Initial dye tracer measurements will also be collected downstream of the dye injection point to record the dye concentration in the outfall prior to effluent reaching the receiving water.

Following the field studies, the dye tracer study data will be summarized and analyzed. Dilution modeling will be conducted using the collected receiving water data and effluent data. Dilution modeling analyses will first focus on the field tracer study conditions. The field-measured dilutions will be used to compare and select the correct dilution model (Visual Plumes or CORMIX2) for application. Dilution modeling will be completed for the effluent and receiving water conditions specified in Ecology's Permit Writer's Manual and according to the Guidance for Conducting Mixing Zone Analyses. Water quality standards compliance for temperature and thermal plumes, as well as water quality chemical criteria will be assessed. A report will be prepared summarizing the outfall mixing zone study, including the field and modeling work, and supporting documentation, and the report will be submitted to Ecology.

2. Field Study Methods

The field dilution (mixing) study of the CSF Outfall 001 diffuser will include site-specific receiving water measurements, a dye tracer study, and field measurements documentation. The field study is planned to be performed during a five-day period in October 2018 that corresponds with neap tidal elevation exchanges.

2.1 Field Study Methodology

These field data collections will include recording measurements of ambient current velocities, temperatures, conductivity, and depths at two sites immediately east and west of the outfall diffuser mid-point (current meter arrays), water column measurements of dye tracer concentrations, temperature, salinity, density, depths, and turbidity over a range of depths and locations along the Acute Mixing Zone Boundaries (AZB) and the Chronic Mixing Zone Boundaries (MZB), and at the Extended Mixing Zone Boundaries (EMZB) (refer to Figure 1-5 for these boundaries and the current meter locations).

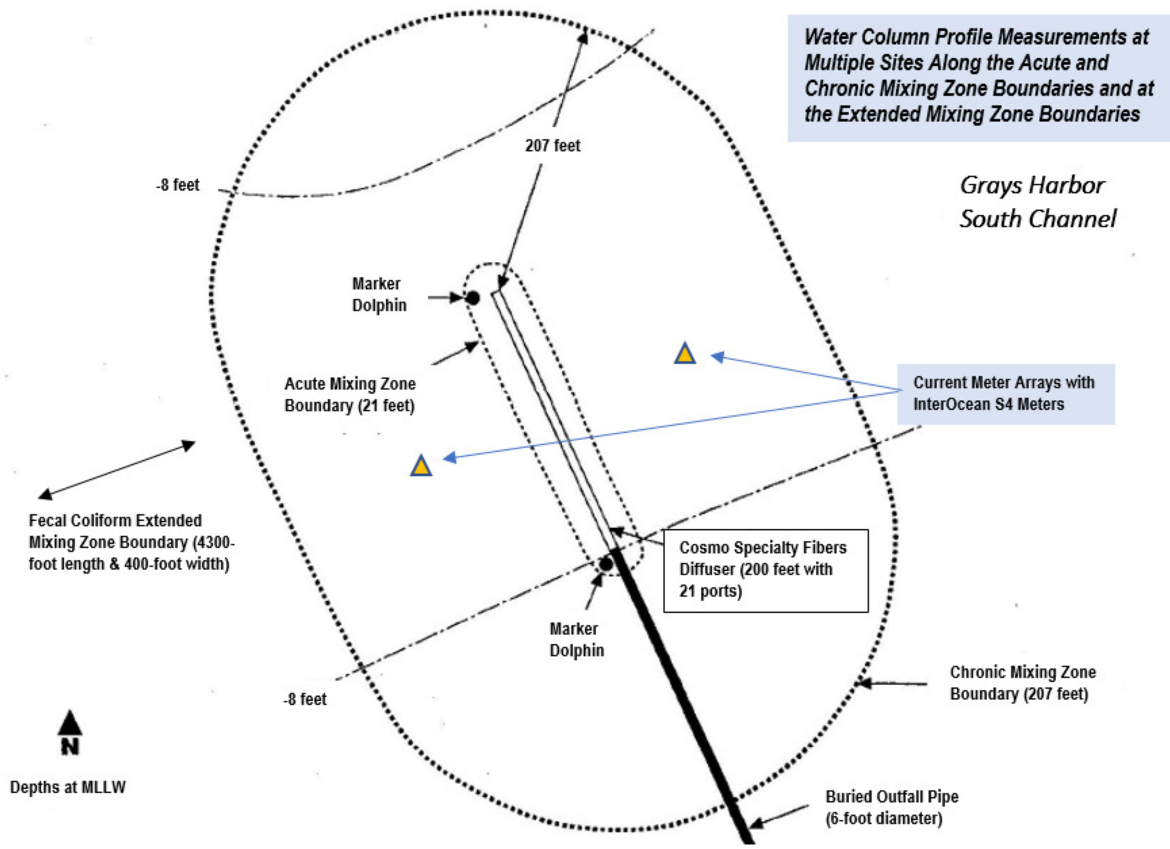

Figure 1-5. Diagram of Cosmo Specialty Fibers Outfall 001 Diffuser in the South Channel of Grays Harbor and Acute and Chronic Mixing Zone Boundaries, and Locations of Current Meter Arrays and Sampling Regions

