TECHNICAL MEMORANDUM

# Water Quality Compliance Evaluation for the Phase 5B Project – Salmon Creek Treatment Plant Improvements

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## Summary

This technical memorandum provides an evaluation of the Salmon Creek Treatment Plant (SCTP) Phase 5B plant capacity expansion with regard to water quality in the Columbia River and Washington water quality standards (Washington Administrative Code [WAC] 173-201A). The Phase 5B effluent flows will be discharged into the Columbia River through the existing SCTP outfall and multi-port diffuser until the replacement outfall and diffuser are completed under the Phase 5A project in 2023.

This evaluation has been prepared to be consistent with WAC 173-201A, and to align with the Washington State Department of Ecology (Ecology) *Water Quality Program Permit Writer's Manual* (Permit Writer's Manual) (2015) and *Water Quality Program Guidance Manual: Supplemental Guidance on Implementing the Tier II Antidegradation* (Ecology, 2011). The elements of the water quality and antidegradation evaluations and the results are summarized as follows:

1. ***Assessment of dilution performance of the existing SCTP outfall diffuser with Phase 5B effluent flows***:
   - Dilution modeling for acute aquatic life criteria conditions yield a minimum dilution factor of 14 at the acute zone boundary under low river flow and the highest daily maximum effluent flow.
   - Dilution modeling for chronic aquatic life criteria conditions yield 59 under critical dry season low river stage and velocities, and 54 under critical wet season conditions and maximum monthly effluent flows.
   - Model-predicted dilution factors for human-health-criteria non-carcinogen conditions and human-health-criteria carcinogen conditions are 63 and 114, respectively.
   - These dilution factors that represent critical acute and chronic aquatic-life-criteria conditions and human-health-criteria conditions have been applied in the evaluation of compliance with water quality standards and antidegradation rules.
2. ***Assessment of compliance with state water quality standards***:
   - Dissolved oxygen - The calculated worst-case decrease in dissolved oxygen at the mixing zone boundary is limited to 0.1 mg/L during the summer salmon rearing and migration period and during the September–June spawning, rearing and migration period. According to WAC 173-201A-200(1)(d), a reduction in dissolved oxygen of less than 0.2 mg/L is allowed, even in waterbodies that do not meet the applicable dissolved oxygen criterion. Therefore, the Phase 5B

SCTP discharge would not cause or contribute to a violation of DO criteria. Furthermore, field measurements of Columbia River dissolved oxygen levels in the dry season in 2015, showed no violation of DO concentration criteria or saturation criteria.

- Temperature – The temperature standards include biologically-based criteria and criteria for preventing acute lethality and barriers to migration of salmonids. The estimated maximum excess temperature for the SCTP discharge at the Phase 5B effluent flows is 0.05°C, and it is not a "measurable" temperature increase which is defined as *greater* than 0.3°C in the temperature standards. In addition, the Phase 5B discharge to the river does not exceed any of the criteria preventing acute lethality and barriers to migration of salmonids.
- pH - Based on calculation of the mixed pH at the SCTP mixing zone boundary, the mixed pH would not be less than 6.5 or more than 8.5, and therefore would not cause or contribute to a violation of the pH criteria.
- Toxic Substances - Evaluation of the dilution factors required for the SCTP effluent maximum effluent concentrations to comply with the aquatic life and human health-based water quality criteria demonstrate that the existing SCTP diffuser with Phase 5B flow will provide sufficient dilutions to comply with acute and chronic aquatic life criteria for ammonia, metals, and organic chemicals. The Phase 5B discharge will comply with human health-based criteria, with two chemicals to be resolved. The 2016 EPA-approved human health criteria for arsenic is lower than the measured background arsenic concentrations in the Columbia River by an order of magnitude and is therefore not attainable. The plasticizer, Bis(2-Ethylhexyl) Phthalate, is ubiquitous in municipal wastewater effluents due to PVC piping and other plastics and additional source monitoring is needed to reduce their sources to sewage systems.

3. ***Assessment of compliance with state antidegradation rules***:

- Ecology has specified in Washington's antidegradation rule (WAC 173-201A-300) that a Tier II review "will only be conducted for new or expanded actions conducted under authorizations including NPDES permits". The SCTP Phase 5B is neither a new or expanded action, and this additional assessment demonstrates that the Phase 5B discharge will not create any degradation or measurable change in water quality in the Columbia River.

4. ***Review of biological resources and uses of the Columbia River discharge site:***

- The biological resources of the Columbia River include listed salmonid species, eulachon, sturgeon and their aquatic habitat. This water quality evaluation documents that the SCTP Phase 5B discharge will not cause or contribute to violations of water quality standards. These standards have been developed to protect sensitive aquatic organisms, including ESA-listed species, and aquatic organisms using the lower Columbia River are protected by these standards.

# Outfall Dilution Assessment

This assessment of the dilution performance of the existing SCTP outfall diffuser reviews the dilution modeling assumptions and inputs and presents the modeling results. These dilution results are applied in the evaluation of compliance with water quality standards and are provided for Ecology's use in the National Pollutant Discharge Elimination System (NPDES) permit renewal.

Updated dilution modeling of projected Phase 5B effluent flows was developed to provide predicted dilution performance of the existing SCTP outfall diffuser under critical (worst-case) receiving water conditions for a range of effluent flows and receiving water conditions at the discharge site. This additional dilution analysis was specifically performed because the Phase 5B project is proposing an incremental increase in permitted effluent flows in 2022 to be discharged through the existing outfall and diffuser prior to the construction and operation of the replacement outfall and diffuser under Phase 5A. Phase 5A dilution modeling has evaluated projected effluent flows for 2025, 2040, and buildout conditions with these flows discharged through the Phase 5A replacement outfall and diffuser. Outfall dilution modeling was conducted for specific effluent flows and temperatures and critical receiving water conditions of temperatures, discharge depth, tidal direction, and current velocities in accordance with guidance provided in Chapters 6 and 7 and Appendix C of the Permit Writer's Manual.

The modeling assumptions and specific inputs of effluent flow and temperature and receiving water conditions are defined in the following section. The modeling conditions that produce the lowest predicted dilutions identify the site-specific critical conditions for the discharge. Previous dilution modeling analyses of the existing SCTP outfall diffuser include the Outfall Dilution Study Report for the SCTP (CH2M HILL, January 2004) and the Addendum to the Outfall Dilution Study Report for the SCTP (CH2M HILL, May 2004) include detailed documentation and justification for the selection and application of the model UM3 (Frick et al., 2003). This model selection was developed using the results of the field tracer study performed in 2003, including the review and input from Ecology technical staff.

## Dilution Modeling Assumptions and Inputs

Dilution modeling input and analyses were based on the site-specific current and water column measurements collected during the low river flow period in 2015 (a historically low flow water year), available effluent flow and temperature data and statistics between 2010 and 2016, and projected effluent flows for SCTP Phase 5B. Modeling was conducted to represent discharge scenarios specified in the Permit Writer's Manual.

The existing SCTP outfall is located in the Columbia River near River Mile 96, and it terminates with a diffuser composed of five risers at 10-foot spacing, at an average port depth of approximately 17 feet during low river flows (each riser has three 5-inch by 5-inch ports). The current NPDES Permit authorizes a mixing zone boundary of 217 feet in all directions from the diffuser, and an acute zone boundary of 22 feet in all directions from the diffuser. These mixing zone boundaries were established based on the WAC 173-201A-400(7)(b) for discharges to estuaries (where tidal-induced flow reversals occur), as well as the average diffuser port depth under 7Q10 low river flow.

Eleven combinations of discharge and ambient receiving water conditions were modeled to represent the range of critical discharge conditions for the existing SCTP outfall and diffuser. The model-predicted flux-average dilutions are presented at the acute criteria exceedance boundary (acute zone boundary) and at the chronic criteria compliance boundary (or mixing zone boundary) for the various effluent flows and critical receiving water conditions. Seasonal discharge scenarios were developed to match guidance provided in the following Permit Writer's Manual tables: Table 11 (Effluent and Receiving Water Design Conditions for Temperature), Table 12 (Applicable Criteria/Design Conditions), and Appendix C Table C-1 (Point Source Steady-State Flow for Mixing Zone Analysis) and Table C-3 (Critical Ambient Conditions).

The dry season (May through October) modeling scenarios are summarized as follows:

- **Acute Criteria Conditions**—7Q10 dry season low river flow and the maximum *daily* dry weather effluent flow for Phase 5B (Year 2022)
- **Chronic Criteria Conditions**—7Q10 dry season low river flow and maximum *month* dry weather effluent flow for Phase 5B (Year 2022)
- **Human Health (Non-carcinogen) Criteria Condition**—30Q5 low river flow and maximum month dry weather effluent flow for Phase 5B (Year 2022)
- **Human Health (Carcinogen) Criteria Condition**—harmonic mean river flow and annual average effluent flow for Phase 5B (Year 2022)

The wet season (November through April) scenarios are summarized as follows:

- **Acute Criteria Condition**—7Q10 wet season river flow and the maximum *daily* wet weather effluent flow for Phase 5B (Year 2022)
- **Chronic Criteria Condition**—7Q10 wet season river flow and the maximum *month* wet weather effluent flow for Phase 5B (Year 2022)

These dry and wet season scenarios align with the guidance defined in Tables 11 and 12 of the Permit Writer's Manual for critical-low-flow conditions and human-health-criteria conditions for carcinogens and non-carcinogens. The 7Q10 river flow is defined as the 7-day low flow period with a recurrence interval of 10 years, and the 30Q5 river flow is defined as the 30-day low flow period with a recurrence interval of 5 years. The modeling scenarios, including effluent flows and temperature used, river flow, current velocities, and temperatures, and discharge port depths, are summarized in Table 1.

Effluent flow values were developed based on the Phase 5B Engineering Report and applying interpolation between actual 2016 and projected 2025 flows from the *Salmon Creek Wastewater Management System Wastewater Facilities Plan/ General Sewer Plan Amendment* (Facilities Plan) (CH2M, 2013) to represent the Phase 5B effluent flows in 2022. Effluent flow projection for 2022 are summarized in Table 1 and applied in dilution modeling. The record period used to develop effluent temperatures for modeling was January 2010 through April 2016. A 99th percentile effluent temperature of 23.0 degrees Celsius (°C) was calculated to represent *dry season* conditions, and a 99th percentile effluent temperature of 19.8°C was calculated to represent *wet season* conditions. Both temperatures were used to represent maximum temperature for **acute** water quality criteria. A 95th percentile effluent temperature of 22.7°C was calculated to represent *dry season* conditions, and a 95th percentile effluent temperature of 19.5°C was calculated to represent *wet season* conditions. These temperatures were used to represent maximum temperature for **chronic** water quality criteria. An effluent temperature of 17.8°C was calculated to represent annual average conditions.

Columbia River receiving water conditions used in the modeling were developed from field measurements at the replacement offshore diffuser site, and these were collected by CH2M during August to October 2015 under low river flow conditions. The receiving water characteristics applied in the modeling of the selected outfall diffuser configuration are also summarized in Table 1.

Other key model inputs include ambient temperature and water (discharge) depth. The current meter records and water column profiles collected in 2015 were also used to validate ambient river temperatures used for the modeling of dry season conditions. Long-term records collected by the U.S. Geological Survey (USGS) at Vancouver, Washington (Gage 14144700) for the 13-year period from August 1967 to October 1979 were used to develop a cumulative frequency distribution of river temperature.

Based on these data sources, a 90th percentile ambient river temperature of 21.1°C was calculated to represent typical dry season (May through October) conditions. Similarly, a 90th percentile ambient river temperature of 10.7°C was calculated to represent typical wet weather (November through April) conditions. An annual average temperature of 12.4°C is based on the 13-year period of record (1967 to 1979) collected by the USGS for the Columbia River at Vancouver, Washington.  Discharge depths in the modeling evaluation represent the average depth of the existing diffuser ports relative to 7Q10 low flow conditions.  The dilution performance of the SCTP outfall diffuser was modeled using UM3 and the following model input parameters:

- **Number, diameter, and spacing of discharge ports**: five, 9.8-inch diameter ports with a spacing of 10 feet on center. *Note: the actual port configuration is as follows: five risers each with three, 5-inch by 5-inch square ports oriented in a triangular arrangement. Because the UM3 model cannot simulate this type of discharge configuration, the equivalent port size of a single 9.8-inch-diameter* *port on each riser was modeled. This modeling configuration was accepted by Ecology in previous analyses as a conservative representation of the 3-port turreted diffuser risers.*

- **Effluent flows and temperatures**: refer to Table 1.
- **Ports' horizontal angle**: 169° relative to the ambient current direction.
- **Ports' vertical angle**: 0° relative to the water surface.
- **Angle of diffuser axis relative to ambient current direction**: 90°.
- **Discharge depth**: refer to Table 1.
- **Ambient temperature**: 21.1°C (dry season, 90th percentile), 10.7°C (wet season, 90th percentile), and 12.4°C (annual average).
- **Ambient current speeds**: 12.9, 31.1, and 37.6 centimeters per second (cm/sec) (10th, 50th, and 90th percentile dry season ebb tide, respectively); 4.2, 15.5, and 25.1 cm/sec (10th, 50th, and 90th percentile dry season flood tide, respectively); 17.1 cm/sec (50th percentile, flood tide-7Q10 high, wet season); 32.0 cm/sec (50th percentile, ebb tide-30Q5 flow); 34.4 cm/sec (50th percentile, ebb tide-7Q10 high, wet season); and 59.4 cm/sec (50th percentile, ebb tide-harmonic mean).

## Dilution Modeling Results

Table 1 is the modeling summary table and it includes the defined scenarios (based on water quality criteria, effluent flow scenario, and critical river flow scenario), effluent flow and temperatures, river flow and temperature, ambient current velocity, diffuser discharge depth, and model-predicted dilution factors at the acute zone boundary (AZB) and mixing zone boundary (MZB) for the existing SCTP diffuser.

The column at the right side of the summary table shows modeling results for the chronic water quality criteria. For chronic mixing zones located in tidally-influenced freshwater, Appendix C of the Permit Writer's Manual specifies that the critical receiving water current velocity is defined as the 50th-percentile current velocity derived from a cumulative frequency distribution analysis *over at least one tidal cycle*. Since site-specific current velocities (measured during the low river flow period) demonstrated that flood tide currents occur approximately 24 percent of the time at the proposed discharge site, a time-weighted proportion (i.e., 24 percent flood tide/76 percent ebb tide, calculated based on 2015 site-specific current measurements under lowest river flows) was applied to the dilution factors to conservatively represent tidally-averaged results at the chronic mixing zone boundary. Since chronic water quality criteria for aquatic life are based on average four-day exposure concentrations, this method provides representative dilution factors at the chronic mixing zone boundary.

The model-predicted dilution factors are summarized in Table 1 for the projected Phase 5B effluent flows. The Permit Writer's Manual specifies that dilutions in a tidally influenced river to be flux-average dilutions at both the AZB and at the MZB. The results of the dilution modeling for dry and wet season acute dilution conditions are represented by Model Case Nos. 5B1 to 5B5; dry and wet season chronic dilution conditions by Model Case Nos. 5B6 to 5B9; and for human health conditions by Model Case Nos. 5B10 and 5B11. The UM3 model input and output are included in Attachment 1.

The modeling results for acute aquatic life criteria conditions show predicted dilution factors at the AZB (22 feet from the diffuser) range from 14 to 24 under all seasonal effluent and receiving water conditions. The worst-case acute dilution factor (DF) of 14 is predicted to occur under dry season conditions, a 7Q10-low river flow (83,506 cfs), the lowest 10th percentile flood tide current velocity (4.2 cm/sec), and the highest daily maximum effluent flow (16.5 million gallons per day).

The modeling results also show that the predicted dilution factors at the chronic MZB (217 feet from the diffuser) are 59 under critical dry season conditions of low river stage and velocities, and 54 under critical wet season conditions and maximum monthly effluent flows. The lowest predicted dilution factor at the chronic MZB is based on the tidally-averaged/time weighted DF of 54 (represented by Model Case Nos. 5B8 and 5B9). Model-predicted dilution factors applicable for human-health-criteria non-carcinogen conditions and human-health-criteria carcinogen conditions are 63 and 114, respectively. These dilution factors that represent critical acute and chronic aquatic-life-criteria conditions and human-health-criteria conditions have been applied in the evaluation of compliance with water quality standards and antidegradation rules, which is presented in the following section.

**Table 1**

**Model-Predicted Dilution Factors Under Critical Dry Season, Wet Season, and Annual Average Discharge Conditions for the Existing Salmon Creek Outfall - Projected 2022 Effluent Flows**

*Salmon Creek WWTP Phase 5B Project*

| | Columbia River Receiving Water Conditions | | | | | | Effluent Conditions[b] | | | Outfall Diffuser Configuration | | Model-Predicted Dilution Factors (DF) at Mixing Zone Boundaries[d] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model Case No.** | **Seasonal Basis[a]** | **River Discharge** | **River Flow (cfs)** | **Temperature (deg. C)** | **Tidal Condition** | **Current Speed (cm/sec)** | **Flow Rate (mgd)** | **Temperature Frequency** | **Temperature (deg. C)** | **Equivalent No./Size Ports & Spacing (ft)** | **Diffuser Discharge Depth (feet)[c]** | **Acute Zone (22 feet)[e]** | **Mixing Zone (217 feet)[f]** | **Tidally-Averaged & Time Weighted (Chronic Only)[g]** |
| **Acute Water Quality Criteria** | | | | | | | | | | | | | | |
| SCTP-5B1 | dry | 7Q10-dry | 83,506 | 21.1 (90th percentile) | ebb (downstream) | 12.9 (10th percentile) | 16.5 (highest daily maximum) | 99th percentile (dry season) | 23.0 | 5-9.8" ports at 10-ft spacing | 17.0 | 18 | n/a | n/a |
| SCTP-5B2 | | | | | | 37.6 (90th percentile) | | | | | | 24 | n/a | n/a |
| SCTP-5B3 | | | | | flood (upstream) | 4.2 (10th percentile) | | | | | | **14** | n/a | n/a |
| SCTP-5B4 | | | | | | 25.1 (90th percentile) | | | | | | 22 | n/a | n/a |
| SCTP5-5B5 | wet | 7Q10-wet | 108,766 | 10.7 (90th percentile) | ebb (downstream) | 34.4 (50th percentile) | 23.0 (highest daily max.) | 99th percentile (wet season) | 19.8 | 5-9.8" ports at 10-ft spacing | 17.6 | 22 | n/a | n/a |
| **Chronic Water Quality Criteria** | | | | | | | | | | | | | | |
| SCTP-5B6 | dry | 7Q10-dry | 83,506 | 21.1 (90th percentile) | ebb (downstream) | 31.1 (50th percentile) | 13.2 (highest monthly avg.) | 95th percentile (dry season) | 22.7 | 5-9.8" ports at 10-ft spacing | 17.0 | n/a | 62 | **59** |
| SCTP-5B7 | | | | | flood (upstream) | 15.5 (50th percentile) | | | | | | n/a | 48 | |
| SCTP-5B8 | wet | 7Q10-wet | 108,766 | 10.7 (90th percentile) | ebb (downstream) | 34.4 (50th percentile) | 17.5 (maximum monthly) | 95th percentile (wet season) | 19.5 | 5-9.8" ports at 10-ft spacing | 17.6 | n/a | 56 | **54** |
| SCTP-5B9 | | | | | flood (upstream) | 17.1 (50th percentile) | | | | | | n/a | 47 | |
| **Human Health Criteria: *Carcinogen*** | | | | | | | | | | | | | | |
| SCTP-5B10 | annual | harmonic mean | 191,106 | 12.4 (50th percentile) | ebb (downstream) | 59.4 (50th percentile) | 13.3 (annual average) | 50th percentile | 17.8 | 5-9.8" ports at 10-ft spacing | 18.2 | n/a | **114** | n/a |
| **Human Health Criteria: *Non-Carcinogen*** | | | | | | | | | | | | | | |
| SCTP-5B11 | annual | 30Q5 | 99,893 | 12.4 (50th percentile) | ebb (downstream) | 32.0 (50th percentile) | 13.2 (highest monthly avg.) | 50th percentile | 17.8 | 5-9.8" ports at 10-ft spacing | 17.1 | n/a | **63** | n/a |

**Notes:**

[a] Dry season is assumed to be the period from May 1 to October 31, wet season from November 1 to April 30.

[b] Effluent temperature values are based on effluent measurements from January 2010 through April 2016. Effluent flow values were interpolated between actual 2016 and projected 2025 flows from the Facilities Plan, tp develop projected 2022 effluent flows.

[c] Discharge depth represents the average depth of the diffuser ports based on (relative to) 7Q10 low flow conditions, which have been measured at the existing SCTP diffuser site (RM 96) in the Columbia River.

[d] Based on procedures in the Water Quality Program Permit Writer's Manual (Ecology, revised 2015), model-predicted dilution factors for discharges in 'marine and rotating direction' environments (i.e., estuaries) are flux-average values for both acute and chronic conditions.

[e] The zone where the acute criteria may be exceeded (i.e., acute zone boundary) is a distance of 22 feet (6.7 meters) from any discharge port in both the upstream and the downstream direction.

[f] The mixing zone boundary is 217 feet (66.2 meters) in all directions from the diffuser, both the upstream and the downstream directions.

[g] For chronic mixing zones located in salt water and tidally-influenced freshwater, Appendix C of the Water Quality Program Permit Writer's Manual (Washington Department of Ecology, January 2015) specifies that the critical receiving water current velocity is defined as the 50th percentile current velocity derived from a cumulative frequency distribution analysis *over at least one tidal cycle.* Since site-specific current velocities (measured during the low river flow period) demonstrated that flood tides occur approximately 24 percent of the time at the proposed outfall site, this time-weighted proportion (i.e., 24% flood tide/76% ebb tide) was applied in order to represent tidally-averaged results at the chronic mixing zone boundary.

# Discharge Compliance with Water Quality Standards

## Water Quality Standards and Assessments

The Water Quality Standards for Surface Waters of the State of Washington (WAC Chapter 173-201A) include narrative and numerical receiving water quality standards, as well as antidegradation rules in Chapter 173-201A-300 that are consistent with the federal Clean Water Act. These standards address many water quality parameters: dissolved oxygen, temperature, toxicity, turbidity, pH, coliform bacteria, dissolved gases, aesthetic water conditions, radioisotope concentrations, and toxic substances. Effects on each of these water quality parameters have been evaluated in the sections below using projected Phase 5B effluent flows, existing wastewater data, updated dilution factors for the existing SCTP outfall diffuser, and background Columbia River receiving water data.

Ecology has designated the lower Columbia River for spawning, rearing, and migration of aquatic life in WAC 173-201A-602, and this designation is protective of rearing and migration year-round as well as salmon and trout spawning and emergence during the non-summer period (defined as September 17 to June 13). This designation is relevant to the application of water quality numeric standards for dissolved oxygen, temperature, pH, and turbidity.

Ecology's 2014 303(d) list includes approximately 13 miles of the lower Columbia River from the confluence of the Willamette River (RM 102) to the confluence of the Lewis River (RM 88) as impaired for temperature and dissolved oxygen. The existing SCTP outfall is located at RM 96. This reach of the Columbia River is also listed as impaired for bacteria based on the 1998 Water Quality Assessment, and no new bacteria data have been incorporated into the assessment since the 1998 listing.

Ecology's 2014 303(d) list was approved by the U.S. Environmental Protection Agency (EPA) in July 2016. Both are Category 5 listings, meaning that a total maximum daily load (TMDL) study is expected to be developed unless additional data collections result in reclassify or removal of the Category 5 listings. Reaches of the lower Columbia River have been listed for temperature for decades, and EPA has taken the lead of developing temperature TMDLs for the Columbia and Snake Rivers. The dissolved oxygen listing is more recent and based on shallow shoreline measurements collected in 2006-2009 to assess impact of aquatic plant growth areas on water quality, and these data are not considered representative of the flowing Columbia River.

In August through October of 2015, the Alliance had three months of water quality monitoring conducted at RM 96 as part of the SCTP Phase 5A project for outfall replacement design and these extensive data collections have been submitted to Ecology's EIM for application in the next 303(d) water quality assessment. Figures 1 and 2 provide plots of the 2015 dissolved oxygen data collected near RM 96 during critical low flow conditions. Figure 1 shows both 2015 and historical dissolved oxygen measurements relative to the DO criteria; and Figure 2 shows the DO saturation values for these 2015 water quality monitoring data. These data plots clearly illustrate dissolved oxygen compliance during the dry season low river flow conditions in 2015.

In addition, the Alliance and City of Vancouver are conducting dry season water quality monitoring of the Columbia River in 2018 to provide Ecology with new field measurements of dissolved oxygen, pH, temperature and conductivity conditions between RM 110 and RM 95 under low river flow conditions. The 2018 Columbia River Water Quality Monitoring Program is being conducted in accordance with a Quality Assurance Project Plan that was reviewed by Ecology prior to the start of monitoring. The SCTP discharge compliance with temperature, dissolved oxygen, bacteria, and other standards are discussed below.

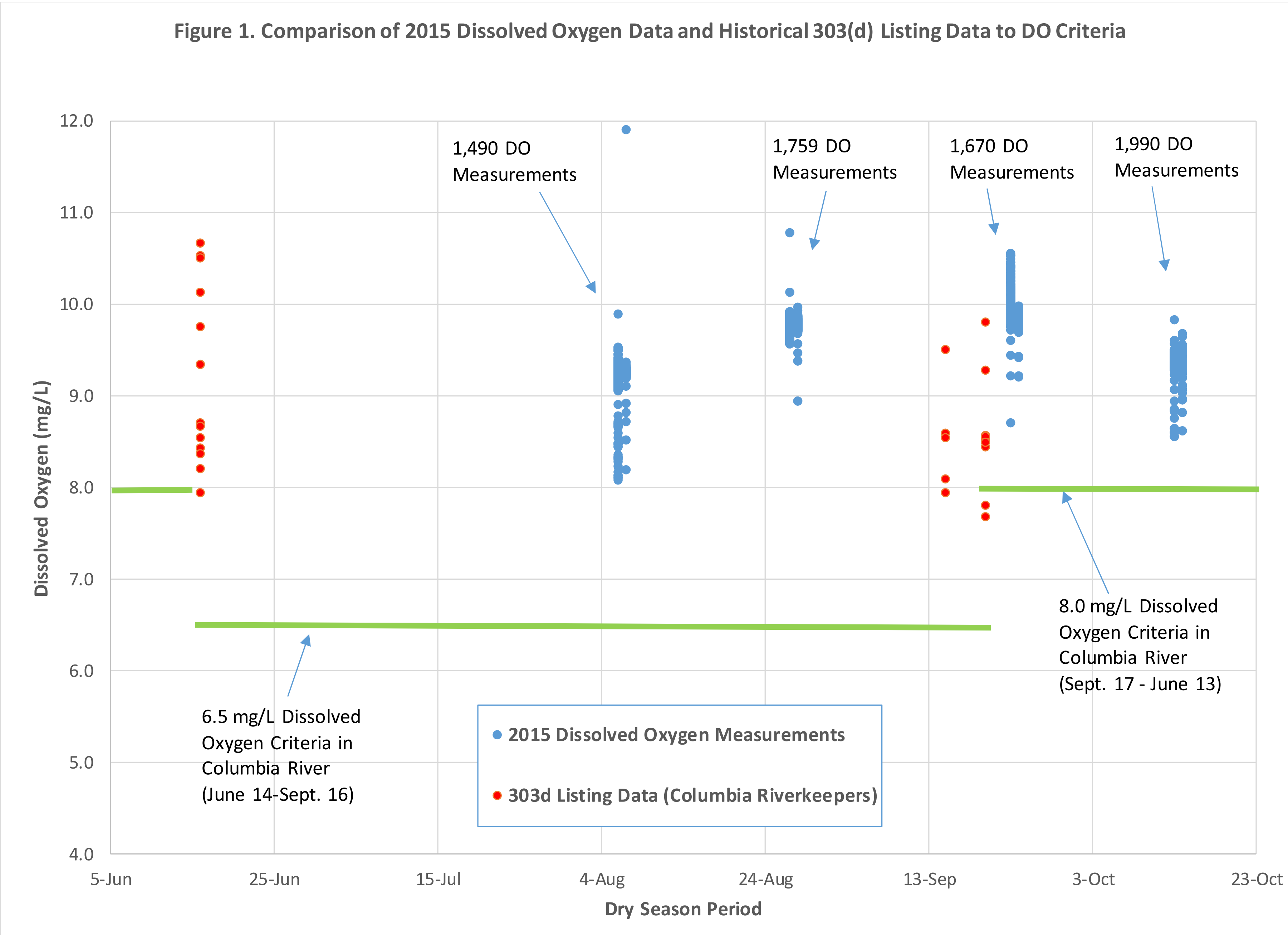
Figure 1. Comparison of 2015 Dissolved Oxygen Data and Historical 303(d) Listing Data to DO Criteria
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
Dissolved Oxygen (mg/L)
1,490 DO Measurements
1,759 DO Measurements
1,670 DO Measurements
1,990 DO Measurements
8.0 mg/L Dissolved Oxygen Criteria in Columbia River (Sept. 17 - June 13)
6.5 mg/L Dissolved Oxygen Criteria in Columbia River (June 14-Sept. 16)
2015 Dissolved Oxygen Measurements
303d Listing Data (Columbia Riverkeepers)
5-Jun
25-Jun
15-Jul
4-Aug
24-Aug
13-Sep
3-Oct
23-Oct
Dry Season Period

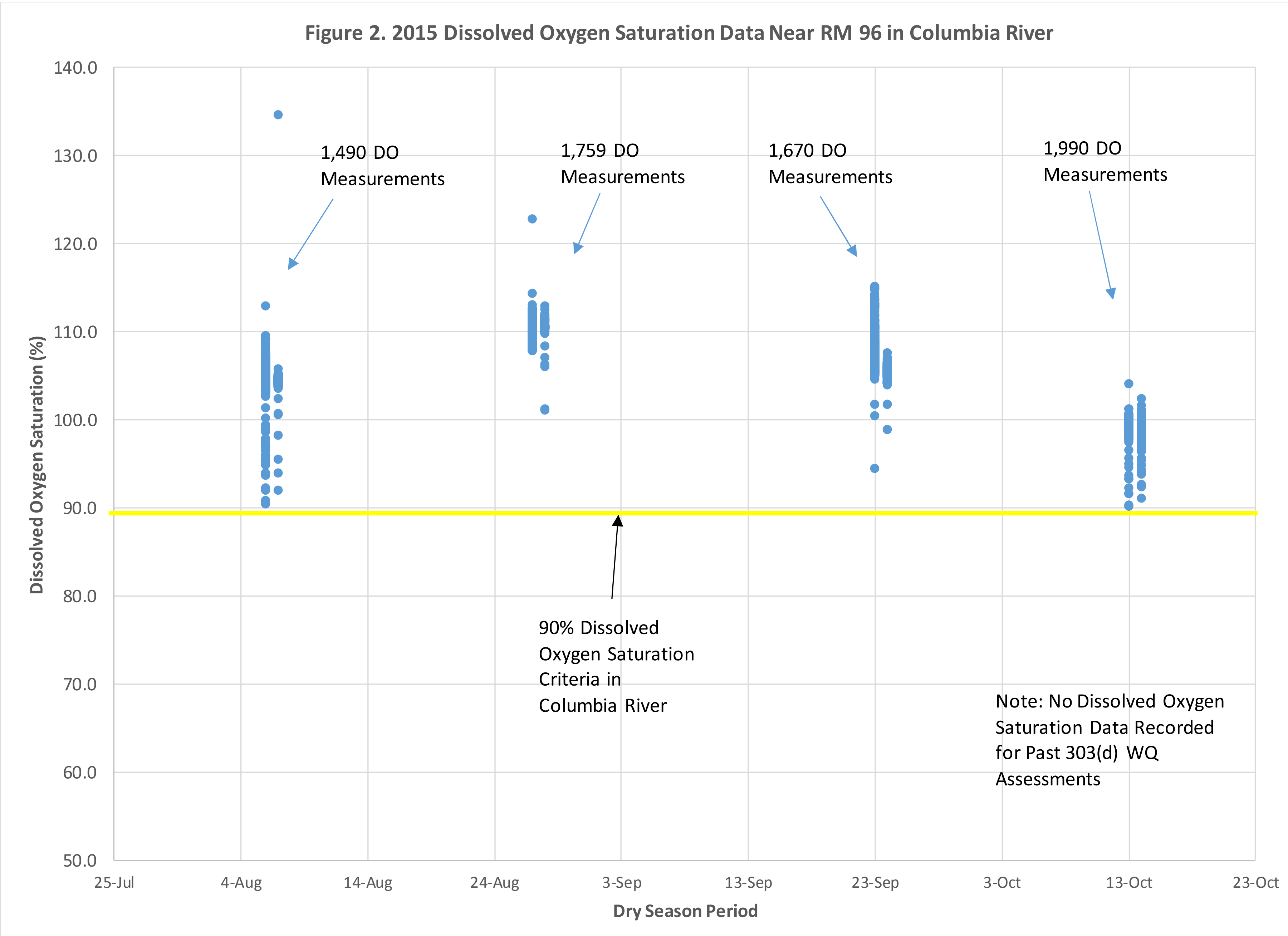
Figure 2. 2015 Dissolved Oxygen Saturation Data Near RM 96 in Columbia River
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
Dissolved Oxygen Saturation (%)
1,490 DO Measurements
1,759 DO Measurements
1,670 DO Measurements
1,990 DO Measurements
90% Dissolved Oxygen Saturation Criteria in Columbia River
Note: No Dissolved Oxygen Saturation Data Recorded for Past 303(d) WQ Assessments
25-Jul
4-Aug
14-Aug
24-Aug
3-Sep
13-Sep
23-Sep
3-Oct
13-Oct
23-Oct
Dry Season Period

## Water Quality Compliance Evaluation

This section provides evaluations of the SCTP Phase 5B discharge compliance with water quality standards for dissolved oxygen, temperature, turbidity, pH, coliform bacteria, dissolved gases, aesthetic water conditions, radioisotope concentrations, toxicity, and toxic substances.

### Dissolved Oxygen

The applicable water quality standard for dissolved oxygen (WAC 173-201A-200(1)(d)) specifies a lowest 1-day minimum dissolved oxygen of 6.5 milligrams per liter (mg/L) during the summer period when salmon rearing and migration may occur, and a lowest 1-day minimum dissolved oxygen of 8.0 mg/L during the period when salmon spawning, rearing, and migration may occur (September 17 to June 13). The aquatic life dissolved oxygen criteria also state that "when a water body's dissolved oxygen (DO) is lower than the criteria in Table 200 (1)(d) (or within 0.2 mg/L of the criteria) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the DO of that water body to decrease more than 0.2 mg/L." Site-specific criteria for the lower Columbia River also specify that "dissolved oxygen shall exceed 90 percent saturation."

As presented in Figures 1 and 2, these 2015 dissolved oxygen data collected near the SCTP existing outfall at RM 96 during critical low flow conditions show 2015 dissolved oxygen measurements and DO saturation values were in compliance with dissolved oxygen criteria. The ongoing 2018 dry season water quality monitoring of the Columbia River will provide Ecology with new field measurements of dissolved oxygen (as well as temperature, pH, and conductivity) under low river flow conditions.

The wastewater discharge influence on the receiving waters can be identified as immediate dissolved oxygen demand that occurs during the rapid dilution process in the river and farfield dissolved oxygen demand that occurs over days as the discharge plume is transported away from the diffuser. To evaluate Columbia River water dissolved oxygen concentrations at the completion of wastewater dilution (at the MZB) Ecology's spreadsheet calculation "Dissolved oxygen concentration following initial dilution" was applied assuming the lowest model-predicted dilution factor at the MZB boundary under 7Q10 low river flow conditions (applied worst-case DF = 59 for dry season; see Table 1). This calculation assumes a conservative effluent dissolved oxygen concentration of 2 mg/L, and an immediate effluent dissolved oxygen demand (DOD) of 2 mg/L. These spreadsheet calculations are provided in Exhibit 1 and 2 in Attachment 2.

Using the mass balance calculation in Ecology's spreadsheet and a conservative assumption that the ambient DO concentration is just above the criteria, the dissolved oxygen concentration in the Columbia River at the SCTP discharge MZB is determined as follows:

$$DO_{ambient} + \left(\frac{DO_{effluent} - DOD_{effluent} - DO_{ambient}}{DF\ at\ the\ MZB}\right) = DO_{mixed}$$

$$6.6\frac{mg}{L} + \left(\frac{3\frac{mg}{L} - \frac{2mg}{L} - 6.6\frac{mg}{L}}{54}\right) = 6.5\frac{mg}{L}$$

And

$$8.1\frac{mg}{L} + \left(\frac{3\frac{mg}{L} - \frac{2mg}{L} - 8.1\frac{mg}{L}}{54}\right) = 8.0\frac{mg}{L}$$

The calculated worst-case decrease in dissolved oxygen is the difference between the dissolved oxygen concentration of the effluent and ambient ($DO_{mixed}$) and the ambient dissolved oxygen ($DO_{ambient}$). According to WAC 173-201A-200(1)(d), a reduction in dissolved oxygen of less than 0.2 mg/L is allowed, even in waterbodies that do not meet the applicable dissolved oxygen criterion. Under these worst-case scenarios, the decrease in dissolved oxygen at the MZB is limited to 0.1 mg/L (during the summer salmon rearing and migration period) and 0.1 mg/L (during the September–June spawning, rearing and migration period). Therefore, the SCTP discharge proposed in the Phase 5B Engineering Report would not cause or contribute to a violation of these DO criteria.