The dye will be injected into discharge from Pond D to the Outfall Wet Well and the effluent flow drops as it enters the outfall structure. The dye injection rate will be monitored and adjusted to keep the initial concentrations as constant as possible matching the effluent flow. Since effluent flows are only recorded where mill effluent exits Pond A, then Ponds B and C will need to be valved closed so that effluent is directed from Pond outlet directly to the Pond D discharge gate. This method was employed during the 2016 DOH dye study (DOH, July 2016). Initial dye measurements will be recorded using a SCUFA instrument either by pumping effluent from a hose deployed into the outfall or by deploying a SCUFA inside a housing approximately 75 feet downstream from the injection site, to allow for complete mixing in the pipeline.

Dye standards will be prepared with the dye used in the study, CSF effluent, and background Grays Harbor water. Water will be collected from the study site prior to the dye study, and fluorometers will be calibrated before going into the field. Immediately following the dye study, a second set of fluorometer calibration measurements will be recorded using effluent, dye, and background water.

A fluorescent, water soluble, biodegradable dye (Rhodamine WT), will be used as the wastewater surrogate tracer since it can be accurately measured to 0.5 to 1.0 parts per billion. Based on the plant discharge flow, we will inject Rhodamine WT at a rate sufficient to produce a target discharge concentration of approximately 1,250 to 1500 parts per billion (ppb). Assuming a practical dye detection limit of 1.0 to 2.0 ppb above background, the field team will be able to accurately measure the range of dilutions at the acute and chronic mixing zone boundaries.

Specific details of these field activities and measurements are as follows:

- Measurements of conductivity, temperature, depth, and current speed and direction will be recorded in the South Channel approximately 100 feet east and west of the outfall diffuser mid-point throughout the field tracer study (refer to Figure 1-5); and measurements will be recorded every 10 minutes for the period of deployment (minimum of 48-hours), using two InterOcean S4 current meters on two separate anchored cable arrays.
- Initial dye concentrations (prior to discharge) will be monitored in the effluent with a Turner Designs Self-Contained Underwater Fluorescence Apparatus (SCUFA) in a flow-through housing.
- Receiving water dye measurements will be monitored using a Turner Designs SCUFA mounted onto a Seabird SBE-19+ or equivalent; or using Model 10-AU Field Fluorometer (pump through mode) with associated CTD instrument.
- Field tracer measurements will be performed from a 24-foot work vessel, and field sampling site locations will be recorded using a Differential Global Positioning System, and water depths will be recorded using a fathometer.

The dye measurement period will be approximately 10 to 12 hours to capture ebb and flood tidal conditions, and the duration will be limited to daylight hours for safety reasons.

The dye tracer study will include the following elements:

- Vertical profile measurements of dye concentration with depth at pre-selected distances from the outfall (acute and chronic mixing zone boundaries) in the path of the discharge plume;
- Measurements of conductivity, temperature, and turbidity at the same locations as dye measurements, as well as background (up-current) measurements;
- Sampling position coordinates determined using DGPS logging;
- Plume travel measurements using cruciform drogue releases near the outfall (as needed) to assess the plume location and rate of travel downstream from the outfall location; and

- Calibration of equipment before and, in the case of fluorometers, after field data collections.

The field work will require a five-day period for instrument preparations and calibrations, field installation of instruments, the dye tracer study, and post-study calibration and downloading data.

2.2 Instrumentation

Field instruments for the dilution study, including backup units, are listed in Table 1.

Table 1
Field Equipment for Outfall Mixing Zone Study

Equipment Item	Purpose	No. of Units	Accuracy Standard
Turner Model 10-AU Fluorometer	Fluorescent dye measurement	1	Detection to 0.5 ppb
Turner SCUFA Fluorometer	Fluorescent dye and turbidity measurements	4	Detection to 0.5 ppb and 0.5 NTU
Seabird SBE 19 CTD	Measure conductivity, tem-perature, and depth	2	Conductivity ±0.001 S/m Temperature ±0.001 °C Depth = 0.5% of full scale
Laptop Computer	Record Seabird CTD data	2	N/A
Garmin or Trimble DGPS	Survey positioning measurements	2	± 3 meters
MasterFlex Peristaltic Pump	Used for dye injection into effluent at constant rate	2	0.2 ml/min
Positive Displacement or Peristaltic Pump	Pump receiving water thru fluorometer (if needed)	2	1 ml/min; minimum delivery rate of 3 Liters/min
InterOcean S4 Current Meter	Measures in-situ current speed, temperature, conductivity & water depth	3	Speed = ±0.2 cm/sec Conductivity ±0.001 S/m Temperature ±0.001 °C Depth = ±0.2 cm