The farfield dissolved oxygen demand on the Columbia River dissolved oxygen concentrations have been evaluated using Ecology's PermitCalc_DOSag spreadsheet model that applies the Streeter-Phelps farfield dissolved model. Ecology's PermitCalc_DOSag calculates the critical DO concentration, travel time to the critical DO concentration, and the distance downstream to the critical DO concentration. The model inputs applied in the farfield DO demand modeling are listed in the model sheets and these include:

Effluent discharge flows for Phase 5B (2022) - applied both maximum day dry weather (16.5 mgd) and maximum month dry weather (13.2 mgd);

Effluent CBOD for Phase 5B treatment operations – 3.83 mg/L;

Effluent NBOD for Phase 5B treatment operations – 0.69 mg/L;

Effluent DO and temperature – 2 mg/L DO and 23.0 degrees C;

River discharge flow at 7Q10 low flow condition – 83,506 cfs;

River upstream CBOD and NBOD – 0.5 mg/L and 1.75 mg/L, respectively; and

River DO and temperature – 8.1 mg/L and 21.1 degrees C;

Reaeration rate in river – 0.20/day (base e) [Based on large river reaeration rate in Bennett & Rathbun (1972) and EPA Surface WQ Modeling Guidance (1985)]

BOD decay rate in river – 0.07 /day (base e) [Based on BOD decay reaction rates in Willamette River by McCutcheon (1983) and EPA Surface WQ Modeling Guidance (1985)]

These Streeter-Phelps DO Sag calculations are provided in Exhibit 3 and 4 in Attachment 2 for the two effluent discharge flows. These farfield DO Sag modeling analyses show a critical DO concentration of 8.09 mg/L for both maximum day and maximum month dry weather effluent discharges for the Phase 5B operations under critical dry season low river flow conditions. The critical DO concentration is 0.01 mg/L below the initial or background river concentration of 8.1 mg/L. The travel time and distance to the critical DO concentration is 1.2 days and 19.9 miles for both Phase 5B effluent discharge rates modeled. Under these worst-case scenarios, the farfield decrease in dissolved oxygen is limited to 0.01 mg/L during critical low river flow conditions and therefore, the SCTP Phase 5B advanced treated effluent would not cause or contribute to an exceedance of DO criteria in the Columbia River.

### Temperature

The temperature standards (WAC 173-201A-200(1)(c)) include narrative and numeric criteria. The lower Columbia River has specific temperature criteria that are defined in WAC 173-201A-602, Table 602. The numeric criteria for the lower Columbia River are:

> "Temperature shall not exceed a 1-day maximum (1-DMax) of 20.0°C due to human activities. When natural conditions exceed a 1-DMax of 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed 0.3°C due to any single source or 1.1°C due to all such activities combined."

In addition, WAC 173-201A-200(1)(c) stipulates that the maximum incremental temperature increase allowed and resulting from an individual point source cannot exceed 28/T+7 (in °C) at the MZB, where T is background temperature. This maximum incremental temperature is only relevant when background river temperatures are equal to or less than 16.3°C.

The temperature standards also have guidelines for preventing acute lethality and barriers to migration of salmonids in WAC 173-201A-200(1c)(vii), as follows:

“(vii) The department will incorporate the following guidelines on preventing acute lethality and barriers to migration of salmonids into determinations of compliance with the narrative requirements for use protection established in this chapter (e.g., WAC 173-201A-310(1), 173-201A-400(4), and 173-201A-410 (1)(c)). The following site-level considerations do not, however, override the temperature criteria established for waters in subsection (1)(c) of this section or WAC 173-201A-600 through 173-201A-602:

(A) Moderately acclimated (16-20°C, or 60.8-68°F) adult and juvenile salmonids will generally be protected from acute lethality by discrete human actions maintaining the 7-DADMax temperature at or below 22°C (71.6°F) and the 1-day maximum (1-DMax) temperature at or below 23°C (73.4°F).

(B) Lethality to developing fish embryos can be expected to occur at a 1-DMax temperature greater than 17.5°C (63.5°F).

(C) To protect aquatic organisms, discharge plume temperatures must be maintained such that fish could not be entrained (based on plume time of travel) for more than two seconds at temperatures above 33°C (91.4°F) to avoid creating areas that will cause near instantaneous lethality.

(D) Barriers to adult salmonid migration are assumed to exist any time the 1-DMax temperature is greater than 22°C (71.6°F) and the adjacent downstream water temperatures are 3°C (5.4°F) or more cooler.”

The compliance temperatures at the MZB in the river for the SCTP wastewater discharge are summarized below. Based on an assumed maximum SCTP effluent temperature of 23°C and minimum dry season dilution factor of 59 at the MZB, each compliance temperature condition has been assessed and the estimated maximum allowable effluent temperature is identified for each, as follows, with answers provided in brackets.

1. Aquatic life temperature criteria (1-day maximum temperature at or below 23°C)—[Maximum effluent temperature prior to discharge = 23.1°C]

2. Site-specific temperature criteria (year-round) = 20.0°C (1-DMax) due to human activities—[Maximum mixed effluent temperature at MZB = 20.06°C]

3. Site-specific temperature criteria (year-round) when natural conditions > 1-DMax of 20.0 °C, then no temperature increase greater than 0.3°C—[Maximum mixed effluent temperature at MZB = 20.06°C; temperature change of 0.06°C]

4. Individual point source (year-round) cannot exceed 28/T+7 at the MZB, where T is background temperature—[not relevant due to high dilutions]

5. Acute lethality protection (adult and juvenile salmon) = 7-DADMax temperature =/< 22°C, and 1-DMax temperature =/< 23°C —[Maximum mixed effluent temperature at AZB = 20.2°C]

6. Acute lethality protection (fish embryo) = 1-DMax temperature < 17.5°C—[not applicable to Columbia River site]

7. Acute lethality protection (fish) = plume discharge temperature after 2 seconds < 33.0°C—[Maximum effluent temperature 23.1°C]

8. Migration protection (adult salmon) = 1-DMax temperature < 22°C, and background river temperature =/> 3°C cooler—[Maximum mixed effluent temperature at MZB = 20.06°C]

To support this screening-level temperature compliance assessment of the SCTP Phase 5B discharge, the temperature calculations described below have been developed.

An energy (mass) balance equation was applied to calculate the excess temperature at the MZB (the difference between the mixed temperature of effluent and river water and the background river temperature or temperature criteria). The worst-case temperature screening evaluation assumed that the river water temperature equals the temperature criterion of 20.0°C (year-round), and applied the maximum measured effluent temperature of 23.10°C (based on effluent data for the period of May 2010 through April 2016).

Using a mass balance equation and applying the following inputs, the mixed temperature increase at the MZB was calculated:

$$(Q_0 \times T_{effluent}) + (Q_{entrain} \times T_{criterion}) = (Q_0 + Q_{entrain}) \times (T_{mixed})$$

where $T_{criterion}$ is the temperature of the receiving stream (based on applicable temperature criterion, $T_{criterion}$ = 20.0°C), $T_{effluent}$ is the maximum daily effluent temperature ($T_{effluent}$ = 23.0°C), $Q_0$ represents the effluent dilution factor prior to dilution ($Q_0$ = 1), and $Q_{entrain}$ is the river dilution portion that mixes with the effluent, $Q_{entrain}$ = 59.

Using the model-predicted dry season minimum dilution factor of 59 at the MZB, $Q_o$ = 1 (by definition) and $Q_{entrain}$ = 58, solving the equation for $T_{mixed}$ yields:

$$\frac{(1 \times 23.10°C) + (58 \times 20.0°C)}{59} = T_{mixed} = 20.05°C$$

The average temperature increase is the difference between the temperature of combined wastewater and stream mixture at the mixing zone boundary ($T_{mixed}$) and the applicable stream temperature criterion ($T_{criterion}$), or (20.05°C) – (20.0°C) = 0.05°C. Therefore, at the flows proposed in the Phase 5B Engineering Report, the estimated worst-case excess temperature difference is 0.05°C, and it is, therefore, not a "measurable" temperature increase (defined as *greater* than 0.3°C).

### Turbidity

The turbidity criterion allows a maximum turbidity change at the MZB of 5 nephelometric turbidity units (NTU) when background river turbidity is 50 NTU or less, and up to a 10 percent increase in stream turbidity when background river turbidity is greater than 50 NTU (WAC 173-201A-200(1)(e). SCTP is not required to monitor effluent turbidity or receiving water turbidity, and there are no turbidity values.

Based on the model-predicted dilution factors at the MZB summarized in Table 1, the effluent discharged through the SCTP outfall diffuser will be diluted by a minimum dry season dilution factor of 59 and a minimum wet season dilution factor of 54, and the mixed effluent and river turbidity will not exceed the turbidity criterion.

### Total Dissolved Gas

The numeric and narrative standards for total dissolved gas are set forth in WAC 173-201A-200(1)(f), which limits dissolved gases in freshwater to less than 110 percent of saturation. The SCTP discharge will not release dissolved gases such as hydrogen sulfide, carbon dioxide, or other gases that would cause or contribute to a violation of this criterion in the Columbia River. The treated wastewater discharged to the Columbia River will contain dissolved oxygen as the only significant dissolved gas and will not exceed 110 percent saturation for dissolved gases. Therefore, the SCTP discharge would not cause or contribute to a violation of this criterion.

### pH

The effluent pH limit in the NPDES permit is a daily maximum of 6.0 to 9.0 standard units. The applicable pH standard for the Columbia River (WAC 173-201A-200(1)(g)) is between 6.5 and 8.5. According to effluent data from January 2010 through June 2015, effluent pH has remained between 6.13 and 7.39. Based on a calculation of the mixed pH at the MZB using Ecology's Reasonable Potential Analysis (RPA) calculation spreadsheet (March 2015 version), the worst-case mixed pH at the MZB would not be less than 6.5 or more than 8.5. Therefore, the SCTP discharge would not cause or contribute to a violation of this criterion.

### Bacteria

The numeric and narrative bacterial standards are set forth in WAC 173-201A, Table 200(2)(b). The freshwater bacteria criterion for primary contact recreation applicable in the lower Columbia River specify that "fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL [milliliter], with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies/100 mL." Because the SCTP uses ultraviolet light disinfection to treat the wastewater before discharge, and the capacity of the disinfection unit process exceeds the Phase 5 flows, discharge would not cause or contribute to a violation of this criterion.

### Radioisotopes

WAC 173-201A-250 prohibits radioisotope concentrations in excess of maximum permissible concentrations defined in federal statutes. The influent flow and loads are not known to contain radioisotopes, and SCTP treatment unit processes are not known to create or concentrate such isotopies. Therefore, the discharge is not expected to contain any radioisotopes.

### Toxic Substances

WAC 173-201A-240 prohibits discharge of toxic pollutants in amounts that may be harmful to beneficial uses. WAC 173-201A-240, Table 240(3), establishes numeric criteria for the protection of aquatic organisms in freshwater and marine water, and the EPA-approved numeric criteria for the protection of human health were established in November 2016. An evaluation of the dilution factors required for the SCTP effluent maximum discharge concentrations to comply with the aquatic life and human health-based water quality criteria is presented in Table 2.

The dilution factors required for SCTP effluent compliance with acute aquatic life criteria is 8 (based on copper) and 13 (based on cyanide method detection limits, not measured cyanide). The minimum model-predicted acute dilution factor is 14 under dry season conditions. The dilution factors required for SCTP effluent compliance with chronic aquatic life criteria is 12 (based on copper) and 20 (based on ammonia in the wet season). The minimum model-predicted chronic dilution factor is 59 under dry season conditions and 54 under wet season conditions. The effluent ammonia concentrations applied in this screening analysis (Table 2) represents effluent concentrations in 2011-2015 (9.4 mg/L maximum in wet season and 11.0 mg/L in dry season), and the SCTP Phase 5B effluent ammonia concentration will be lower as a result of treatment improvements.

For human health-based criteria, a required dilution factor of 125 is calculated for arsenic; however, the receiving water data show that the current approved human health criteria for arsenic is lower than the measured background arsenic concentrations in the Columbia River by an order of magnitude and is therefore not attainable. In addition, three other detected chemicals that require high dilution factors were Bis(2-Ethylhexyl)Phthalate and pesticides beta-BHC and heptachlor. The pesticides beta-BHC and heptachlor are legacy pesticides and no longer sold, so these may be due to a private residence's improper disposal of old pesticides into the sewage system, and ongoing monitoring will resolve these sources. Bis(2-Ethylhexyl)Phthalate is ubiquitous in municipal wastewater effluents and state and federal restriction could be needed to reduce their sources to sewage systems.

## Antidegradation Rule

Washington's antidegradation rule is defined in WAC 173-201A-300, and the rule specifies the following purpose of the antidegradation policy:

"(a) Restore and maintain the highest possible quality of the surface waters of Washington;

(b) Describe situations under which water quality may be lowered from its current condition;

(c) Apply to human activities that are likely to have an impact on the water quality of a surface water;

(d) Ensure that all human activities that are likely to contribute to a lowering of water quality, at a minimum, apply all known, available, and reasonable methods of prevention, control, and treatment (AKART); and

(e) Apply three levels of protection for surface waters of the state, as generally described below:

(i) Tier I is used to ensure existing and designated uses are maintained and protected and applies to all waters and all sources of pollution.

(ii) Tier II is used to ensure that waters of a higher quality than the criteria assigned in this chapter are not degraded unless such lowering of water quality is necessary and in the overriding public interest. Tier II applies only to a specific list of polluting activities.

(iii) Tier III is used to prevent the degradation of waters formally listed in this chapter as "outstanding resource waters," and applies to all sources of pollution."

Washington's antidegradation rule provides the three levels of protection (Tiers I, II, and III) listed above. Tier I protections include maintaining and protecting existing designated uses, improving water quality conditions to align with water quality standards and protect existing designated uses, and identifying where natural conditions (exclusive of human actions) do not allow water quality standards to be met. Washington's antidegradation rule also provides that waterbodies "may not be further degraded" except as authorized by the rule (refer to WAC 173-201A-310(1)).

Tier II antidegradation protections address "new or expanded actions … that are expected to cause a measurable change in the quality of the water," and such actions "may not be allowed unless the department determines that the lowering of water quality is necessary and in the overriding public interest" (refer to WAC 173-201A-320(1)). Ecology has specified in the rule that a Tier II review will only be conducted for new or expanded actions. Public involvement with the Tier II review are conducted in accordance with the processes associated with NPDES discharge permits, as well as other permitting.

Ecology has interpreted "degradation" as a "measurable change in water quality" away from conditions unaffected by the source area (after allowing for mixing consistent with WAC 173-201A-400(7)). In the context of this rule, a measurable change is defined by Ecology as a:

(a) Temperature increase of 0.3°C or greater
(b) Dissolved oxygen decrease of 0.2 mg/L or greater
(c) Bacteria level increase of 2 colony forming units/100 mL or greater
(d) pH change of 0.1 units or greater
(e) Turbidity increase of 0.5 NTU or greater, or
(f) Any detectable increase in the concentration of a toxic or radioactive substance

Ecology rules specifies that "to determine that a lowering of water quality is necessary and in the overriding public interest, an analysis must be conducted for new or expanded actions when the resulting action has the potential to cause a measurable change in the physical, chemical, or biological quality of a water body." The preceding evaluation of water quality standards compliance for the SCTP Phase 5B wastewater discharge to the Columbia River provides specific results to demonstrate that the discharge will not cause a measurable change in the river water quality.

**Table 2**

**Evaluation of Dilution Requirements for Water Quality Compliance for the Salmon Creek Treatment Plant Outfall 001 Discharge to the Columbia River**

*Salmon Creek WWTP Phase 5B Project*

| Parameter | Water Quality Criteria[a] | | | No. of Effluent Samples | Maximum Effluent Concentration (2011-2015) (ug/L) | | Reasonable Potential Multiplying Factor (95% Confidence Limit & 95% Probability)[d] | Human Health Reasonable Potential Multiplying Factor | Upper 90th-% Background River Concentration (µg/L)[e] | Median Background River Concentration (µg/L)[e] | Aquatic Life | | Human Health |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aquatic Life | | 2016 Final CWA-Effective Human Health Criteria[g] | | | | | | | | Minimum Dilution to Meet WQ Criteria at Acute Zone Boundary[f] | Minimum Dilution to Meet WQ Criteria at Mixing Zone Boundary[f] | Minimum Dilution to Meet HH-WQ Criteria at Mixing Zone Boundary[f] |
| | Acute (µg/L)[b] | Chronic (µg/L)[c] | (µg/L) | | | | | | | | | | |
| Antimony | -- | -- | 6 | 19 | 0.22 | | 1.39 | 0.55 | 0.1 | 0.1 | -- | -- | 0.04 |
| Arsenic[i] | 360 | 190 | 0.018 | 19 | 1.85 | | 1.39 | 0.55 | 1.24 | 1.24 | 0.01 | 0.02 | 125 |
| Cadmium | 2.1 | 0.7 | -- | 19 | 0.03 | 1/2 DL | 1.39 | -- | 0.1 | 0.1 | 0.1 | 0.2 | -- |
| Chromium (+3) | 336 | 112 | -- | 19 | 0.56 | | 1.39 | -- | 0.44 | 0.44 | 0.004 | 0.01 | -- |
| Copper | 10.3 | 7.0 | 1300 | 19 | 59.6 | | 1.39 | 0.55 | 0.8 | 0.8 | 8 | 12 | 0.03 |
| Lead | 36.1 | 1.4 | -- | 19 | 0.47 | | 1.39 | -- | 0.13 | 0.13 | 0.02 | 1 | -- |
| Mercury | 2.1 | 0.012 | 0.14 | 9 | 0.0024 | | 1.81 | 0.70 | 0.0068 | 0.0068 | 0.01 | 1 | 0.1 |
| Nickel | 904.5 | 97.7 | 80 | 19 | 1.5 | | 1.39 | 0.55 | 0.83 | 0.83 | 0.003 | 0.03 | 0.02 |
| Selenium | 20 | 5.0 | 60 | 19 | 0.2 | | 1.39 | 0.55 | 0.5 | 0.5 | 0.04 | 0.2 | 0.01 |
| Silver | 1.4 | -- | -- | 19 | 0.03 | | 1.39 | -- | 0.01 | 0.01 | 0.04 | -- | -- |
| Thallium | -- | -- | 1.7 | 19 | 0.05 | 1/2 DL | 1.39 | 0.55 | 0.01 | 0.01 | -- | -- | 0.02 |
| Zinc | 73.1 | 64.9 | 1000 | 19 | 60.0 | | 1.39 | 0.55 | 4.5 | 4.5 | 1 | 1 | 0.04 |
| Cyanide | 1.0 | 5.2 | 9 | 4 | 5.0 | 1/2 DL | 2.59 | 0.93 | 0.0 | 0 | 13 | 2 | 1 |
| Bis(2-Ethylhexyl)Phthlate | -- | -- | 0.045 | 4 | 16.8 | | 2.59 | 0.93 | 0.0 | 0 | -- | -- | 349 |
| 1,2-Dichloroethane | -- | -- | 8.9 | 4 | 0.5 | 1/2 DL | 2.59 | 0.93 | 0.0 | 0 | -- | -- | 0.1 |
| Dichlorobromomethane | -- | -- | 0.73 | 4 | 0.5 | 1/2 DL | 2.59 | 0.93 | 0.0 | 0 | -- | -- | 1 |
| Benzene | -- | -- | 0.44 | 4 | 0.5 | 1/2 DL | 2.59 | 0.93 | 0.0 | 0 | -- | -- | 1 |
| beta-BHC (pesticide) | | | 0.0013 | 4 | 0.02 | j | 2.59 | 0.93 | 0.0 | 0 | -- | -- | 14 |
| Heptachlor (pesticide) | 0.53 | 0.0036 | 0.00000034 | 4 | 0.019 | j | 2.59 | 0.93 | 0.0 | 0 | 0.1 | 14 | 52172 |
| Chloroform | -- | -- | 100 | 4 | 0.5 | 1/2 DL | 2.59 | 0.93 | 0.0 | 0 | -- | -- | 0.005 |
| Napthalene | -- | -- | -- | 4 | 0.2 | 1/2 DL | 2.59 | 0.93 | 0.0 | 0 | -- | -- | -- |
| Toluene | -- | -- | 72 | 4 | 1.1 | | 2.59 | 0.93 | 0.0 | 0 | -- | -- | 0.01 |
| Phenol | -- | -- | 9000 | 4 | 10 | 1/2 DL | 2.59 | 0.93 | 0.0 | 0 | -- | -- | 0.001 |
| Ammonia 2011-15 (Dry Season)[h] | 2310 | 299 | -- | 264 | 11000 | | 1.0 | | 50 | 30 | **5** | **37** | -- |
| Ammonia 2011-15 (Wet Season) | 2310 | 473 | -- | 256 | 9400 | | 1.0 | | 50 | 30 | **4** | **20** | -- |

**Note:**

a Freshwater acute & chronic criteria from Chapter 173-201A-240 WAC (2016) Water Quality Standards for Washington. Human health criteria are existing 2016 water quality standards. Mixed river and effluent hardness of 58.5 mg/L (acute)

b The freshwater acute criteria is a 1-hour average concentration not to be exceeded more than once every three years on the average, with the exception of silver, which is an instantaneous concentration not to be exceeded at any time.

c The freshwater chronic criteria is a 4-day average concentration not to be exceeded more than once every three years on the average.

d The reasonable potential multiplying factor assumes a coefficient of variation of 0.6, based on guidance on Table 3-2 (p.54) in the Technical Support Document (EPA, 1991) and Ecology's RPA spreadsheet.

e Background receiving water analytical data collected during ebb tide conditions in August to October 2015 near Columbia River RM 96. These background river data are based on clean sampling and low detection analytical methods.

f The acute zone boundary for the outfall is point of acute aquatic life criteria compliance and the chronic mixing zone boundary is the point of chronic aquatic life and human health criteria compliance.

g The revised water quality criteria for human health (HHC) were made effective by EPA on 12/28/2016. The lowest HHC - water & organisms or organisms only - is presented in this table for compliance assessment.

h Total ammonia as N. Criteria calculated using worst-case receiving water pH of 8.5 and temperature of 22.0°C (summer-dry season; May-Oct) and worst-case pH of 8.5 and temperature of 15 °C (winter- wet season; Nov-April).

i Note that the current HHC for arsenic is lower than the concentration in the Columbia River and therefore not attainable.

j Single detected values reported from priority pollutant samples collected in 2012 and no other detected values in 2011, 2013, and 2014 samples.