2.3 Quality Assurance/Quality Control

The QA/QC objective for the field study is to collect measurements of wastewater dilution and receiving water conditions that are of known and acceptable quality. The following requirements will be followed to achieve the objectives:

- Provide verifiable dye injection rates and initial dye concentrations
- Provide verifiable equipment calibration with pre- and post-study calibrations of the fluorometer instruments
- Provide verifiable laboratory quality control and quality assurance documentation
- Maintain accurate positioning for measurements
- Provide equipment redundancy (backup equipment)
- Examine dye injection site and downstream sample collection site to verify proper mixing before initial dilution samples are taken

This study plan has been developed as the basic element of quality assurance and control activities for the field study. A field operations memorandum will also be developed and discussed with CSF prior to the field study to define the detailed study schedule, communications, personnel assignments, and field safety procedures. Project specific field safety instructions will be prepared by CH2M and reviewed by CSF personnel.

Equipment Calibration

All equipment will be obtained prior to the beginning of the dye study. Each instrument will be checked and calibrated upon its arrival to confirm that it is in working condition. Each instrument will also be calibrated immediately prior to the beginning of the dye study and, when appropriate, following the study. Calibration methods for each instrument are described below.

Dye Pumps -- The dye pumps will be calibrated at the location where it will be used during the dye study. The pumps will be equipped with a micrometer control to accurately determine pumping rate. The flow rate scale will be calibrated with the dye at ambient temperature by repeatedly discharging dye into a graduated cylinder for a fixed period of time at various flow rate scale settings. According to the manufacturer, reproducible metering accuracy of greater than 1 percent can be expected when handling medium-viscosity fluids if fluid differential pressure, fluid viscosity, and electric line voltage remain constant. To verify that none of these factors is affecting expected dye flow rates during dye injection, dye flow rates will be verified and logged prior to the start of dye injection and at 1-hour intervals during injection.

Fluorometers – Fluorometers (Turner Design SCUFA and 10-AU fluorometers) will be calibrated according to the manufacturer's specifications such that they measure total dye concentration in the appropriate range for their use (measurements in the receiving water will have a range of 1 to 100.0 ppb; and effluent initial dye measurements will have a range of 1000 to 2000 ppb). Standards will be prepared with the dye used in the study, effluent from the plant, and background river water. Water will be collected from the study site prior to the dye study, and fluorometers will be calibrated before going into the field. Immediately following the dye study, a second set of fluorometer calibration measurements will be recorded using effluent, dye, and background water. This second set of calibration measurements will be compared to the pre-study calibration data, after correction for temperature. Both calibration curves will be used to correct or adjust the observed dye concentration and dilution.

CTD Units -- CTD units will be calibrated to the manufacturer's specifications before conducting the dye study. Calibration results will be used during data reduction and calculation of the water column density structure. Calibration history will be incorporated for the unit that will be used.

Current Meters – These instruments are calibrated by InterOcean at their facility in San Diego according to their specifications. Calibration results will be used during data reduction and the calibration history will be incorporated for the units used.

2.4 Organization and Schedule

Primary responsibility for the mixing zone study and field data collections will rest with CH2M's project manager (PM) and the technical team leader – David Wilson. The PM is responsible for accomplishing the scope of work, assigning resources, communications, schedules, and reviewing deliverable. All work will be performed by experienced CH2M and Solmar Hydro personnel. Table 2 lists the key personnel that will be involved in the project.

Table 2
Key Personnel for Outfall Mixing Zone Study

Personnel	Responsibility	Address
David Wilson	Project Manager & Technical Leader	CH2M/Bellevue
Paula Stoppler and Craig McKinney	Project Management	Cosmo Specialty Fibers
Brad Paulson	Modeler & Scientist	CH2M/Bellevue
Mike Stanaway and Erin Thatcher	Field Scientists	CH2M/Bellevue
Mike Stecher	Hydrographer & Vessel Operator	Solmar Hydro/Portland

When QA problems or deficiencies requiring special action arise in the field, the Technical and Senior Field Leaders will identify the appropriate corrective action to be initiated and implemented. Problems are documented in writing, along with the corrective action taken.

Table 3 provides the schedule for the field data collections for this Outfall Mixing Zone Study for the CSF Outfall 001. The field tracer study will occur during 5-day period that is scheduled to correspond with a neap tidal period in either April-May 2018 or October 2018. The field study timing is dependent on receiving the Army Corps Nationwide #3 permit to allow outfall and diffuser repairs during the Washington Department of Fish and Wildlife in-water construction work window (July 15 to February 14). If the permit approval does not allow repair work completion before February 14, 2018, then the outfall repair work will need to take place after July 15, 2018 and the field study will need to occur in October 2018.

Table 3
Schedule for Field Data Collections & Mixing Zone Study

Date	Task
November 30, 2017	Submit Study Plan to Ecology
February 2018	Receive Comments & Approval from Ecology
April-May or October 2018	Conduct Field Data Collections
January 2019	Submit Study Report to Ecology

3. Dilution Modeling

Dilution modeling will be conducted using the collected receiving water and effluent data. Dilution modeling analyses will first focus on the dilution results measured in the field tracer study. Dilutions and plume behavior observed will be used to compare and select the appropriate dilution model (Visual Plumes UM3 or DKHW, or CORMIX2) for application to Outfall 001. Sensitivity model runs will be performed to select the most representative model, and the remaining modeling will be conducted using that selected model.

3.1 Model Selection

Based on evaluations of available dilution models, the following will be considered for use in modeling the CSF Outfall 001: 1) Visual Plumes, a model interface and file manager that includes both DKHW and UM3 models (Frick et al., 2000), and 2) CORMIX2 (Jirka et al., 1996). The dilution model selection and approach will be developed through screening model runs and reviews with a senior reviewer and modeler. One of these mathematical models will be applied (depending upon which was shown to best represent the diffuser) to simulate the outfall dilution and plume behavior (rise and dimensions). These models are discussed in more detail below.

Visual Plumes

Visual Plumes is an update of the PLUMES modeling system developed by the Environmental Research Division (NERL) of EPA (Baumgartner et al., 1994). Visual Plumes (VP) is a Windows-based computer application that supersedes the DOS PLUMES (Baumgartner et al., 1994) mixing zone modeling system. VP simulates single and merging submerged plumes in arbitrarily stratified ambient flow and buoyant surface discharges. VP includes the DKHW model that is based on UDKHDEN (Muellenhoff et al., 1985), the surface discharge model PDS, the three-dimensional UM3 model based on UM, and the NRFIELD model based on RSB. The Brooks equations (Brooks, 1960) are retained to simulate farfield plume behavior.

The time-series file-linking capability provides a way to simulate outfall performance over long periods of time. Most effluent and ambient variables can be input from files that store data that change with time. This is the heart of the pollutant-buildup capability, designed for one-dimensional tidal rivers or estuaries to estimate background pollution from the source in question. The time-series file linking capability is served by "'summary graphics', i.e., graphics that focus on overall performance indicators, like mixing zone dilutions or concentrations."

The following briefly describes the capabilities of the individual models contained within the Visual Plumes model interface.

DKHW

DKHW is a three-dimensional hydrodynamic model that considers variable ambient receiving water current and density profiles with depth. DKHW uses a fourth-order integration routine along the centerline of the effluent plume to trace its position and average dilution over time. The model calculates the average dilution, plume trajectory, and trapping level for submerged, buoyant plumes from a single diffuser or single row of multiple diffuser ports in either stagnant or flowing environments. DKHW is sensitive to water column density gradients and ambient velocities. Jet-integral plumes models such as DKHW provide relatively conservative dilution estimates (i.e., they predict lower dilutions than are actually achieved), which are based on comparisons of field and dilution modeling results.

The model output of each DKHW run provides sequential calculation of both dilution and plume distance from the port until initial dilution is completed, and this output can be used to summarize the dilutions and plume depth at the acute criteria zone boundary and at the completion of initial dilution. The method of Brooks is used to develop dilution predictions in the farfield, typically at the mixing zone boundary. These equations are retained in VP to simulate far-field behavior.

UM3

UM3 calculates the flux-average dilution, plume trajectory, and trapping level for submerged, buoyant plumes from a single diffuser or single row of multiple diffuser ports in either stagnant or flowing environments. UM3 is a two-dimensional mathematical model that analyzes effluent discharges by tracing the position of the plume through its trajectory path. The model approximates the plume development by using single, one step integrations over discrete time increments.

The output of each UM3 model run provide sequential calculation of both dilution and plume distance from the port until initial dilution is completed, and the output were used to predict the dilutions and plume depth at the completion of initial dilution and at various distances downstream of the outfall. As stated previously, the VP interface contains farfield dilution algorithms based on equations developed by Brooks. The farfield estimates will be used to develop predicted dilutions at mixing zone boundary.

CORMIX

The CORMIX modeling system, developed for EPA at Cornell University, is a rule-based system that classifies the interaction of discharges and the receiving water (Jirka et al., 1996). The program makes many of the decisions for the model user based on the input parameters that are provided. The system was designed for the non-specialist model user, in order that plume predictions could be made without having prior knowledge about dilution modeling and mixing processes. The CORMIX models use empirically-derived curve fit equations to make dilution predictions. These equations are selected from length scales that are determined from parameters input by the user.