## Acute and Chronic Toxicity

The most recent permit requires the SCTP to perform quarterly acute and bi-annually chronic whole effluent toxicity (WET) testing. All of the required WET test results have been in compliance with the permit effluent limits for both acute and chronic toxicity since 2011 through 2015. Because the projected Phase 5B discharge is not expected to result in an increase in pollutant concentrations, it is not expected to cause or contribute to a violation of acute and chronic toxicity criteria.

# Biological Resources and Uses of the Columbia River

The Columbia River supports both anadromous and non-anadromous (resident) species of fish. At the SCTP outfall discharge site, the Columbia River is used by anadromous fish primarily for migration. Fourteen salmonids are federally listed as threatened or endangered within this watershed. Juvenile salmon occur in the river estuary all year, as different species, size classes, and life history types continually move downstream and enter tidal waters from upstream.

StreamNet (2012) shows the following fish uses in the Columbia River in the vicinity of the SCTP outfall site:

- Spring, summer, and fall Chinook—migration
- Coho—rearing and migration
- Summer and winter steelhead—migration
- Sockeye—migration
- Chum—migration
- Pink—migration
- Bull trout—migration

Lower Columbia River Chinook salmon and Lower Columbia River steelhead are federal threatened species under the Endangered Species Act (ESA), and critical habitat was designated for both species in 2000 (National Marine Fisheries Service [NMFS] and National Oceanic and Atmospheric Administration [NOAA], 2000). The Columbia River is included as critical habitat for the lower Columbia River Chinook salmon and lower Columbia River steelhead (StreamNet, 2012). These species use the lower Columbia River for rearing and migration.

Lower Columbia River coho salmon is a state endangered and federal threatened species, and no critical habitat has been designated for the lower Columbia River coho salmon. Columbia River chum salmon is a federal threatened species, and critical habitat was designated for Columbia River chum salmon in 2000 (NMFS and NOAA, 2000).

NOAA NMFS listed river eulachon (also known as “smelt”) for protection under the ESA on May 17, 2010. Eulachon (*Thaleichthys pacificus*) ascend the Columbia River to spawn in the lower mainstem and tributaries. The lower Columbia River is included in the listing of critical habitat areas for eulachon (NOAA, 2012).

The SCTP discharge is rapidly diluted and it does not have any adverse effects on the listed salmonid species, eulachon, or their aquatic habitat. As reviewed in the preceding section, the SCTP discharge does not and will not cause or contribute to violations of temperature or other instream water quality standards. These standards have been developed to protect sensitive cold-water aquatic organisms, including ESA-listed species, and there are no uniquely sensitive species using the lower Columbia River that would not be adequately protected by these standards.

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# Attachment 1
# UM3 Model Input and Output

/ UM3. 7/26/2017 8:17:33 AM

**Case** **5B1;** ambient file c:\plumes\ plume 10.001.db; Diffuser table record 1:00 ---------------------------------

Ambient Table:

| Depth | Amb-cur | Amb-dir | Amb-sal | Amb-tem | Amb-pol | Decay | Far-spd | Far-dir | Disprsn | Density |
|---|---|---|---|---|---|---|---|---|---|---|
| m | m/s | deg | psu | C | kg/kg | s-1 | m/s | deg | m0.67/s2 | sigma-T |
| 0 | 0.129 | 90 | 0.08 | 21.1 | 0 | 0 | 0.129 | 90 | 0.00068 | -1.906 |
| 6 | 0.129 | 90 | 0.08 | 21.1 | 0 | 0 | 0.129 | 90 | 0.00068 | -1.906 |

Diffuser table:

| P-dia | P-elev | V-angle | H-angle | Ports | Spacing | AcuteMZ | ChrncMZ | P-depth | Ttl-flo | Eff-sal | Temp | Polutnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) | (m) | (deg) | (deg) | () | (m) | (m) | (m) | (m) | (MGD) | (psu) | (C) | (%) |
| 0.249 | 0.61 | 0 | 169 | 5 | 3.05 | 7.4 | 74 | 5.18 | 16.5 | 0 | 23 | 100 |

Simulation:

Froude number: 85.44; effleunt density (sigma-T) -2.399; effleunt velocity 2.969(m/s);

| Step | Depth | Amb-cur | P-dia | Polutnt | Dilutn | CL-diln | x-posn | y-posn | Time | **Distance** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (m) | (m/s) | (m) | (%) | () | () | (m) | (m) | (s) | **(m)** | |
| 0 | 5.18 | 0.129 | 0.249 | 100 | 1 | 1 | 0 | 0 | 0.0; | **0.00** | |
| 10 | 5.18 | 0.129 | 0.3 | 82.03 | 1.219 | 1 | -0.115 | 0.023 | 0.0442; | **0.12** | |
| 20 | 5.18 | 0.129 | 0.366 | 67.3 | 1.486 | 1 | -0.251 | 0.0516 | 0.108; | **0.26** | |
| 30 | 5.18 | 0.129 | 0.445 | 55.21 | 1.811 | 1 | -0.411 | 0.0873 | 0.199; | **0.42** | |
| 40 | 5.18 | 0.129 | 0.541 | 45.29 | 2.207 | 1.133 | -0.597 | 0.132 | 0.329; | **0.61** | |
| 50 | 5.18 | 0.129 | 0.658 | 37.15 | 2.691 | 1.376 | -0.813 | 0.188 | 0.512; | **0.83** | |
| 60 | 5.179 | 0.129 | 0.8 | 30.48 | 3.28 | 1.669 | -1.06 | 0.258 | 0.768; | **1.09** | |
| 70 | 5.179 | 0.129 | 0.971 | 25 | 3.998 | 2.021 | -1.341 | 0.346 | 1.122; | **1.38** | |
| 80 | 5.178 | 0.129 | 1.176 | 20.51 | 4.874 | 2.442 | -1.657 | 0.456 | 1.607; | **1.72** | |
| 90 | 5.177 | 0.129 | 1.423 | 16.83 | 5.941 | 2.94 | -2.008 | 0.593 | 2.263; | **2.09** | |
| 100 | 5.175 | 0.129 | 1.716 | 13.8 | 7.242 | 3.526 | -2.391 | 0.764 | 3.137; | **2.51** | |
| 110 | 5.173 | 0.129 | 2.064 | 11.32 | 8.827 | 4.205 | -2.804 | 0.974 | 4.285; | **2.97** | |
| 120 | 5.169 | 0.129 | 2.471 | 9.289 | 10.76 | 4.983 | -3.243 | 1.231 | 5.77; | **3.47** | |
| 124 | 5.168 | 0.129 | 2.651 | 8.582 | 11.65 | 5.321 | -3.424 | 1.349 | 6.473; | **3.68** | bottom hit; |
| 128 | 5.165 | 0.129 | 2.837 | 7.958 | 12.56 | 5.687 | -3.624 | 1.488 | 7.316; | **3.92** | merging; |
| 130 | 5.163 | 0.129 | 2.946 | 7.649 | 13.07 | 5.951 | -3.827 | 1.635 | 8.22; | **4.16** | |
| 140 | 5.139 | 0.129 | 3.805 | 6.275 | 15.93 | 7.83 | -5.111 | 2.661 | 14.68; | **5.76** | |
| | | | | | **18** | | | | | **6.7** | **acute zone (6.7 m)** |
| 149 | 5.097 | 0.129 | 5.03 | 5.251 | 19.04 | 11.2 | -6.451 | 3.908 | 22.79; | **7.54** | |
| 150 | 5.092 | 0.129 | 5.198 | 5.148 | 19.42 | 11.52 | -6.604 | 4.062 | 23.8; | **7.75** | |
| 160 | 5.02 | 0.129 | 7.294 | 4.223 | 23.67 | 13.54 | -8.104 | 5.726 | 34.96; | **9.92** | |
| 170 | 4.929 | 0.129 | 10.34 | 3.464 | 28.85 | 15.89 | -9.463 | 7.517 | 47.26; | **12.09** | |
| 178 | 4.85 | 0.129 | 13.68 | 2.957 | 33.81 | 18.08 | -10.4 | 8.967 | 57.41; | **13.73** | matched energy radial vel = 0.117m/s; |
| 180 | 4.829 | 0.129 | 14.67 | 2.842 | 35.17 | 18.68 | -10.61 | 9.327 | 59.95; | **14.13** | |
| 190 | 4.729 | 0.129 | 20.75 | 2.331 | 42.87 | 22.02 | -11.55 | 11.1 | 72.57; | **16.02** | |
| 192 | 4.709 | 0.129 | 22.23 | 2.241 | 44.61 | 22.77 | -11.72 | 11.44 | 75.07; | **16.38** | surface; |

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 26.4 m

| conc | dilutn | width | distnce | time | | | | |
|---|---|---|---|---|---|---|---|---|
| (%) | | (m) | (m) | (hrs) | (kg/kg) | (s-1) | /s)(m0.67/s2) | |
| 2.23727 | 44.68 | 27.07 | 20 | 0.0078 | 0 | 0 | 0.129 | 6.80E-04 |
| 2.2391 | 44.64 | 27.98 | 25 | 0.0186 | 0 | 0 | 0.129 | 6.80E-04 |
| 2.2397 | 44.63 | 28.85 | 30 | 0.0293 | 0 | 0 | 0.129 | 6.80E-04 |
| 2.23865 | 44.65 | 29.7 | 35 | 0.0401 | 0 | 0 | 0.129 | 6.80E-04 |
| 2.23431 | 44.73 | 30.53 | 40 | 0.0509 | 0 | 0 | 0.129 | 6.80E-04 |
| 2.22553 | 44.91 | 31.33 | 45 | 0.0616 | 0 | 0 | 0.129 | 6.80E-04 |
| 2.21282 | 45.17 | 32.11 | 50 | 0.0724 | 0 | 0 | 0.129 | 6.80E-04 |
| 2.19666 | 45.5 | 32.88 | 55 | 0.0832 | 0 | 0 | 0.129 | 6.80E-04 |
| 2.17763 | 45.9 | 33.63 | 60 | 0.0939 | 0 | 0 | 0.129 | 6.80E-04 |
| 2.1566 | 46.35 | 34.36 | 65 | 0.105 | 0 | 0 | 0.129 | 6.80E-04 |
| 2.13379 | 46.84 | 35.07 | 70 | 0.115 | 0 | 0 | 0.129 | 6.80E-04 |
| 2.11026 | 47.37 | 35.78 | 75 | 0.126 | 0 | 0 | 0.129 | 6.80E-04 |

count: 12

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8:17:33 AM. amb fills: 2

/ UM3. 7/26/2017 8:18:28 AM

**Case** **5B2;** ambient file c:\plumes\ plume 10.001.db; Diffuser table record 1:00 ---------------------------------

Ambient Table:

| Depth | Amb-cur | Amb-dir | Amb-sal | Amb-tem | Amb-pol | Decay | Far-spd | Far-dir | Disprsn | Density |
|---|---|---|---|---|---|---|---|---|---|---|
| m | m/s | deg | psu | C | kg/kg | s-1 | m/s | deg | m0.67/s2 | sigma-T |
| 0 | 0.376 | 90 | 0.08 | 21.1 | 0 | 0 | 0.376 | 90 | 0.00068 | -1.906 |
| 6 | 0.376 | 90 | 0.08 | 21.1 | 0 | 0 | 0.376 | 90 | 0.00068 | -1.906 |

Diffuser table:

| P-dia | P-elev | V-angle | H-angle | Ports | Spacing | AcuteMZ | ChrncMZ | P-depth | Ttl-flo | Eff-sal | Temp | Polutnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) | (m) | (deg) | (deg) | () | (m) | (m) | (m) | (m) | (MGD) | (psu) | (C) | (%) |
| 0.249 | 0.61 | 0 | 169 | 5 | 3.05 | 7.4 | 74 | 5.18 | 16.5 | 0 | 23 | 100 |

Simulation:

Froude number: 85.44; effleunt density (sigma-T) -2.399; effleunt velocity 2.969(m/s);

| Step | Depth | Amb-cur | P-dia | Polutnt | Dilutn | CL-diln | x-posn | y-posn | Time | **Distance** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (m) | (m/s) | (m) | (%) | () | () | (m) | (m) | (s) | **(m)** | |
| 0 | 5.18 | 0.376 | 0.249 | 100 | 1 | 1 | 0 | 0 | 0.0; | **0.00** | |
| 10 | 5.18 | 0.376 | 0.3 | 82.03 | 1.219 | 1 | -0.0916 | 0.0192 | 0.0352; | **0.09** | |
| 20 | 5.18 | 0.376 | 0.364 | 67.3 | 1.486 | 1 | -0.195 | 0.0442 | 0.0836; | **0.20** | |
| 30 | 5.18 | 0.376 | 0.441 | 55.21 | 1.811 | 1 | -0.311 | 0.0766 | 0.15; | **0.32** | |
| 40 | 5.18 | 0.376 | 0.534 | 45.29 | 2.207 | 1.095 | -0.438 | 0.118 | 0.238; | **0.45** | |
| 50 | 5.18 | 0.376 | 0.645 | 37.15 | 2.691 | 1.311 | -0.577 | 0.172 | 0.356; | **0.60** | |
| 60 | 5.18 | 0.376 | 0.775 | 30.48 | 3.28 | 1.559 | -0.726 | 0.239 | 0.509; | **0.76** | |
| 70 | 5.18 | 0.376 | 0.927 | 25 | 3.998 | 1.841 | -0.882 | 0.323 | 0.706; | **0.94** | |
| 80 | 5.179 | 0.376 | 1.103 | 20.51 | 4.874 | 2.154 | -1.044 | 0.427 | 0.954; | **1.13** | |
| 90 | 5.179 | 0.376 | 1.301 | 16.83 | 5.941 | 2.498 | -1.21 | 0.554 | 1.264; | **1.33** | |
| 100 | 5.179 | 0.376 | 1.523 | 13.8 | 7.242 | 2.873 | -1.378 | 0.709 | 1.646; | **1.55** | |
| 110 | 5.178 | 0.376 | 1.766 | 11.32 | 8.827 | 3.288 | -1.548 | 0.898 | 2.12; | **1.79** | |
| 120 | 5.177 | 0.376 | 2.029 | 9.289 | 10.76 | 3.758 | -1.723 | 1.133 | 2.713; | **2.06** | |
| 124 | 5.177 | 0.376 | 2.14 | 8.582 | 11.65 | 3.981 | -1.795 | 1.242 | 2.992; | **2.18** | merging; |
| 127 | 5.177 | 0.376 | 2.228 | 8.175 | 12.23 | 4.219 | -1.898 | 1.409 | 3.418; | **2.36** | bottom hit; |
| 130 | 5.175 | 0.376 | 2.361 | 7.703 | 12.98 | 4.563 | -2.074 | 1.709 | 4.186; | **2.69** | |
| 140 | 5.17 | 0.376 | 3.029 | 6.319 | 15.82 | 6.573 | -2.669 | 2.86 | 7.143; | **3.91** | |
| 150 | 5.162 | 0.376 | 4.063 | 5.184 | 19.28 | 9.428 | -3.221 | 4.155 | 10.49; | **5.26** | |
| 160 | 5.152 | 0.376 | 5.541 | 4.253 | 23.5 | 11.25 | -3.717 | 5.561 | 14.14; | **6.69** | |
| | | | | | **24** | | | | | **6.7** | **acute zone (6.7 m)** |
| 165 | 5.147 | 0.376 | 6.479 | 3.852 | 25.95 | 12.31 | -3.944 | 6.307 | 16.09; | **7.44** | |
| 170 | 5.141 | 0.376 | 7.572 | 3.489 | 28.65 | 13.48 | -4.159 | 7.086 | 18.12; | **8.22** | |
| 180 | 5.127 | 0.376 | 10.3 | 2.862 | 34.92 | 16.24 | -4.56 | 8.767 | 22.52; | **9.88** | |
| 190 | 5.112 | 0.376 | 13.9 | 2.348 | 42.57 | 19.62 | -4.931 | 10.65 | 27.48; | **11.74** | |
| 192 | 5.109 | 0.376 | 14.74 | 2.257 | 44.29 | 20.38 | -5.002 | 11.06 | 28.55; | **12.14** | matched energy radial vel = 0.278m/s; |
| 200 | 5.095 | 0.376 | 18.33 | 1.926 | 51.9 | 23.76 | -5.287 | 12.86 | 33.29; | **13.90** | |
| 208 | 5.071 | 0.376 | 21.61 | 1.644 | 60.8 | 27.73 | -5.688 | 15.84 | 41.14; | **16.83** | surface; |