CORMIX 2, designed for submerged *multiport* line diffusers, is the module that was considered for application. The developers of CORMIX recently incorporated a three-dimensional jet-integral model for the nearfield (CORJET). This jet-integral model is very similar to UDKHDEN and typically provides similar nearfield prediction results, although it is accessible only when CORMIX determines that the ambient discharge conditions are stable. More typically, CORMIX 2 simplifies nearfield mixing processes and represents a line of individual discharge ports as an “equivalent slot” (a line source) of momentum and buoyancy. This occurs when CORMIX predicts that a hydrodynamically unstable discharge will occur or the discharge depth triggers this mode. Thus, under these conditions, mixing is based on the plume characteristics *after* the individual ports have merged.

3.2 Modeling Objectives and Approach

Modeling will be used to predict wastewater dilutions based upon the field performance study results and receiving water conditions. The field-measured dilutions will be used for direct comparisons to dilution model results using Visual Plumes (DKHW & UM3) and CORMIX2. The basis for model selection will be carefully documented. After model selection, measured receiving water and effluent conditions shall be used to accurately “calibrate” the model predictions. The validation and calibration of models using field tracer study will be consistent with Section 1.6.2 in the Guidance for Conducting Mixing Zone Analyses in Ecology’s Permit Writer’s Manual. Dilution modeling will be conducted using the collected receiving water data and pertinent CSF effluent data (i.e. continuous flows and temperature data) for the study day.

Dilution modeling analyses will be developed for existing mill effluent flows for the minimum and maximum density stratifications, and the tidal velocity percentiles as specified in Ecology’s Permit Writer’s Manual and to be consistent with the Guidance for Conducting Mixing Zone Analyses in

Ecology's Permit Writer's Manual. A summary of the preliminary model input parameters used to develop the discharge scenarios are provided as follows:

- **Ambient current speed:** based on a frequency distribution analysis of site-specific currents, the calculated 10^{th}, 50^{th}, and 90^{th} percentile current speeds under ebb and flood tide conditions;
- **Water (discharge) depth**: for acute and chronic aquatic life and human health criteria, the critical receiving water depth is the discharge depth at the diffuser under MLLW and MTL;
- **Ambient water column density profiles:** minimum and maximum density stratification conditions from field studies and other Grays Harbor references;
- **Number of diffuser ports**: twenty-one (21);
- **Port diameter**: 12-inch;
- **Port spacing**: 10 feet on center for diffuser configuration;
- **Port discharge angles**: ports are alternately directed upstream and downstream at a 90° angle relative to the diffuser axis; and diffuser ports are directed upward at a vertical angle of 15°;
- **Port elevation (height above bottom)**: TBD from drawings and inspections;
- **Effluent flow rates**: *2018 discharge conditions*--highest daily maximum for acute conditions, highest monthly maximum for chronic and human health non-carcinogen criteria conditions, and annual average for human health carcinogen criteria conditions;
- **Effluent temperature**: TBD from CSF records;
- **Acute Zone Boundary**: 20.7 feet in any spatial direction from any discharge port; and
- **Chronic Mixing Zone Boundary**: 207 feet in any direction from the diffuser.

The results of the dilution modeling will include: 1) predicted dilutions, plume depth, and temperatures at the Acute and Chronic Mixing Zone boundaries, and a comparison of model-predicted versus field-measured dilution for the field study flow. The dilution model output will be included with the outfall mixing zone study report.

4. Data Analysis and Study Report

The field data collected will be compiled and analyzed to define ambient current velocities at the diffuser site, background receiving water temperature and conductivity (and density stratification during tidal conditions), and effluent temperature. These data are used in the dilution modeling, and the evaluation of compliance with water quality temperature standards.

A draft Outfall Mixing Zone Study Report will be prepared that summarizes the results of the field data collections, dilution modeling, and the evaluation of compliance with water quality temperature standards. Water column temperatures, depths, and current speeds and directions will be presented in tabular formats. The draft Outfall Mixing Zone Study Report will be submitted to CSF for review approximately three months after the field studies. Following review and completion, a final Outfall Mixing Zone Study Report will be submitted to CSF for submission to Ecology in accordance with the NPDES Permit timeline.

References

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Washington Department of Health (DOH). July 2016. Cosmo Specialty Fibers Dye Study, April 9-12, 2016. Draft Report. Washington Department of Health, Office of Environmental Health & Safety. Olympia, WA.

Appendix A

Cosmo Specialty Fibers - NPDES Permit Section S13

S13. Mixing study

S13.A. General requirements for mixing study for Outfall 001

The Permittee must

1. Submit a Plan of Study to Ecology for review by November 30, 2017, prior to initiation of the effluent mixing study. The Permittee must submit a paper copy and an electronic copy (preferably as a PDF).

2. Determine the degree of mixing during critical conditions, as defined in WAC 173-201A-020 Definitions - "Critical Condition," or as close to critical conditions as reasonably possible.

3. Use the *Guidance for Conducting Mixing Zone Analyses* (Ecology, 2008) to establish the critical condition scenarios.

4. Measure the dilution ratio in the field with dye using study protocols specified in the Guidance, Section 5.0 "Conducting a Dye Study," as well as other protocols listed in Subpart C "Protocols." The Permittee may use mixing models as an acceptable alternative or adjunct to a dye study if:

   a. The critical ambient conditions necessary for model input are known or will be established with field studies.

   b. If the diffuser is visually inspected for integrity or has been recently tested for performance by the use of tracers.

5. Consult the Guidance mentioned above when choosing the appropriate model.

6. Use models if critical condition scenarios that need to be examined are quite different from the set of conditions present during the dye study.

7. Must conduct validation/calibration in accordance with the Guidance mentioned above, in particular, Section 5.2 "Quantify Dilution" if it determines it needs to validate (and possibly calibrate) a model.

8. Apply the resultant dilution ratios for acute and chronic boundaries in accordance with directions found in Ecology's *Permit Writer's Manual* (2010), Chapter VI and Appendix 6.

S13.B. Reporting requirements

The Permittee must:

1. Include the results of the effluent mixing study in the Effluent Mixing Report and submit it to Ecology for approval within 12 months after Ecology's approval of the Plan of Study. The Permittee must submit a paper copy and an electronic copy (preferably as a PDF).

2. Submit to Ecology any available information it has regarding background physical conditions or background concentrations of chemical substances in the receiving water (for which there are criteria in chapter 173-201A WAC) as part of the Effluent Mixing Report.

3. Locate the outfall and mixing zone boundaries with GPS coordinates and identify the accuracy of station locations in the report.

4. If the results of the mixing study, toxicity tests, and chemical analysis indicate that the concentration of any pollutant(s) exceeds or has a reasonable potential to exceed the state water quality standards, chapter 173-201A WAC, Ecology may issue an administrative order to require a

reduction of pollutants or modify this permit to impose effluent limits to meet the water quality standards.

S13.C. Protocols

The Permittee must determine the dilution ratio using protocols outlined in the following references, approved modifications thereof, or by another method approved by Ecology:

1. Akar, P.J. and G.H. Jirka, Cormix2: An Expert System for Hydrodynamic Mixing Zone Analysis of Conventional and Toxic Multiport Diffuser Discharges, USEPA Environmental Research Laboratory, Athens, GA, Draft, July 1990.

2. Baumgartner, D.J., W.E. Frick, P.J.W. Roberts, and C.A. Bodeen, *Dilution Models for Effluent Discharges, USEPA*, Pacific Ecosystems Branch, Newport, OR, 1993.

3. Doneker, R.L. and G.H. Jirka, Cormix1: An Expert System for Hydrodynamic Mixing Zone Analysis of Conventional and Toxic Submerged Single Port Discharges, USEPA, Environmental Research Laboratory, Athens, GA, EPA/600-3-90/012, 1990.

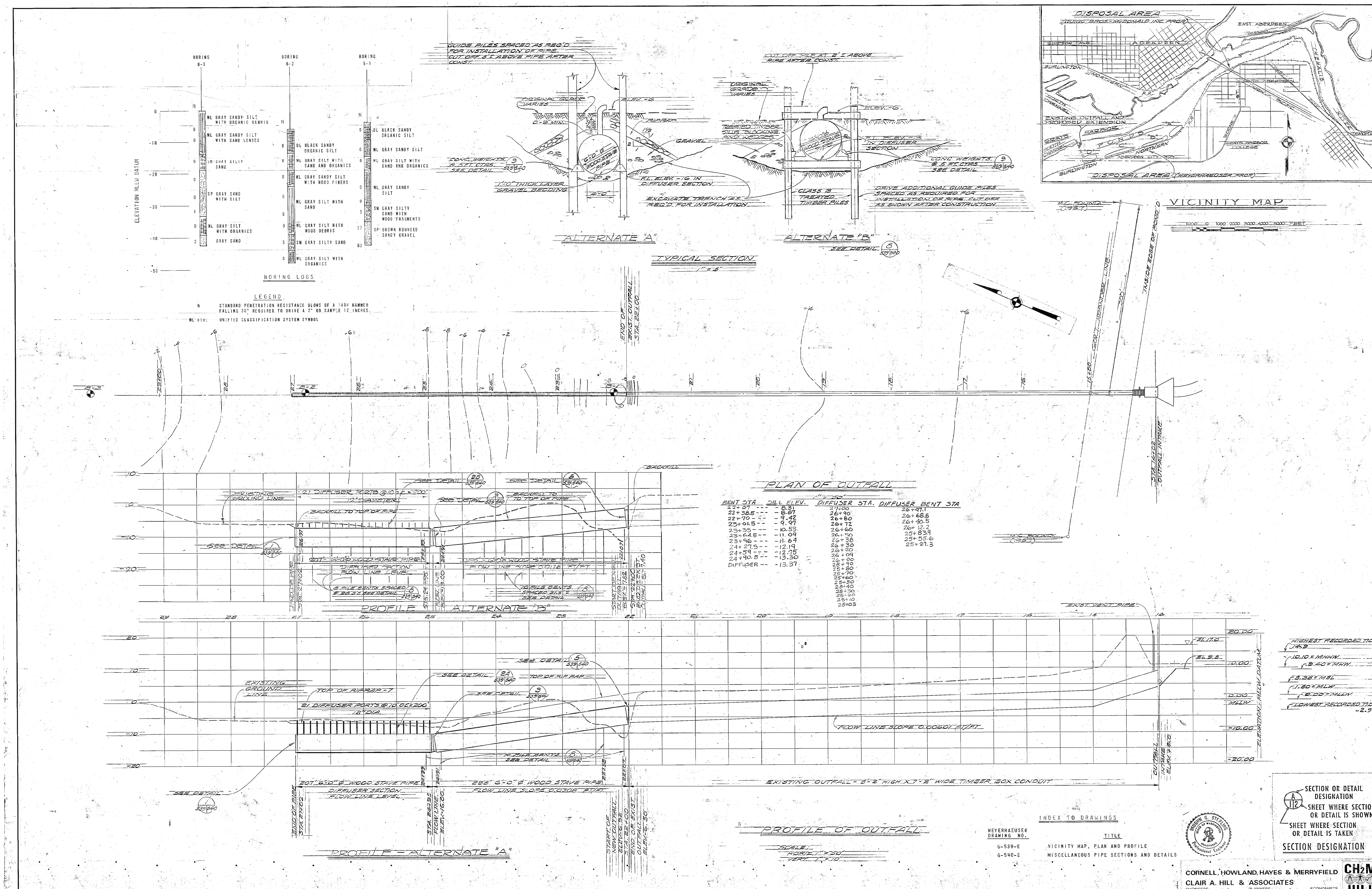
4. Ecology, *Permit Writer's Manual*, Water Quality Program, Department of Ecology, Olympia, WA 98504, revised November 2014, including most current addenda.