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 25.78 m

| conc | dilutn | width | distnce | time | | | | |
|---|---|---|---|---|---|---|---|---|
| (%) | | (m) | (m) | (hrs) | (kg/kg) | (s-1) | /s)(m0.67/s2) | |
| 1.63888 | 60.99 | 25.98 | 20 | 0.00234 | 0 | 0 | 0.376 | 6.80E-04 |
| 1.64081 | 60.92 | 26.3 | 25 | 0.00604 | 0 | 0 | 0.376 | 6.80E-04 |
| 1.64166 | 60.88 | 26.61 | 30 | 0.00973 | 0 | 0 | 0.376 | 6.80E-04 |
| 1.64217 | 60.87 | 26.92 | 35 | 0.0134 | 0 | 0 | 0.376 | 6.80E-04 |
| 1.64252 | 60.85 | 27.22 | 40 | 0.0171 | 0 | 0 | 0.376 | 6.80E-04 |
| 1.64277 | 60.84 | 27.53 | 45 | 0.0208 | 0 | 0 | 0.376 | 6.80E-04 |
| 1.64295 | 60.84 | 27.83 | 50 | 0.0245 | 0 | 0 | 0.376 | 6.80E-04 |
| 1.64304 | 60.83 | 28.12 | 55 | 0.0282 | 0 | 0 | 0.376 | 6.80E-04 |
| 1.643 | 60.83 | 28.41 | 60 | 0.0319 | 0 | 0 | 0.376 | 6.80E-04 |
| 1.64277 | 60.84 | 28.7 | 65 | 0.0356 | 0 | 0 | 0.376 | 6.80E-04 |
| 1.6423 | 60.86 | 28.99 | 70 | 0.0393 | 0 | 0 | 0.376 | 6.80E-04 |
| 1.64154 | 60.89 | 29.27 | 75 | 0.043 | 0 | 0 | 0.376 | 6.80E-04 |

count: 12

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| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| / | UM3. | 7/26/2017 | 9:01:43 AM | | | | | | | | | | |
| **Case** | **5B3;** | ambient | file | C:\Plumes\Diffuser | table | | record | | 1:00 --------------------------------- | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ambient | Table: | | | | | | | | | | |
| | Depth | Amb-cur | Amb-dir | Amb-sal | Amb-tem | Amb-pol | Decay | Far-spd | Far-dir | Disprsn | Density |
| | m | m/s | deg | psu | C | kg/kg | s-1 | m/s | deg | m0.67/s2 | sigma-T |
| | 0 | 0.042 | 90 | 0.08 | 21.1 | 0 | 0 | 0.042 | 90 | 0.00068 | -1.906 |
| | 6 | 0.042 | 90 | 0.08 | 21.1 | 0 | 0 | 0.042 | 90 | 0.00068 | -1.906 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diffuser | table: | | | | | | | | | | | | |
| | P-dia | P-elev | V-angle | H-angle | Ports | Spacing | AcuteMZ | ChrncMZ | P-depth | Ttl-flo | Eff-sal | Temp | Polutnt |
| | (m) | (m) | (deg) | (deg) | () | (m) | (m) | (m) | (m) | (MGD) | (psu) | (C) | (%) |
| | 0.249 | 0.61 | 0 | 169 | 5 | 3.05 | 7.4 | 74 | 5.18 | 16.5 | 0 | 23 | 100 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Simulation: | | | | | | | | | | | | | | | | | |
| Froude | number: | 85.44; | effleunt | density | (sigma-T) | -2.399; | effleunt | velocity | 2.969(m/s); | | | | | | | | |
| | | Depth | Amb-cur | P-dia | Polutnt | Dilutn | CL-diln | x-posn | y-posn | Time | **Distance** | | | | | | |
| | Step | (m) | (m/s) | (m) | (%) | () | () | (m) | (m) | (s) | **(m)** | | | | | | |
| | 0 | 5.18 | 0.042 | 0.249 | 100 | 1 | 1 | 0 | 0 | 0.0; | **0.00** | | | | | | |
| | 10 | 5.18 | 0.042 | 0.3 | 82.03 | 1.219 | 1 | -0.126 | 0.0247 | 0.0485; | **0.13** | | | | | | |
| | 20 | 5.18 | 0.042 | 0.366 | 67.3 | 1.486 | 1 | -0.278 | 0.0551 | 0.12; | **0.28** | | | | | | |
| | 30 | 5.18 | 0.042 | 0.446 | 55.21 | 1.811 | 1 | -0.461 | 0.0925 | 0.224; | **0.47** | | | | | | |
| | 40 | 5.18 | 0.042 | 0.543 | 45.29 | 2.207 | 1.142 | -0.681 | 0.138 | 0.377; | **0.69** | | | | | | |
| | 50 | 5.18 | 0.042 | 0.662 | 37.15 | 2.691 | 1.391 | -0.944 | 0.195 | 0.6; | **0.96** | | | | | | |
| | 60 | 5.179 | 0.042 | 0.806 | 30.48 | 3.28 | 1.694 | -1.256 | 0.265 | 0.924; | **1.28** | | | | | | |
| | 70 | 5.178 | 0.042 | 0.982 | 25 | 3.998 | 2.062 | -1.627 | 0.351 | 1.391; | **1.66** | | | | | | |
| | 80 | 5.177 | 0.042 | 1.195 | 20.51 | 4.874 | 2.509 | -2.065 | 0.458 | 2.063; | **2.12** | | | | | | |
| | 90 | 5.175 | 0.042 | 1.454 | 16.83 | 5.941 | 3.051 | -2.577 | 0.591 | 3.023; | **2.64** | | | | | | |
| | 100 | 5.171 | 0.042 | 1.768 | 13.8 | 7.242 | 3.708 | -3.174 | 0.755 | 4.385; | **3.26** | | | | | | |
| | 110 | 5.165 | 0.042 | 2.149 | 11.32 | 8.827 | 4.501 | -3.863 | 0.96 | 6.302; | **3.98** | | | | | | |
| | 120 | 5.156 | 0.042 | 2.609 | 9.289 | 10.76 | 5.455 | -4.65 | 1.214 | 8.973; | **4.81** | | | | | | |
| | 127 | 5.145 | 0.042 | 2.986 | 8.087 | 12.36 | 6.235 | -5.263 | 1.427 | 11.43; | **5.45** | bottom | hit; | | | | |
| | 128 | 5.144 | 0.042 | 3.044 | 7.928 | 12.61 | 6.371 | -5.355 | 1.46 | 11.83; | **5.55** | merging; | | | | | |
| | 130 | 5.138 | 0.042 | 3.174 | 7.62 | 13.12 | 6.695 | -5.646 | 1.567 | 13.12; | **5.86** | | | | | | |
| | | | | | | **14** | | | | | **6.7** | **acute zone (6.7 m)** | | | | | |
| | 138 | 5.094 | 0.042 | 3.915 | 6.504 | 15.37 | 8.358 | -7.21 | 2.174 | 20.87; | **7.53** | | | | | | |
| | 140 | 5.076 | 0.042 | 4.156 | 6.251 | 15.99 | 8.891 | -7.689 | 2.369 | 23.47; | **8.05** | | | | | | |
| | 150 | 4.923 | 0.042 | 5.758 | 5.128 | 19.49 | 12.87 | -10.58 | 3.636 | 41.25; | **11.19** | | | | | | |
| | 160 | 4.603 | 0.042 | 8.199 | 4.207 | 23.76 | 15.83 | -14.16 | 5.408 | 68.09; | **15.16** | | | | | | |
| | 169 | 4.112 | 0.042 | 11.38 | 3.52 | 28.39 | 18.66 | -17.73 | 7.406 | 100.3; | **19.21** | matched | energy | radial | vel | = | 0.0832m/s |
| | 170 | 4.044 | 0.042 | 11.81 | 3.451 | 28.96 | 19 | -18.14 | 7.648 | 104.4; | **19.69** | | | | | | |
| | 180 | 3.22 | 0.042 | 17.03 | 2.831 | 35.3 | 22.73 | -22.15 | 10.24 | 148.8; | **24.40** | stream | limit | reached; | | | |
| | 182 | 3.026 | 0.042 | 18.32 | 2.721 | 36.73 | 23.55 | -22.92 | 10.78 | 158.5; | **25.33** | surface; | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Const | Eddy | Diffusivity. | Farfield | dispersion | based | on | wastefield | width | of | 22.49 m |
| | conc | dilutn | width | distnce | time | | | | | |
| | (%) | | (m) | (m) | (hrs) | (kg/kg) | (s-1) | /s)(m0.67/s2) | | |
| | 2.7197 | 36.75 | 24.92 | 30 | 0.0309 | 0 | 0 | 0.042 | 6.80E-04 | |
| | 2.68927 | 37.17 | 27.28 | 35 | 0.064 | 0 | 0 | 0.042 | 6.80E-04 | |
| | 2.61054 | 38.29 | 29.46 | 40 | 0.097 | 0 | 0 | 0.042 | 6.80E-04 | |
| | 2.5117 | 39.8 | 31.48 | 45 | 0.13 | 0 | 0 | 0.042 | 6.80E-04 | |
| | 2.41025 | 41.47 | 33.38 | 50 | 0.163 | 0 | 0 | 0.042 | 6.80E-04 | |
| | 2.31347 | 43.21 | 35.18 | 55 | 0.196 | 0 | 0 | 0.042 | 6.80E-04 | |
| | 2.22371 | 44.95 | 36.89 | 60 | 0.229 | 0 | 0 | 0.042 | 6.80E-04 | |
| | 2.14168 | 46.67 | 38.53 | 65 | 0.262 | 0 | 0 | 0.042 | 6.80E-04 | |
| | 2.06669 | 48.37 | 40.1 | 70 | 0.295 | 0 | 0 | 0.042 | 6.80E-04 | |
| | 1.99826 | 50.03 | 41.61 | 75 | 0.329 | 0 | 0 | 0.042 | 6.80E-04 | |
| count: | 10 | | | | | | | | | |
| | ; | | | | | | | | | |
| 9:01:44 | AM. | amb | fills: | 2 | | | | | | |

/ UM3. 7/26/2017 8:19:29 AM

**Case** **5B4;** ambient file c:\plumes\ plume 10.001.db; Diffuser table record 1:00 ---------------------------------

Ambient Table:

| Depth | Amb-cur | Amb-dir | Amb-sal | Amb-tem | Amb-pol | Decay | Far-spd | Far-dir | Disprsn | Density |
|---|---|---|---|---|---|---|---|---|---|---|
| m | m/s | deg | psu | C | kg/kg | s-1 | m/s | deg | m0.67/s2 | sigma-T |
| 0 | 0.251 | 90 | 0.08 | 21.1 | 0 | 0 | 0.251 | 90 | 0.00068 | -1.906 |
| 6 | 0.251 | 90 | 0.08 | 21.1 | 0 | 0 | 0.251 | 90 | 0.00068 | -1.906 |

Diffuser table:

| P-dia | P-elev | V-angle | H-angle | Ports | Spacing | AcuteMZ | ChrncMZ | P-depth | Ttl-flo | Eff-sal | Temp | Polutnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) | (m) | (deg) | (deg) | () | (m) | (m) | (m) | (m) | (MGD) | (psu) | (C) | (%) |
| 0.249 | 0.61 | 0 | 169 | 5 | 3.05 | 7.4 | 74 | 5.18 | 16.5 | 0 | 23 | 100 |

Simulation:

Froude number: 85.44; effleunt density (sigma-T) -2.399; effleunt velocity 2.969(m/s);

| Step | Depth | Amb-cur | P-dia | Polutnt | Dilutn | CL-diln | x-posn | y-posn | Time | **Distance** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (m) | (m/s) | (m) | (%) | () | () | (m) | (m) | (s) | **(m)** | |
| 0 | 5.18 | 0.251 | 0.249 | 100 | 1 | 1 | 0 | 0 | 0.0; | **0.00** | |
| 10 | 5.18 | 0.251 | 0.3 | 82.03 | 1.219 | 1 | -0.102 | 0.0209 | 0.0393; | **0.10** | |
| 20 | 5.18 | 0.251 | 0.365 | 67.3 | 1.486 | 1 | -0.22 | 0.0475 | 0.0944; | **0.23** | |
| 30 | 5.18 | 0.251 | 0.443 | 55.21 | 1.811 | 1 | -0.355 | 0.0814 | 0.171; | **0.36** | |
| 40 | 5.18 | 0.251 | 0.538 | 45.29 | 2.207 | 1.116 | -0.508 | 0.125 | 0.278; | **0.52** | |
| 50 | 5.18 | 0.251 | 0.652 | 37.15 | 2.691 | 1.347 | -0.678 | 0.179 | 0.422; | **0.70** | |
| 60 | 5.18 | 0.251 | 0.789 | 30.48 | 3.28 | 1.621 | -0.867 | 0.249 | 0.617; | **0.90** | |
| 70 | 5.179 | 0.251 | 0.951 | 25 | 3.998 | 1.94 | -1.072 | 0.336 | 0.875; | **1.12** | |
| 80 | 5.179 | 0.251 | 1.143 | 20.51 | 4.874 | 2.309 | -1.291 | 0.444 | 1.212; | **1.37** | |
| 90 | 5.178 | 0.251 | 1.366 | 16.83 | 5.941 | 2.728 | -1.523 | 0.578 | 1.645; | **1.63** | |
| 100 | 5.178 | 0.251 | 1.624 | 13.8 | 7.242 | 3.196 | -1.763 | 0.741 | 2.192; | **1.91** | |
| 110 | 5.177 | 0.251 | 1.916 | 11.32 | 8.827 | 3.712 | -2.01 | 0.94 | 2.877; | **2.22** | |
| 120 | 5.175 | 0.251 | 2.242 | 9.289 | 10.76 | 4.281 | -2.26 | 1.18 | 3.726; | **2.55** | |
| 124 | 5.175 | 0.251 | 2.382 | 8.582 | 11.65 | 4.525 | -2.362 | 1.29 | 4.12; | **2.69** | bottom hit; |
| 126 | 5.174 | 0.251 | 2.454 | 8.249 | 12.12 | 4.673 | -2.413 | 1.348 | 4.331; | **2.76** | merging; |
| 130 | 5.173 | 0.251 | 2.615 | 7.71 | 12.96 | 5.054 | -2.626 | 1.604 | 5.257; | **3.08** | |
| 140 | 5.163 | 0.251 | 3.353 | 6.325 | 15.8 | 6.865 | -3.435 | 2.702 | 9.283; | **4.37** | |
| 150 | 5.148 | 0.251 | 4.532 | 5.188 | 19.26 | 10.07 | -4.24 | 4.012 | 14.16; | **5.84** | |
| | | | | | **22** | | | | | **6.7** | **acute zone (6.7 m)** |
| 160 | 5.128 | 0.251 | 6.261 | 4.256 | 23.48 | 11.88 | -4.97 | 5.442 | 19.54; | **7.37** | |
| 161 | 5.125 | 0.251 | 6.47 | 4.173 | 23.95 | 12.08 | -5.038 | 5.589 | 20.09; | **7.52** | |
| 170 | 5.105 | 0.251 | 8.698 | 3.492 | 28.63 | 14.09 | -5.603 | 6.937 | 25.22; | **8.92** | |
| 180 | 5.08 | 0.251 | 12.05 | 2.864 | 34.9 | 16.8 | -6.147 | 8.491 | 31.18; | **10.48** | |
| 186 | 5.064 | 0.251 | 14.61 | 2.543 | 39.3 | 18.72 | -6.438 | 9.46 | 34.91; | **11.44** | matched energy radial vel = 0.194m/s; |
| 190 | 5.054 | 0.251 | 16.59 | 2.35 | 42.54 | 20.13 | -6.62 | 10.13 | 37.49; | **12.10** | |
| 199 | 5.029 | 0.251 | 21.96 | 1.966 | 50.84 | 23.78 | -7.001 | 11.71 | 43.62; | **13.64** | surface; |

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 26.13 m

| conc | dilutn | width | distnce | time | | | | |
|---|---|---|---|---|---|---|---|---|
| (%) | | (m) | (m) | (hrs) | (kg/kg) | (s-1) | /s)(m0.67/s2) | |
| 1.95913 | 51.02 | 26.26 | 15 | 0.0015 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.96287 | 50.92 | 26.73 | 20 | 0.00704 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.96403 | 50.89 | 27.2 | 25 | 0.0126 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.96466 | 50.87 | 27.66 | 30 | 0.0181 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.96505 | 50.86 | 28.11 | 35 | 0.0236 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.96521 | 50.86 | 28.56 | 40 | 0.0292 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.965 | 50.87 | 29 | 45 | 0.0347 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.96421 | 50.89 | 29.43 | 50 | 0.0402 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.96261 | 50.93 | 29.85 | 55 | 0.0458 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.96006 | 50.99 | 30.27 | 60 | 0.0513 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.95647 | 51.09 | 30.69 | 65 | 0.0568 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.95174 | 51.21 | 31.09 | 70 | 0.0624 | 0 | 0 | 0.251 | 6.80E-04 |
| 1.94619 | 51.36 | 31.5 | 75 | 0.0679 | 0 | 0 | 0.251 | 6.80E-04 |

count: 13

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8:19:29 AM. amb fills: 2

/ UM3. 7/26/2017 7:54:28 AM

**Case** **5B5;** ambient file C:\Plumes\ Diffuser table record 1:00 ---------------------------------

Ambient Table:

| Depth | Amb-cur | Amb-dir | Amb-sal | Amb-tem | Amb-pol | Decay | Far-spd | Far-dir | Disprsn | Density |
|---|---|---|---|---|---|---|---|---|---|---|
| m | m/s | deg | psu | C | kg/kg | s-1 | m/s | deg | m0.67/s2 | sigma-T |
| 0 | 0.344 | 90 | 0.08 | 10.7 | 0 | 0 | 0.344 | 90 | 0.00068 | -0.238 |
| 6 | 0.344 | 90 | 0.08 | 10.7 | 0 | 0 | 0.344 | 90 | 0.00068 | -0.238 |

Diffuser table:

| P-dia | P-elev | V-angle | H-angle | Ports | Spacing | AcuteMZ | ChrncMZ | P-depth | Ttl-flo | Eff-sal | Temp | Polutnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) | (m) | (deg) | (deg) | () | (m) | (m) | (m) | (m) | (MGD) | (psu) | (C) | (%) |
| 0.249 | 0.61 | 0 | 169 | 5 | 3.05 | 7.4 | 74 | 5.4 | 23 | 0 | 19.8 | 100 |

Simulation:

Froude number: 69.39; effluent density (sigma-T) -1.692; effluent velocity 4.139(m/s);

| Step | Depth | Amb-cur | P-dia | Polutnt | Dilutn | CL-diln | x-posn | y-posn | Time | **Distance** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (m) | (m/s) | (m) | (%) | () | () | (m) | (m) | (s) | **(m)** | | | | | | |
| 0 | 5.4 | 0.344 | 0.249 | 100 | 1 | 1 | 0 | 0 | 0.0; | **0.00** | | | | | | |
| 10 | 5.4 | 0.344 | 0.3 | 82.03 | 1.219 | 1 | -0.103 | 0.021 | 0.0282; | **0.11** | | | | | | |
| 20 | 5.4 | 0.344 | 0.365 | 67.3 | 1.485 | 1 | -0.221 | 0.0476 | 0.068; | **0.23** | | | | | | |
| 30 | 5.4 | 0.344 | 0.443 | 55.21 | 1.81 | 1 | -0.356 | 0.0816 | 0.123; | **0.37** | | | | | | |
| 40 | 5.4 | 0.344 | 0.538 | 45.29 | 2.206 | 1.116 | -0.51 | 0.125 | 0.2; | **0.53** | | | | | | |
| 50 | 5.4 | 0.344 | 0.652 | 37.15 | 2.689 | 1.347 | -0.682 | 0.18 | 0.305; | **0.71** | | | | | | |
| 60 | 5.4 | 0.344 | 0.789 | 30.48 | 3.277 | 1.621 | -0.872 | 0.249 | 0.445; | **0.91** | | | | | | |
| 70 | 5.399 | 0.344 | 0.951 | 25 | 3.995 | 1.942 | -1.079 | 0.336 | 0.632; | **1.13** | | | | | | |
| 80 | 5.399 | 0.344 | 1.143 | 20.51 | 4.869 | 2.312 | -1.301 | 0.444 | 0.877; | **1.37** | | | | | | |
| 90 | 5.398 | 0.344 | 1.368 | 16.83 | 5.936 | 2.733 | -1.535 | 0.578 | 1.191; | **1.64** | | | | | | |
| 100 | 5.397 | 0.344 | 1.626 | 13.8 | 7.235 | 3.204 | -1.779 | 0.742 | 1.589; | **1.93** | | | | | | |
| 110 | 5.396 | 0.344 | 1.92 | 11.32 | 8.819 | 3.725 | -2.029 | 0.941 | 2.087; | **2.24** | | | | | | |
| 120 | 5.394 | 0.344 | 2.249 | 9.289 | 10.75 | 4.298 | -2.283 | 1.181 | 2.705; | **2.57** | | | | | | |
| 124 | 5.394 | 0.344 | 2.39 | 8.582 | 11.64 | 4.544 | -2.386 | 1.291 | 2.993; | **2.71** | bottom | hit; | | | | |
| 126 | 5.393 | 0.344 | 2.463 | 8.249 | 12.11 | 4.691 | -2.438 | 1.35 | 3.146; | **2.79** | merging; | | | | | |
| 130 | 5.391 | 0.344 | 2.623 | 7.709 | 12.95 | 5.071 | -2.654 | 1.605 | 3.821; | **3.10** | | | | | | |
| 140 | 5.38 | 0.344 | 3.364 | 6.324 | 15.79 | 6.874 | -3.473 | 2.701 | 6.743; | **4.40** | | | | | | |
| 150 | 5.363 | 0.344 | 4.546 | 5.188 | 19.25 | 10.09 | -4.29 | 4.011 | 10.29; | **5.87** | | | | | | |
| | | | | | **22** | | | | | **6.7** | **acute zone (6.7 m)** | | | | | |
| 160 | 5.341 | 0.344 | 6.284 | 4.256 | 23.46 | 11.9 | -5.033 | 5.443 | 14.22; | **7.41** | | | | | | |
| 170 | 5.315 | 0.344 | 8.735 | 3.491 | 28.6 | 14.11 | -5.676 | 6.941 | 18.37; | **8.97** | | | | | | |
| 180 | 5.288 | 0.344 | 12.11 | 2.864 | 34.86 | 16.82 | -6.229 | 8.493 | 22.7; | **10.53** | | | | | | |
| 187 | 5.268 | 0.344 | 15.17 | 2.493 | 40.05 | 19.07 | -6.57 | 9.624 | 25.88; | **11.65** | matched | energy | radial | vel | = | 0.266m/s; |
| 190 | 5.259 | 0.344 | 16.68 | 2.35 | 42.5 | 20.14 | -6.707 | 10.12 | 27.29; | **12.14** | | | | | | |
| 200 | 5.229 | 0.344 | 22.79 | 1.928 | 51.81 | 24.23 | -7.132 | 11.88 | 32.25; | **13.86** | surface; | | | | | |

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 26.96 m

| conc | dilutn | width | distnce | time | | | | |
|---|---|---|---|---|---|---|---|---|
| (%) | | (m) | (m) | (hrs) | (kg/kg) | (s-1) | /s)(m0.67/s2) | |
| 1.91958 | 52.02 | 27.04 | 15 | 9.27E-04 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.92346 | 51.92 | 27.39 | 20 | 0.00496 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.92475 | 51.88 | 27.74 | 25 | 0.009 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.92545 | 51.86 | 28.09 | 30 | 0.013 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.92591 | 51.85 | 28.43 | 35 | 0.0171 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.92624 | 51.84 | 28.76 | 40 | 0.0211 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.92647 | 51.83 | 29.09 | 45 | 0.0252 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.92657 | 51.83 | 29.42 | 50 | 0.0292 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.92651 | 51.83 | 29.74 | 55 | 0.0332 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.9262 | 51.84 | 30.06 | 60 | 0.0373 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.92555 | 51.86 | 30.38 | 65 | 0.0413 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.9245 | 51.89 | 30.7 | 70 | 0.0453 | 0 | 0 | 0.344 | 6.80E-04 |
| 1.92299 | 51.93 | 31.01 | 75 | 0.0494 | 0 | 0 | 0.344 | 6.80E-04 |

count: 13

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7:54:28 AM. amb fills: 2

/ UM3. 7/26/2017 8:20:35 AM

**Case** **5B6;** ambient file c:\plumes\ plume 10.001.db; Diffuser table record 1:00 ---------------------------------

Ambient Table:

| Depth | Amb-cur | Amb-dir | Amb-sal | Amb-tem | Amb-pol | Decay | Far-spd | Far-dir | Disprsn | Density |
|---|---|---|---|---|---|---|---|---|---|---|
| m | m/s | deg | psu | C | kg/kg | s-1 | m/s | deg | m0.67/s2 | sigma-T |
| 0 | 0.311 | 90 | 0.08 | 21.1 | 0 | 0 | 0.311 | 90 | 0.00068 | -1.906 |
| 6 | 0.311 | 90 | 0.08 | 21.1 | 0 | 0 | 0.311 | 90 | 0.00068 | -1.906 |

Diffuser table:

| P-dia | P-elev | V-angle | H-angle | Ports | Spacing | AcuteMZ | ChrncMZ | P-depth | Ttl-flo | Eff-sal | Temp | Polutnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) | (m) | (deg) | (deg) | () | (m) | (m) | (m) | (m) | (MGD) | (psu) | (C) | (%) |
| 0.249 | 0.61 | 0 | 169 | 5 | 3.05 | 7.4 | 74 | 5.18 | 13.2 | 0 | 22.7 | 100 |

Simulation:

Froude number: 73.85; effleunt density (sigma-T) -2.328; effleunt velocity 2.375(m/s);

| Step | Depth | Amb-cur | P-dia | Polutnt | Dilutn | CL-diln | x-posn | y-posn | Time | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (m) | (m/s) | (m) | (%) | () | () | (m) | (m) | (s) | |
| 0 | 5.18 | 0.311 | 0.249 | 100 | 1 | 1 | 0 | 0 | 0.0; | |
| 10 | 5.18 | 0.311 | 0.3 | 82.03 | 1.219 | 1 | -0.0906 | 0.0191 | 0.0435; | |
| 20 | 5.18 | 0.311 | 0.364 | 67.3 | 1.486 | 1 | -0.193 | 0.0439 | 0.103; | |
| 30 | 5.18 | 0.311 | 0.441 | 55.21 | 1.811 | 1 | -0.307 | 0.0761 | 0.185; | |
| 40 | 5.18 | 0.311 | 0.534 | 45.29 | 2.208 | 1.092 | -0.432 | 0.118 | 0.294; | |
| 50 | 5.18 | 0.311 | 0.644 | 37.15 | 2.691 | 1.307 | -0.569 | 0.171 | 0.438; | |
| 60 | 5.18 | 0.311 | 0.774 | 30.48 | 3.28 | 1.553 | -0.714 | 0.238 | 0.625; | |
| 70 | 5.179 | 0.311 | 0.925 | 25 | 3.998 | 1.83 | -0.866 | 0.322 | 0.865; | |
| 80 | 5.179 | 0.311 | 1.098 | 20.51 | 4.874 | 2.138 | -1.024 | 0.425 | 1.167; | |
| 90 | 5.179 | 0.311 | 1.294 | 16.83 | 5.941 | 2.475 | -1.184 | 0.552 | 1.542; | |
| 100 | 5.178 | 0.311 | 1.513 | 13.8 | 7.242 | 2.844 | -1.347 | 0.706 | 2.006; | |
| 110 | 5.178 | 0.311 | 1.751 | 11.32 | 8.828 | 3.252 | -1.513 | 0.895 | 2.58; | |
| 120 | 5.177 | 0.311 | 2.009 | 9.289 | 10.76 | 3.717 | -1.683 | 1.129 | 3.301; | |
| 124 | 5.176 | 0.311 | 2.112 | 8.629 | 11.58 | 3.925 | -1.756 | 1.243 | 3.653; | merging; |
| 128 | 5.175 | 0.311 | 2.245 | 8.015 | 12.47 | 4.287 | -1.946 | 1.564 | 4.649; | bottom hit; |
| 130 | 5.174 | 0.311 | 2.338 | 7.704 | 12.98 | 4.528 | -2.065 | 1.775 | 5.302; | |
| 140 | 5.167 | 0.311 | 3 | 6.32 | 15.82 | 6.559 | -2.644 | 2.93 | 8.902; | |
| 150 | 5.156 | 0.311 | 4.021 | 5.184 | 19.28 | 9.385 | -3.18 | 4.224 | 12.96; | |
| 160 | 5.144 | 0.311 | 5.477 | 4.253 | 23.5 | 11.21 | -3.661 | 5.631 | 17.39; | |
| 165 | 5.136 | 0.311 | 6.399 | 3.852 | 25.95 | 12.27 | -3.882 | 6.38 | 19.75; | acute zone; |
| 170 | 5.129 | 0.311 | 7.473 | 3.489 | 28.65 | 13.45 | -4.092 | 7.165 | 22.23; | |
| 180 | 5.112 | 0.311 | 10.15 | 2.862 | 34.92 | 16.2 | -4.484 | 8.86 | 27.61; | |
| 190 | 5.092 | 0.311 | 13.67 | 2.348 | 42.57 | 19.58 | -4.847 | 10.77 | 33.69; | |
| 192 | 5.088 | 0.311 | 14.49 | 2.257 | 44.29 | 20.35 | -4.917 | 11.19 | 35.0; | matched energy radial vel = 0.227m/s; |
| 200 | 5.068 | 0.311 | 17.78 | 1.926 | 51.9 | 23.73 | -5.215 | 13.14 | 41.23; | |
| 209 | 5.03 | 0.311 | 21.36 | 1.612 | 62.02 | 28.24 | -5.68 | 16.73 | 52.68; | surface; |

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 25.53 m

| conc | dilutn | width | distnce | time | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (%) | | (m) | (m) | (hrs) | (kg/kg) | (s-1) | /s)(m0.67/s2) | | |
| 1.6066 | 62.22 | 25.71 | 20 | 0.00208 | 0 | 0 | 0.311 | 6.80E-04 | |
| 1.60889 | 62.13 | 26.09 | 25 | 0.00655 | 0 | 0 | 0.311 | 6.80E-04 | |
| 1.60977 | 62.09 | 26.46 | 30 | 0.011 | 0 | 0 | 0.311 | 6.80E-04 | |
| 1.61027 | 62.08 | 26.83 | 35 | 0.0155 | 0 | 0 | 0.311 | 6.80E-04 | |
| 1.6106 | 62.06 | 27.2 | 40 | 0.0199 | 0 | 0 | 0.311 | 6.80E-04 | |
| 1.61082 | 62.05 | 27.56 | 45 | 0.0244 | 0 | 0 | 0.311 | 6.80E-04 | |
| 1.61091 | 62.05 | 27.91 | 50 | 0.0289 | 0 | 0 | 0.311 | 6.80E-04 | |
| 1.61079 | 62.06 | 28.27 | 55 | 0.0333 | 0 | 0 | 0.311 | 6.80E-04 | |
| 1.61037 | 62.07 | 28.61 | 60 | 0.0378 | 0 | 0 | 0.311 | 6.80E-04 | |
| 1.60954 | **62.1** | 28.95 | 65 | 0.0423 | 0 | 0 | 0.311 | 6.80E-04 | Chronic MZ (66 m) |
| 1.60822 | 62.15 | 29.29 | 70 | 0.0467 | 0 | 0 | 0.311 | 6.80E-04 | |
| 1.60636 | 62.23 | 29.63 | 75 | 0.0512 | 0 | 0 | 0.311 | 6.80E-04 | |

count: 12

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8:20:35 AM. amb fills: 2

/ UM3. 7/26/2017 8:21:16 AM

**Case** **5B7;** ambient file c:\plumes\ plume 10.001.db; Diffuser table record 1:00 ---------------------------------

Ambient Table:

| Depth | Amb-cur | Amb-dir | Amb-sal | Amb-tem | Amb-pol | Decay | Far-spd | Far-dir | Disprsn | Density |
|---|---|---|---|---|---|---|---|---|---|---|
| m | m/s | deg | psu | C | kg/kg | s-1 | m/s | deg | m0.67/s2 | sigma-T |
| 0 | 0.155 | 90 | 0.08 | 21.1 | 0 | 0 | 0.155 | 90 | 0.00068 | -1.906 |
| 6 | 0.155 | 90 | 0.08 | 21.1 | 0 | 0 | 0.155 | 90 | 0.00068 | -1.906 |

Diffuser table:

| P-dia | P-elev | V-angle | H-angle | Ports | Spacing | AcuteMZ | ChrncMZ | P-depth | Ttl-flo | Eff-sal | Temp | Polutnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) | (m) | (deg) | (deg) | () | (m) | (m) | (m) | (m) | (MGD) | (psu) | (C) | (%) |
| 0.249 | 0.61 | 0 | 169 | 5 | 3.05 | 7.4 | 74 | 5.18 | 13.2 | 0 | 22.7 | 100 |

Simulation:

Froude number: 73.85; effleunt density (sigma-T) -2.328; effleunt velocity 2.375(m/s);

| | Depth | Amb-cur | P-dia | Polutnt | Dilutn | CL-diln | x-posn | y-posn | Time | |
|---|---|---|---|---|---|---|---|---|---|---|
| Step | (m) | (m/s) | (m) | (%) | () | () | (m) | (m) | (s) | |
| 0 | 5.18 | 0.155 | 0.249 | 100 | 1 | 1 | 0 | 0 | 0.0; | |
| 10 | 5.18 | 0.155 | 0.3 | 82.03 | 1.219 | 1 | -0.108 | 0.0218 | 0.0518; | |
| 20 | 5.18 | 0.155 | 0.365 | 67.3 | 1.486 | 1 | -0.234 | 0.0493 | 0.125; | |
| 30 | 5.18 | 0.155 | 0.444 | 55.21 | 1.811 | 1 | -0.379 | 0.084 | 0.229; | |
| 40 | 5.18 | 0.155 | 0.54 | 45.29 | 2.208 | 1.125 | -0.546 | 0.128 | 0.374; | |
| 50 | 5.18 | 0.155 | 0.655 | 37.15 | 2.691 | 1.362 | -0.736 | 0.183 | 0.575; | |
| 60 | 5.179 | 0.155 | 0.794 | 30.48 | 3.28 | 1.645 | -0.949 | 0.253 | 0.85; | |
| 70 | 5.179 | 0.155 | 0.961 | 25 | 3.998 | 1.981 | -1.185 | 0.341 | 1.222; | |
| 80 | 5.178 | 0.155 | 1.159 | 20.51 | 4.874 | 2.375 | -1.443 | 0.451 | 1.717; | |
| 90 | 5.177 | 0.155 | 1.394 | 16.83 | 5.941 | 2.832 | -1.72 | 0.587 | 2.366; | |
| 100 | 5.176 | 0.155 | 1.669 | 13.8 | 7.242 | 3.354 | -2.014 | 0.754 | 3.204; | |
| 110 | 5.174 | 0.155 | 1.987 | 11.32 | 8.828 | 3.941 | -2.321 | 0.959 | 4.27; | |
| 120 | 5.171 | 0.155 | 2.35 | 9.289 | 10.76 | 4.593 | -2.638 | 1.207 | 5.608; | |
| 124 | 5.17 | 0.155 | 2.507 | 8.582 | 11.65 | 4.872 | -2.766 | 1.32 | 6.231; | bottom hit; |
| 127 | 5.169 | 0.155 | 2.622 | 8.135 | 12.29 | 5.089 | -2.868 | 1.415 | 6.761; | merging; |
| 130 | 5.166 | 0.155 | 2.761 | 7.689 | 13 | 5.419 | -3.096 | 1.638 | 8.01; | |
| 140 | 5.146 | 0.155 | 3.547 | 6.308 | 15.85 | 7.211 | -4.074 | 2.709 | 14.11; | |
| 150 | 5.114 | 0.155 | 4.814 | 5.175 | 19.32 | 10.61 | -5.105 | 4.054 | 21.94; | |
| 156 | 5.088 | 0.155 | 5.858 | 4.595 | 21.75 | 11.68 | -5.696 | 4.944 | 27.19; | acute zone; |
| 160 | 5.069 | 0.155 | 6.695 | 4.245 | 23.55 | 12.46 | -6.068 | 5.557 | 30.84; | |
| 170 | 5.017 | 0.155 | 9.383 | 3.482 | 28.7 | 14.69 | -6.905 | 7.124 | 40.26; | |
| 180 | 4.962 | 0.155 | 13.14 | 2.857 | 34.99 | 17.4 | -7.61 | 8.712 | 49.93; | |
| 182 | 4.951 | 0.155 | 14.04 | 2.746 | 36.4 | 18.01 | -7.736 | 9.031 | 51.88; | matched energy radial vel = 0.124m/s; |
| 190 | 4.906 | 0.155 | 18.29 | 2.344 | 42.65 | 20.71 | -8.2 | 10.32 | 59.79; | |
| 195 | 4.877 | 0.155 | 21.52 | 2.123 | 47.09 | 22.64 | -8.46 | 11.13 | 64.85; | surface; |

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 25.69 m

| conc | dilutn | width | distnce | time | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (%) | | (m) | (m) | (hrs) | (kg/kg) | (s-1) | /s)(m0.67/s2) | | |
| 2.11558 | 47.25 | 25.85 | 15 | 0.00182 | 0 | 0 | 0.155 | 6.80E-04 | |
| 2.12006 | 47.15 | 26.61 | 20 | 0.0108 | 0 | 0 | 0.155 | 6.80E-04 | |
| 2.12118 | 47.12 | 27.35 | 25 | 0.0197 | 0 | 0 | 0.155 | 6.80E-04 | |
| 2.12161 | 47.11 | 28.07 | 30 | 0.0287 | 0 | 0 | 0.155 | 6.80E-04 | |
| 2.12096 | 47.13 | 28.77 | 35 | 0.0377 | 0 | 0 | 0.155 | 6.80E-04 | |
| 2.11822 | 47.19 | 29.46 | 40 | 0.0466 | 0 | 0 | 0.155 | 6.80E-04 | |
| 2.11267 | 47.31 | 30.13 | 45 | 0.0556 | 0 | 0 | 0.155 | 6.80E-04 | |
| 2.10404 | 47.51 | 30.78 | 50 | 0.0645 | 0 | 0 | 0.155 | 6.80E-04 | |
| 2.09291 | 47.76 | 31.43 | 55 | 0.0735 | 0 | 0 | 0.155 | 6.80E-04 | |
| 2.07958 | 48.07 | 32.05 | 60 | 0.0825 | 0 | 0 | 0.155 | 6.80E-04 | |
| 2.0643 | **48.42** | 32.67 | 65 | 0.0914 | 0 | 0 | 0.155 | 6.80E-04 | Chronic MZ (66 m) |
| 2.04766 | 48.82 | 33.28 | 70 | 0.1 | 0 | 0 | 0.155 | 6.80E-04 | |
| 2.02961 | 49.25 | 33.87 | 75 | 0.109 | 0 | 0 | 0.155 | 6.80E-04 | |

count: 13

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8:21:16 AM. amb fills: 2

/ UM3. 7/26/2017 7:57:06 AM

**Case 5B8;** ambient file C:\Plumes\ Diffuser table record 1:00 ---------------------------------

Ambient Table:

| Depth | Amb-cur | Amb-dir | Amb-sal | Amb-tem | Amb-pol | Decay | Far-spd | Far-dir | Disprsn | Density |
|---|---|---|---|---|---|---|---|---|---|---|
| m | m/s | deg | psu | C | kg/kg | s-1 | m/s | deg | m0.67/s2 | sigma-T |
| 0 | 0.344 | 90 | 0.08 | 10.7 | 0 | 0 | 0.344 | 90 | 0.00068 | -0.238 |
| 6 | 0.344 | 90 | 0.08 | 10.7 | 0 | 0 | 0.344 | 90 | 0.00068 | -0.238 |