5. Ecology, *Guidance for Conducting Mixing Zone Analyses, Permit Writer's Manual,* (Appendix 6.1), Water Quality Program, Department of Ecology, Olympia, WA 98504, October 1996.

6. Kilpatrick, F.A., and E.D. Cobb, *Measurement of Discharge Using Tracers, Chapter A16, Techniques of Water-Resources Investigations of the USGS*, Book 3, Application of Hydraulics, USGS, U.S. Department of the Interior, Reston, VA, 1985.

7. Wilson, J.F., E.D. Cobb, and F.A. Kilpatrick, *Fluorometric Procedures for Dye Tracing, Chapter A12. Techniques of Water-Resources Investigations of the USGS*, Book 3, Application of Hydraulics, USGS, U.S. Department of the Interior, Reston, VA, 1986.

Appendix B
Outfall 001 As-Built Drawings



PLAN OF OUTFALL

1" = 50'

BENT STA	SILL ELEV.	DIFFUSER STA.	DIFFUSER BENT STA
22+07	-8.31	27+00	26+97.1
22+38.5	-8.87	26+90	26+68.8
22+70	-9.42	26+80	26+40.5
23+01.5	-9.97	26+72	26+12.2
23+33	-10.53	26+60	25+83.9
23+64.5	-11.09	26+50	25+55.6
23+96	-11.64	26+38	25+27.3
24+27.5	-12.19	26+30	
24+59	-12.75	26+20	
24+90.5	-13.30	26+09	
DIFFUSER	-13.37	26+00	
		25+90	
		25+80	
		25+70	
		25+60	
		25+50	
		25+40	
		25+30	
		25+20	
		25+10	
		25+03	

INDEX TO DRAWINGS

WEYERHAEUSER DRAWING NO.	TITLE
G-539-E	VICINITY MAP, PLAN AND PROFILE
G-540-E	MISCELLANEOUS PIPE SECTIONS AND DETAILS

SECTION OR DETAIL DESIGNATION
SHEET WHERE SECTION OR DETAIL IS SHOWN
SHEET WHERE SECTION OR DETAIL IS TAKEN
SECTION DESIGNATION

VAUGHN G. STERLING — STATE OF WASHINGTON — REGISTERED Professional Engineer

CORNELL, HOWLAND, HAYES & MERRYFIELD
CLAIR A. HILL & ASSOCIATES
ENGINEERS · PLANNERS · ECONOMISTS
CH2M HILL

DATE	REV.	TABLE OF REVISIONS	BY	DATE	REV.	TABLE OF REVISIONS	BY	DATE	REV.	TABLE OF REVISIONS	BY	DATE	REV.	TABLE OF REVISIONS	BY	DATE	REV.	TABLE OF REVISIONS	BY