Diffuser table:

| P-dia | P-elev | V-angle | H-angle | Ports | Spacing | AcuteMZ | ChrncMZ | P-depth | Ttl-flo | Eff-sal | Temp | Polutnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) | (m) | (deg) | (deg) | () | (m) | (m) | (m) | (m) | (MGD) | (psu) | (C) | (%) |
| 0.249 | 0.61 | 0 | 169 | 5 | 3.05 | 7.4 | 74 | 5.4 | 17 | 0 | 19.5 | 100 |

Simulation:

Froude number: 52.4; effleunt density (sigma-T) -1.631; effleunt velocity 3.059(m/s);

| Step | Depth | Amb-cur | P-dia | Polutnt | Dilutn | CL-diln | x-posn | y-posn | Time | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (m) | (m/s) | (m) | (%) | () | () | (m) | (m) | (s) | |
| 0 | 5.4 | 0.344 | 0.249 | 100 | 1 | 1 | 0 | 0 | 0.0; | |
| 10 | 5.4 | 0.344 | 0.3 | 82.03 | 1.219 | 1 | -0.0949 | 0.0197 | 0.0354; | |
| 20 | 5.4 | 0.344 | 0.364 | 67.3 | 1.485 | 1 | -0.203 | 0.0452 | 0.0843; | |
| 30 | 5.4 | 0.344 | 0.442 | 55.21 | 1.81 | 1 | -0.324 | 0.078 | 0.152; | |
| 40 | 5.4 | 0.344 | 0.535 | 45.29 | 2.206 | 1.102 | -0.459 | 0.12 | 0.243; | |
| 50 | 5.4 | 0.344 | 0.647 | 37.15 | 2.689 | 1.323 | -0.608 | 0.174 | 0.365; | |
| 60 | 5.399 | 0.344 | 0.78 | 30.48 | 3.278 | 1.58 | -0.768 | 0.242 | 0.526; | |
| 70 | 5.399 | 0.344 | 0.935 | 25 | 3.995 | 1.874 | -0.938 | 0.327 | 0.734; | |
| 80 | 5.398 | 0.344 | 1.116 | 20.51 | 4.87 | 2.205 | -1.117 | 0.433 | 0.999; | |
| 90 | 5.398 | 0.344 | 1.323 | 16.83 | 5.936 | 2.572 | -1.3 | 0.562 | 1.332; | |
| 100 | 5.397 | 0.344 | 1.556 | 13.8 | 7.236 | 2.974 | -1.487 | 0.719 | 1.746; | |
| 110 | 5.395 | 0.344 | 1.814 | 11.32 | 8.82 | 3.415 | -1.678 | 0.911 | 2.258; | |
| 120 | 5.394 | 0.344 | 2.096 | 9.289 | 10.75 | 3.907 | -1.871 | 1.145 | 2.895; | |
| 125 | 5.392 | 0.344 | 2.239 | 8.468 | 11.79 | 4.185 | -1.973 | 1.286 | 3.281; | merging; |
| 126 | 5.392 | 0.344 | 2.267 | 8.328 | 11.99 | 4.26 | -2.01 | 1.34 | 3.429; | bottom hit; |
| 130 | 5.389 | 0.344 | 2.436 | 7.711 | 12.95 | 4.685 | -2.249 | 1.705 | 4.434; | |
| 140 | 5.376 | 0.344 | 3.124 | 6.326 | 15.79 | 6.61 | -2.896 | 2.83 | 7.554; | |
| 150 | 5.358 | 0.344 | 4.2 | 5.189 | 19.24 | 9.578 | -3.505 | 4.109 | 11.13; | |
| 160 | 5.335 | 0.344 | 5.751 | 4.257 | 23.46 | 11.39 | -4.05 | 5.493 | 15.03; | |
| 164 | 5.325 | 0.344 | 6.531 | 3.933 | 25.39 | 12.22 | -4.25 | 6.072 | 16.67; | acute zone; |
| 170 | 5.309 | 0.344 | 7.9 | 3.492 | 28.6 | 13.61 | -4.53 | 6.972 | 19.22; | |
| 180 | 5.28 | 0.344 | 10.81 | 2.865 | 34.86 | 16.35 | -4.957 | 8.566 | 23.75; | |
| 190 | 5.248 | 0.344 | 14.67 | 2.35 | 42.49 | 19.71 | -5.344 | 10.32 | 28.77; | |
| 191 | 5.245 | 0.344 | 15.12 | 2.304 | 43.34 | 20.08 | -5.381 | 10.51 | 29.31; | matched energy radial vel = 0.257m/s; |
| 200 | 5.212 | 0.344 | 19.74 | 1.928 | 51.8 | 23.83 | -5.704 | 12.31 | 34.46; | |
| 204 | 5.197 | 0.344 | 22.12 | 1.781 | 56.07 | 25.73 | -5.842 | 13.18 | 36.96; | surface; |

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 26.29 m

| conc | dilutn | width | distnce | time | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (%) | | (m) | (m) | (hrs) | (kg/kg) | (s-1) | /s)(m0.67/s2) | | |
| 1.77304 | 56.32 | 26.33 | 15 | 4.70E-04 | 0 | 0 | 0.344 | 6.80E-04 | |
| 1.77722 | 56.19 | 26.68 | 20 | 0.00451 | 0 | 0 | 0.344 | 6.80E-04 | |
| 1.77852 | 56.15 | 27.03 | 25 | 0.00854 | 0 | 0 | 0.344 | 6.80E-04 | |
| 1.77921 | 56.13 | 27.37 | 30 | 0.0126 | 0 | 0 | 0.344 | 6.80E-04 | |
| 1.77965 | 56.11 | 27.7 | 35 | 0.0166 | 0 | 0 | 0.344 | 6.80E-04 | |
| 1.77996 | 56.1 | 28.04 | 40 | 0.0207 | 0 | 0 | 0.344 | 6.80E-04 | |
| 1.78017 | 56.1 | 28.37 | 45 | 0.0247 | 0 | 0 | 0.344 | 6.80E-04 | |
| 1.78027 | 56.09 | 28.69 | 50 | 0.0287 | 0 | 0 | 0.344 | 6.80E-04 | |
| 1.78021 | 56.1 | 29.01 | 55 | 0.0328 | 0 | 0 | 0.344 | 6.80E-04 | |
| 1.77991 | 56.11 | 29.33 | 60 | 0.0368 | 0 | 0 | 0.344 | 6.80E-04 | |
| 1.77928 | **56.13** | 29.64 | 65 | 0.0408 | 0 | 0 | 0.344 | 6.80E-04 | Chronic MZ (66 m) |
| 1.77827 | 56.16 | 29.96 | 70 | 0.0449 | 0 | 0 | 0.344 | 6.80E-04 | |
| 1.77681 | 56.2 | 30.26 | 75 | 0.0489 | 0 | 0 | 0.344 | 6.80E-04 | |

count: 13

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7:57:06 AM. amb fills: 2

/ UM3. 7/26/2017 7:58:04 AM

**Case** **5B9;** ambient file C:\Plumes\ Diffuser table record 1:00 ---------------------------------

Ambient Table:

| Depth | Amb-cur | Amb-dir | Amb-sal | Amb-tem | Amb-pol | Decay | Far-spd | Far-dir | Disprsn | Density |
|---|---|---|---|---|---|---|---|---|---|---|
| m | m/s | deg | psu | C | kg/kg | s-1 | m/s | deg | m0.67/s2 | sigma-T |
| 0 | 0.171 | 90 | 0.08 | 10.7 | 0 | 0 | 0.171 | 90 | 0.00068 | -0.238 |
| 6 | 0.171 | 90 | 0.08 | 10.7 | 0 | 0 | 0.171 | 90 | 0.00068 | -0.238 |

Diffuser table:

| P-dia | P-elev | V-angle | H-angle | Ports | Spacing | AcuteMZ | ChrncMZ | P-depth | Ttl-flo | Eff-sal | Temp | Polutnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) | (m) | (deg) | (deg) | () | (m) | (m) | (m) | (m) | (MGD) | (psu) | (C) | (%) |
| 0.249 | 0.61 | 0 | 169 | 5 | 3.05 | 7.4 | 74 | 5.4 | 17.5 | 0 | 19.5 | 100 |

Simulation:

Froude number: 52.4; effleunt density (sigma-T) -1.631; effleunt velocity 3.059(m/s);

| Step | Depth | Amb-cur | P-dia | Polutnt | Dilutn | CL-diln | x-posn | y-posn | Time | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (m) | (m/s) | (m) | (%) | () | () | (m) | (m) | (s) | |
| 0 | 5.4 | 0.171 | 0.249 | 100 | 1 | 1 | 0 | 0 | 0.0; | |
| 10 | 5.4 | 0.171 | 0.3 | 82.03 | 1.219 | 1 | -0.111 | 0.0223 | 0.0413; | |
| 20 | 5.4 | 0.171 | 0.365 | 67.3 | 1.485 | 1 | -0.241 | 0.0502 | 0.1; | |
| 30 | 5.4 | 0.171 | 0.444 | 55.21 | 1.81 | 1 | -0.392 | 0.0853 | 0.184; | |
| 40 | 5.4 | 0.171 | 0.54 | 45.29 | 2.206 | 1.128 | -0.566 | 0.13 | 0.302; | |
| 50 | 5.399 | 0.171 | 0.656 | 37.15 | 2.689 | 1.367 | -0.766 | 0.185 | 0.467; | |
| 60 | 5.399 | 0.171 | 0.796 | 30.48 | 3.278 | 1.655 | -0.993 | 0.255 | 0.694; | |
| 70 | 5.398 | 0.171 | 0.965 | 25 | 3.995 | 1.998 | -1.247 | 0.343 | 1.004; | |
| 80 | 5.397 | 0.171 | 1.166 | 20.51 | 4.87 | 2.403 | -1.527 | 0.453 | 1.422; | |
| 90 | 5.395 | 0.171 | 1.406 | 16.83 | 5.936 | 2.878 | -1.832 | 0.59 | 1.976; | |
| 100 | 5.392 | 0.171 | 1.689 | 13.8 | 7.236 | 3.427 | -2.16 | 0.759 | 2.701; | |
| 110 | 5.388 | 0.171 | 2.02 | 11.32 | 8.82 | 4.052 | -2.506 | 0.966 | 3.635; | |
| 120 | 5.383 | 0.171 | 2.401 | 9.289 | 10.75 | 4.753 | -2.867 | 1.218 | 4.819; | |
| 125 | 5.38 | 0.171 | 2.611 | 8.414 | 11.87 | 5.133 | -3.051 | 1.363 | 5.52; | bottom hit; |
| 127 | 5.379 | 0.171 | 2.699 | 8.087 | 12.35 | 5.302 | -3.125 | 1.425 | 5.822; | merging; |
| 130 | 5.374 | 0.171 | 2.838 | 7.671 | 13.02 | 5.63 | -3.343 | 1.615 | 6.756; | |
| 140 | 5.34 | 0.171 | 3.652 | 6.293 | 15.87 | 7.441 | -4.429 | 2.667 | 12.04; | |
| 150 | 5.281 | 0.171 | 4.967 | 5.162 | 19.35 | 10.95 | -5.615 | 4.029 | 19.05; | |
| 153 | 5.258 | 0.171 | 5.48 | 4.864 | 20.53 | 11.49 | -5.966 | 4.48 | 21.4; | acute zone; |
| 160 | 5.197 | 0.171 | 6.932 | 4.235 | 23.58 | 12.85 | -6.748 | 5.578 | 27.2; | |
| 170 | 5.098 | 0.171 | 9.758 | 3.474 | 28.75 | 15.11 | -7.743 | 7.205 | 35.91; | |
| 180 | 4.992 | 0.171 | 13.74 | 2.85 | 35.04 | 17.84 | -8.573 | 8.834 | 44.77; | |
| 181 | 4.982 | 0.171 | 14.21 | 2.794 | 35.74 | 18.14 | -8.647 | 8.995 | 45.65; | matched energy radial vel = 0.144m/s; |
| 190 | 4.887 | 0.171 | 19.24 | 2.338 | 42.72 | 21.16 | -9.256 | 10.45 | 53.65; | |
| 194 | 4.846 | 0.171 | 21.98 | 2.16 | 46.24 | 22.69 | -9.496 | 11.09 | 57.24; | surface; |

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 26.15 m

| conc | dilutn | width | distnce | time | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (%) | | (m) | (m) | (hrs) | (kg/kg) | (s-1) | /s)(m0.67/s2) | | |
| 2.15035 | 46.44 | 26.21 | 15 | 6.46E-04 | 0 | 0 | 0.171 | 6.80E-04 | |
| 2.15671 | 46.3 | 26.91 | 20 | 0.00877 | 0 | 0 | 0.171 | 6.80E-04 | |
| 2.15804 | 46.27 | 27.59 | 25 | 0.0169 | 0 | 0 | 0.171 | 6.80E-04 | |
| 2.15866 | 46.26 | 28.25 | 30 | 0.025 | 0 | 0 | 0.171 | 6.80E-04 | |
| 2.15866 | 46.26 | 28.9 | 35 | 0.0331 | 0 | 0 | 0.171 | 6.80E-04 | |
| 2.15742 | 46.29 | 29.53 | 40 | 0.0413 | 0 | 0 | 0.171 | 6.80E-04 | |
| 2.15423 | 46.36 | 30.15 | 45 | 0.0494 | 0 | 0 | 0.171 | 6.80E-04 | |
| 2.14865 | 46.48 | 30.76 | 50 | 0.0575 | 0 | 0 | 0.171 | 6.80E-04 | |
| 2.14055 | 46.65 | 31.36 | 55 | 0.0656 | 0 | 0 | 0.171 | 6.80E-04 | |
| 2.13046 | 46.87 | 31.94 | 60 | 0.0737 | 0 | 0 | 0.171 | 6.80E-04 | |
| 2.11848 | **47.14** | 32.52 | 65 | 0.0819 | 0 | 0 | 0.171 | 6.80E-04 | Chronic MZ (66 m) |
| 2.10502 | 47.44 | 33.08 | 70 | 0.09 | 0 | 0 | 0.171 | 6.80E-04 | |
| 2.09026 | 47.78 | 33.64 | 75 | 0.0981 | 0 | 0 | 0.171 | 6.80E-04 | |

count: 13

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7:58:04 AM. amb fills: 2

/ UM3. 7/26/2017 7:42:43 AM

**Case** **5B10;** ambient file C:\Plumes\ Diffuser table record 1:00 ---------------------------------

Ambient Table:

| Depth | Amb-cur | Amb-dir | Amb-sal | Amb-tem | Amb-pol | Decay | Far-spd | Far-dir | Disprsn | Density |
|---|---|---|---|---|---|---|---|---|---|---|
| m | m/s | deg | psu | C | kg/kg | s-1 | m/s | deg | m0.67/s2 | sigma-T |
| 0 | 0.594 | 90 | 0.08 | 12.4 | 0 | 0 | 0.594 | 90 | 0.00068 | -0.422 |
| 6 | 0.594 | 90 | 0.08 | 12.4 | 0 | 0 | 0.594 | 90 | 0.00068 | -0.422 |

Diffuser table:

| P-dia | P-elev | V-angle | H-angle | Ports | Spacing | AcuteMZ | ChrncMZ | P-depth | Ttl-flo | Eff-sal | Temp | Polutnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) | (m) | (deg) | (deg) | () | (m) | (m) | (m) | (m) | (MGD) | (psu) | (C) | (%) |
| 0.249 | 0.61 | 0 | 169 | 5 | 3.05 | 7.4 | 74 | 5.5 | 12.9 | 0 | 17.8 | 100 |

Simulation:

Froude number: 49.99; effleunt density (sigma-T) -1.304; effleunt velocity 2.321(m/s);

| Step | Depth | Amb-cur | P-dia | Polutnt | Dilutn | CL-diln | x-posn | y-posn | Time | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (m) | (m/s) | (m) | (%) | () | () | (m) | (m) | (s) | |
| 0 | 5.5 | 0.594 | 0.249 | 100 | 1 | 1 | 0 | 0 | 0.0; | |
| 10 | 5.5 | 0.594 | 0.299 | 82.03 | 1.219 | 1 | -0.0689 | 0.0155 | 0.0338; | |
| 20 | 5.5 | 0.594 | 0.361 | 67.3 | 1.485 | 1 | -0.143 | 0.0368 | 0.078; | |
| 30 | 5.5 | 0.594 | 0.434 | 55.21 | 1.811 | 1 | -0.221 | 0.0655 | 0.135; | |
| 40 | 5.5 | 0.594 | 0.52 | 45.29 | 2.207 | 1.011 | -0.302 | 0.103 | 0.207; | |
| 50 | 5.5 | 0.594 | 0.617 | 37.15 | 2.69 | 1.173 | -0.385 | 0.151 | 0.297; | |
| 60 | 5.5 | 0.594 | 0.723 | 30.68 | 3.258 | 1.339 | -0.466 | 0.209 | 0.403; | |
| 70 | 5.5 | 0.594 | 0.834 | 25.5 | 3.919 | 1.51 | -0.545 | 0.277 | 0.528; | |
| 80 | 5.499 | 0.594 | 0.953 | 21.2 | 4.713 | 1.696 | -0.624 | 0.362 | 0.678; | |
| 90 | 5.499 | 0.594 | 1.085 | 17.52 | 5.705 | 1.915 | -0.707 | 0.471 | 0.872; | |
| 100 | 5.499 | 0.594 | 1.229 | 14.37 | 6.954 | 2.186 | -0.799 | 0.617 | 1.127; | |
| 110 | 5.498 | 0.594 | 1.383 | 11.79 | 8.476 | 2.52 | -0.897 | 0.809 | 1.462; | |
| 120 | 5.498 | 0.594 | 1.547 | 9.67 | 10.33 | 2.94 | -1.004 | 1.066 | 1.907; | |
| 123 | 5.498 | 0.594 | 1.597 | 9.133 | 11.00 | 3.099 | -1.043 | 1.175 | 2.095; | merging; |
| 130 | 5.495 | 0.594 | 1.796 | 7.953 | 12.63 | 3.82 | -1.323 | 2.026 | 3.558; | |
| 140 | 5.489 | 0.594 | 2.268 | 6.524 | 15.4 | 5.899 | -1.724 | 3.462 | 6.02; | |
| 147 | 5.483 | 0.594 | 2.73 | 5.68 | 17.34 | 8.061 | -1.979 | 4.551 | 7.883; | bottom hit; |
| 150 | 5.48 | 0.594 | 2.965 | 5.352 | 18.77 | 8.534 | -2.084 | 5.046 | 8.727; | |
| 160 | 5.47 | 0.594 | 3.918 | 4.391 | 22.88 | 10.34 | -2.419 | 6.841 | 11.79; | |
| 161 | 5.468 | 0.594 | 4.029 | 4.304 | 23.81 | 10.54 | -2.451 | 7.035 | 12.12; | acute zone; |
| 170 | 5.454 | 0.594 | 4.996 | 3.602 | 27.89 | 12.55 | -2.779 | 9.223 | 15.84; | |
| 180 | 5.424 | 0.594 | 6.085 | 2.955 | 34 | 15.26 | -3.273 | 13.18 | 22.56; | |
| 190 | 5.383 | 0.594 | 7.411 | 2.424 | 41.45 | 18.58 | -3.769 | 18.04 | 30.8; | |
| 200 | 5.328 | 0.594 | 9.027 | 1.988 | 50.52 | 22.62 | -4.264 | 23.95 | 40.8; | |
| 210 | 5.256 | 0.594 | 11 | 1.631 | 61.59 | 27.56 | -4.757 | 31.13 | 52.95; | |
| 220 | 5.164 | 0.594 | 13.4 | 1.338 | 75.08 | 33.59 | -5.248 | 39.87 | 67.71; | |
| 224 | 5.121 | 0.594 | 14.5 | 1.236 | 79.67 | 36.35 | -5.444 | 43.87 | 74.47; | matched energy radial vel = 0.42m/s; |
| 230 | 5.048 | 0.594 | 16.32 | 1.098 | 91.52 | 40.94 | -5.738 | 50.5 | 85.65; | |
| 240 | 4.902 | 0.594 | 19.89 | 0.901 | 111.6 | 49.9 | -6.227 | 63.43 | 107.5; | |
| 242 | 4.869 | 0.594 | 20.69 | 0.866 | **113.8** | 51.91 | -6.324 | 66.33 | 112.4; | surface; Chronic MZ (66 m) |