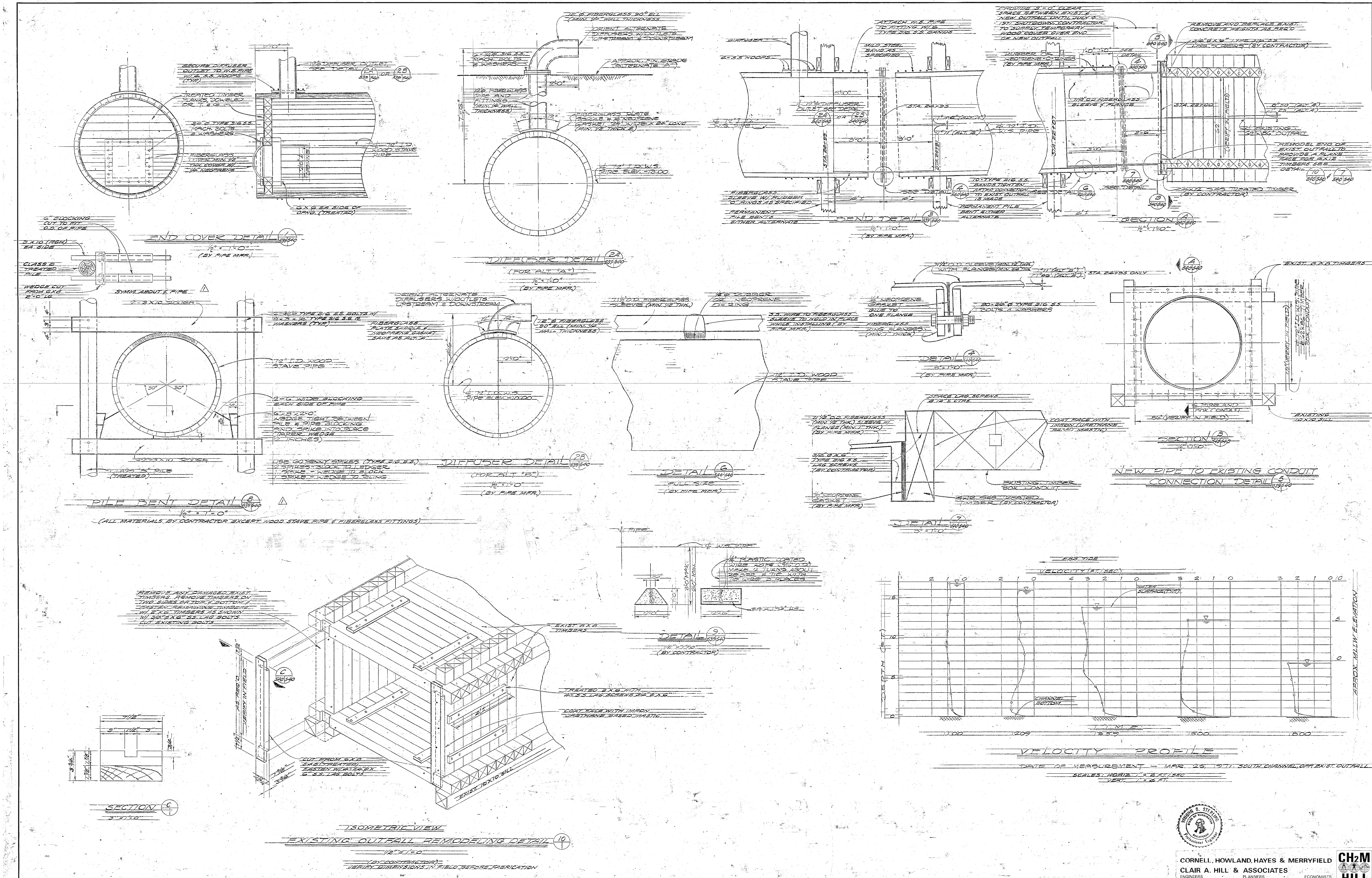
DRAWN BY DML; EKW
APPROVED
DATE
SCALE

Weyerhaeuser Company
Pulp Division
Cosmopolis, Washington

POND "D" OUTFALL EXTENSION
VICINITY MAP, PLAN AND PROFILE

DRAWING NO. G-539-E

RAH WEYERHAEUSER OUTFALL CK PT No1 D-62104 EKW



VAUGHN G. STERLING · STATE OF WASHINGTON · REGISTERED · Professional Engineer

CORNELL, HOWLAND, HAYES & MERRYFIELD
CLAIR A. HILL & ASSOCIATES
ENGINEERS · PLANNERS · ECONOMISTS
CH2M HILL

DATE	REV.	TABLE OF REVISIONS	BY	DATE	REV.	TABLE OF REVISIONS	BY
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Weyerhaeuser Company
Pulp Division
Cosmopolis, Washington

POND "D" OUTFALL EXTENSION
MISCELLANEOUS PIPE
SECTIONS AND DETAILS

DRAWING NO. G-540-E

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