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 24.86 m

| conc | dilutn | width | distnce | time | | | | |
|---|---|---|---|---|---|---|---|---|
| (%) | | (m) | (m) | (hrs) | (kg/kg) | (s-1) | /s)(m0.67/s2) | |
| 0.86256 | 115.8 | 24.99 | 70 | 0.00157 | 0 | 0 | 0.594 | 6.80E-04 |
| 0.86356 | 115.7 | 25.19 | 75 | 0.00391 | 0 | 0 | 0.594 | 6.80E-04 |

count: 2

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7:42:44 AM. amb fills: 2

/ UM3. 7/26/2017 7:45:36 AM

**Case** **5B11;** ambient file C:\Plumes\Diffuser table record 1:00 ---------------------------------

Ambient Table:

| Depth | Amb-cur | Amb-dir | Amb-sal | Amb-tem | Amb-pol | Decay | Far-spd | Far-dir | Disprsn | Density |
|---|---|---|---|---|---|---|---|---|---|---|
| m | m/s | deg | psu | C | kg/kg | s-1 | m/s | deg | m0.67/s2 | sigma-T |
| 0 | 0.32 | 90 | 0.08 | 12.4 | 0 | 0 | 0.32 | 90 | 0.00068 | -0.422 |
| 6 | 0.32 | 90 | 0.08 | 12.4 | 0 | 0 | 0.32 | 90 | 0.00068 | -0.422 |

Diffuser table:

| P-dia | P-elev | V-angle | H-angle | Ports | Spacing | AcuteMZ | ChrncMZ | P-depth | Ttl-flo | Eff-sal | Temp | Polutnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) | (m) | (deg) | (deg) | () | (m) | (m) | (m) | (m) | (MGD) | (psu) | (C) | (%) |
| 0.249 | 0.61 | 0 | 169 | 5 | 3.05 | 7.4 | 74 | 5.2 | 13.2 | 0 | 17.8 | 100 |

Simulation:

Froude number: 51.15; effleunt density (sigma-T) -1.304; effleunt velocity 2.375(m/s);

| | Depth | Amb-cur | P-dia | Polutnt | Dilutn | CL-diln | x-posn | y-posn | Time | |
|---|---|---|---|---|---|---|---|---|---|---|
| Step | (m) | (m/s) | (m) | (%) | () | () | (m) | (m) | (s) | |
| 0 | 5.2 | 0.32 | 0.249 | 100 | 1 | 1 | 0 | 0 | 0.0; | |
| 10 | 5.2 | 0.32 | 0.3 | 82.03 | 1.219 | 1 | -0.0898 | 0.0189 | 0.0431; | |
| 20 | 5.2 | 0.32 | 0.364 | 67.3 | 1.485 | 1 | -0.191 | 0.0436 | 0.102; | |
| 30 | 5.2 | 0.32 | 0.441 | 55.21 | 1.811 | 1 | -0.303 | 0.0757 | 0.182; | |
| 40 | 5.2 | 0.32 | 0.533 | 45.29 | 2.207 | 1.09 | -0.427 | 0.117 | 0.29; | |
| 50 | 5.2 | 0.32 | 0.643 | 37.15 | 2.69 | 1.303 | -0.561 | 0.17 | 0.432; | |
| 60 | 5.199 | 0.32 | 0.772 | 30.48 | 3.279 | 1.546 | -0.703 | 0.237 | 0.615; | |
| 70 | 5.199 | 0.32 | 0.922 | 25 | 3.997 | 1.82 | -0.852 | 0.321 | 0.85; | |
| 80 | 5.199 | 0.32 | 1.094 | 20.51 | 4.872 | 2.123 | -1.006 | 0.424 | 1.144; | |
| 90 | 5.198 | 0.32 | 1.288 | 16.83 | 5.939 | 2.455 | -1.162 | 0.549 | 1.509; | |
| 100 | 5.197 | 0.32 | 1.503 | 13.8 | 7.239 | 2.817 | -1.321 | 0.703 | 1.961; | |
| 110 | 5.196 | 0.32 | 1.738 | 11.32 | 8.824 | 3.219 | -1.482 | 0.892 | 2.521; | |
| 120 | 5.194 | 0.32 | 1.992 | 9.289 | 10.76 | 3.68 | -1.649 | 1.126 | 3.225; | |
| 124 | 5.193 | 0.32 | 2.092 | 8.632 | 11.58 | 3.889 | -1.72 | 1.241 | 3.57; | merging; |
| 128 | 5.191 | 0.32 | 2.226 | 8.013 | 12.47 | 4.255 | -1.909 | 1.568 | 4.56; | bottom hit; |
| 130 | 5.189 | 0.32 | 2.318 | 7.702 | 12.97 | 4.498 | -2.025 | 1.78 | 5.2; | |
| 140 | 5.177 | 0.32 | 2.974 | 6.318 | 15.81 | 6.548 | -2.59 | 2.935 | 8.709; | |
| 150 | 5.16 | 0.32 | 3.984 | 5.183 | 19.28 | 9.348 | -3.109 | 4.222 | 12.64; | |
| 160 | 5.138 | 0.32 | 5.42 | 4.252 | 23.5 | 11.17 | -3.575 | 5.623 | 16.93; | |
| 165 | 5.127 | 0.32 | 6.329 | 3.851 | 25.94 | 12.23 | -3.789 | 6.367 | 19.22; | acute zone; |
| 170 | 5.114 | 0.32 | 7.386 | 3.488 | 28.64 | 13.41 | -3.992 | 7.146 | 21.62; | |
| 180 | 5.086 | 0.32 | 10.01 | 2.862 | 34.92 | 16.17 | -4.371 | 8.833 | 26.82; | |
| 190 | 5.054 | 0.32 | 13.47 | 2.347 | 42.56 | 19.56 | -4.725 | 10.75 | 32.73; | |
| 192 | 5.047 | 0.32 | 14.28 | 2.256 | 44.28 | 20.32 | -4.793 | 11.16 | 34.02; | matched energy radial vel = 0.232m/s; |
| 200 | 5.011 | 0.32 | 17.3 | 1.926 | 51.88 | 23.7 | -5.106 | 13.28 | 40.58; | |
| 210 | 4.938 | 0.32 | 21.2 | 1.58 | 63.25 | 28.77 | -5.62 | 17.4 | 53.38; | surface; |

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 25.37 m

| conc | dilutn | width | distnce | time | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (%) | | (m) | (m) | (hrs) | (kg/kg) | (s-1) | /s)(m0.67/s2) | | |
| 1.57412 | 63.47 | 25.5 | 20 | 0.00149 | 0 | 0 | 0.32 | 6.80E-04 | |
| 1.5768 | 63.36 | 25.87 | 25 | 0.00583 | 0 | 0 | 0.32 | 6.80E-04 | |
| 1.57775 | 63.33 | 26.23 | 30 | 0.0102 | 0 | 0 | 0.32 | 6.80E-04 | |
| 1.57827 | 63.31 | 26.59 | 35 | 0.0145 | 0 | 0 | 0.32 | 6.80E-04 | |
| 1.57862 | 63.29 | 26.95 | 40 | 0.0188 | 0 | 0 | 0.32 | 6.80E-04 | |
| 1.57886 | 63.28 | 27.3 | 45 | 0.0232 | 0 | 0 | 0.32 | 6.80E-04 | |
| 1.57898 | 63.28 | 27.64 | 50 | 0.0275 | 0 | 0 | 0.32 | 6.80E-04 | |
| 1.57893 | 63.28 | 27.98 | 55 | 0.0319 | 0 | 0 | 0.32 | 6.80E-04 | |
| 1.57863 | 63.29 | 28.32 | 60 | 0.0362 | 0 | 0 | 0.32 | 6.80E-04 | |
| 1.57798 | **63.32** | 28.65 | 65 | 0.0405 | 0 | 0 | 0.32 | 6.80E-04 | Chronic MZ (66 m) |
| 1.5769 | 63.36 | 28.98 | 70 | 0.0449 | 0 | 0 | 0.32 | 6.80E-04 | |
| 1.57532 | 63.42 | 29.31 | 75 | 0.0492 | 0 | 0 | 0.32 | 6.80E-04 | |

count: 12

;

7:45:37 AM. amb fills: 2

;

# Attachment 2
# Dissolved Oxygen Calculations

;

Dissolved oxygen concentration following initial dilution.
References: EPA/600/6-85/002b and EPA/430/9-82-011

Based on Lotus File IDOD2.WK1 Revised 19-Oct-93

| INPUT | | |
|---|---|---|
| 1. Dilution Factor at Mixing Zone Boundary (Dry Season): | 59 | |
| 2. Ambient Dissolved Oxygen Concentration (mg/L): | 6.6 | |
| 3. Effluent Dissolved Oxygen Concentration (mg/L): | 2 | |
| 4. Effluent Immediate Dissolved Oxygen Demand (mg/L): | 2 | |
| **OUTPUT** | | |
| | | Difference |
| Dissolved Oxygen at Mixing Zone Boundary (mg/L): | 6.49 | 0.111864 |

Dissolved oxygen concentration following initial dilution.
References: EPA/600/6-85/002b and EPA/430/9-82-011

Based on Lotus File IDOD2.WK1 Revised 19-Oct-93

| INPUT | | |
|---|---|---|
| 1. Dilution Factor at Mixing Zone Boundary (Dry Season): | 59 | |
| 2. Ambient Dissolved Oxygen Concentration (mg/L): | 8.1 | |
| 3. Effluent Dissolved Oxygen Concentration (mg/L): | 2 | |
| 4. Effluent Immediate Dissolved Oxygen Demand (mg/L): | 2 | |
| **OUTPUT** | | Difference |
| Dissolved Oxygen at Mixing Zone Boundary (mg/L): | 7.96 | 0.137288 |

## Streeter-Phelps Analysis of Critical Dissolved Oxygen Sag

### SCTP Phase 5B Projected Effluent with Existing 5-Port Outfall Diffuser (MDDWF)

| INPUT | | | |
|---|---|---|---|
| 1. EFFLUENT CHARACTERISTICS | | | |
| Discharge (cfs) - Max. Day Dry Weather Flow (2022): | | | 25.529279 |
| $CBOD_5$ (mg/L) Phase 5b (2022): | | | 3.83 |
| NBOD (mg/L) Phase 5b (2022): | | | 0.69 |
| Dissolved Oxygen (mg/L) Phase 5b (2022): | | | 2 |
| Temperature (deg C): | | | 23 |
| 2. RECEIVING WATER CHARACTERISTICS | | | |
| Upstream Discharge (cfs): | | | 83506 |
| Upstream $CBOD_5$ (mg/L): | | | 0.5 |
| Upstream NBOD (mg/L): | | | 1.75 |
| Upstream Dissolved Oxygen (mg/L): | | | **8.1** |
| Upstream Temperature (deg C): | | | 21.1 |
| Elevation (ft NGVD): | | | 8.5 |
| Downstream Average Channel Slope (ft/ft): | | | 0.00022 |
| Downstream Average Channel Depth (ft): | | | 45 |
| Downstream Average Channel Velocity (fps): | | | 1.02 |
| 3. REAERATION RATE (Base e) at 20 deg C ($day^{-1}$) (Note 1): | | | 0.20 |
| | Applic. | Applic. | Suggested |
| Reference | Vel (fps) | Dep (ft) | Values |
| Churchill | 1.5 - 6 | 2 - 50 | 0.02 |
| O'Connor and Dobbins | 0.1 - 1.5 | 2 - 50 | 0.04 |
| Owens | 0.1 - 6 | 1 - 2 | 0.02 |
| Tsivoglou-Wallace | 0.1 - 6 | 0.1 - 2 | 0.52 |
| 4. BOD DECAY RATE (Base e) AT 20 deg C ($day^{-1}$) (Note 2): | | | 0.07 |
| (or use *Wright and McDonnell eqn, 1979, for small rivers.) Enter this value -->* | | | 0.04 |

| OUTPUT | |
|---|---|
| 1. INITIAL MIXED RIVER CONDITION | |
| $CBOD_5$ (mg/L): | 0.5 |
| NBOD (mg/L): | 1.7 |
| Dissolved Oxygen (mg/L): | 8.1 |
| Temperature (deg C): | 21.1 |
| 2. TEMPERATURE ADJUSTED RATE CONSTANTS (Base e) | |
| Reaeration (day^-1): | 0.21 |
| BOD Decay (day^-1): | 0.07 |
| 3. CALCULATED INITIAL ULTIMATE CBODU AND TOTAL BODU | |
| Initial Mixed CBODU (mg/L): | 0.7 |
| Initial Mixed Total BODU (CBODU + NBOD, mg/L): | 2.5 |
| 4. INITIAL DISSOLVED OXYGEN DEFICIT | |
| Saturation Dissolved Oxygen (mg/L): | 8.895 |
| Initial Deficit (mg/L): | 0.80 |
| 5. TRAVEL TIME TO CRITICAL DO CONCENTRATION (days): | 1.19 |
| 6. DISTANCE TO CRITICAL DO CONCENTRATION (miles): | 19.89 |
| 7. CRITICAL DO DEFICIT (mg/L): | 0.81 |
| **8. CRITICAL DO CONCENTRATION (mg/L):** | **8.09** |

1). Based on Bennett & Rathbun (1972) and EPA Surface WQ Modeling Guidance (1985).
2). Based on BOD decay rates in Willamette River by McCutcheon (1983).

## Streeter-Phelps Analysis of Critical Dissolved Oxygen Sag

### SCTP Phase 5B Projected Effluent with Existing 5-Port Outfall Diffuser (MMDWF)

| INPUT | | | |
|---|---|---|---|
| 1. EFFLUENT CHARACTERISTICS | | | |
| Discharge (cfs) - Max. Month Dry Weather Flow (2022): | | | 20.423423 |
| $CBOD_5$ (mg/L) Phase 5b (2022): | | | 3.83 |
| NBOD (mg/L) Phase 5b (2022): | | | 0.69 |
| Dissolved Oxygen (mg/L) Phase 5b (2022): | | | 2 |
| Temperature (deg C): | | | 23 |
| 2. RECEIVING WATER CHARACTERISTICS | | | |
| Upstream Discharge (cfs): | | | 83506 |
| Upstream $CBOD_5$ (mg/L): | | | 0.5 |
| Upstream NBOD (mg/L): | | | 1.75 |
| Upstream Dissolved Oxygen (mg/L): | | | **8.1** |
| Upstream Temperature (deg C): | | | 21.1 |
| Elevation (ft NGVD): | | | 8.5 |
| Downstream Average Channel Slope (ft/ft): | | | 0.00022 |
| Downstream Average Channel Depth (ft): | | | 45 |
| Downstream Average Channel Velocity (fps): | | | 1.02 |
| 3. REAERATION RATE (Base e) at 20 deg C ($day^{-1}$) (Note 1): | | | 0.20 |
| | Applic. | Applic. | Suggested |
| Reference | Vel (fps) | Dep (ft) | Values |
| Churchill | 1.5 - 6 | 2 - 50 | 0.02 |
| O'Connor and Dobbins | 0.1 - 1.5 | 2 - 50 | 0.04 |
| Owens | 0.1 - 6 | 1 - 2 | 0.02 |
| Tsivoglou-Wallace | 0.1 - 6 | 0.1 - 2 | 0.52 |
| 4. BOD DECAY RATE (Base e) AT 20 deg C ($day^{-1}$) (Note 2): | | | 0.07 |
| (or use *Wright and McDonnell eqn, 1979, for small rivers.) Enter this value -->* | | | 0.04 |

| OUTPUT | |
|---|---|
| 1. INITIAL MIXED RIVER CONDITION | |
| $CBOD_5$ (mg/L): | 0.5 |
| NBOD (mg/L): | 1.7 |
| Dissolved Oxygen (mg/L): | 8.1 |
| Temperature (deg C): | 21.1 |
| 2. TEMPERATURE ADJUSTED RATE CONSTANTS (Base e) | |
| Reaeration (day^-1): | 0.21 |
| BOD Decay (day^-1): | 0.07 |
| 3. CALCULATED INITIAL ULTIMATE CBODU AND TOTAL BODU | |
| Initial Mixed CBODU (mg/L): | 0.7 |
| Initial Mixed Total BODU (CBODU + NBOD, mg/L): | 2.5 |
| 4. INITIAL DISSOLVED OXYGEN DEFICIT | |
| Saturation Dissolved Oxygen (mg/L): | 8.895 |
| Initial Deficit (mg/L): | 0.80 |
| 5. TRAVEL TIME TO CRITICAL DO CONCENTRATION (days): | 1.20 |
| 6. DISTANCE TO CRITICAL DO CONCENTRATION (miles): | 19.95 |
| 7. CRITICAL DO DEFICIT (mg/L): | 0.81 |
| **8. CRITICAL DO CONCENTRATION (mg/L):** | **8.09** |

1). Based on Bennett & Rathbun (1972) and EPA Surface WQ Modeling Guidance (1985).
2). Based on BOD decay rates in Willamette River by McCutcheon (1983).