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Memorandum

Date:	8 August, 2019
To:	City of Molalla
From:	Jacob Krall, Geosyntec Consultants
Subject:	City of Molalla WWTP, Dissolved Oxygen Analysis

INTRODUCTION

This document provides results using the Oregon Department of Environmental Quality (ODEQ) Streeter-Phelps Equation spreadsheet model[1] which demonstrate that the new City of Molalla Wastewater Treatment Plant (WWTP) effluent discharge to the Molalla River (River) will not violate the antidegradation condition for an existing discharger, specifically:

- The new WWTP will not decrease Dissolved Oxygen (DO) by more than 0.1 mg/L at any location, and
- The new WWTP will not measurably decrease DO at any point in the River below River Mile 18.2 due to the 303d listing for this reach. Based on conversations with ODEQ, no measurable change is taken in this memorandum to mean no change to two decimal places.
- Subject to necessary river flow-based limitations, the WWTP can discharge treated effluent to the River in May and June.

This memorandum considers both conditions in which the City of Molalla is currently permitted to discharge (November-April) and periods where the City is currently not permitted to discharge, focusing on May and June during periods when the river flows are relatively high due to wet weather.

TIME PERIODS WHERE DISCHARGE IS CURRENTLY PERMITTED

For periods when the plant is currently permitted to discharge, the analysis compares conditions with the 2043 design discharges from the new WWTP to current permitted discharges. Specifically, the following conditions were analyzed:

[1] https://www.oregon.gov/deq/FilterPermitsDocs/RPAStreeter-PhelpsDOModel.xlsx

- Low River flow conditions (350 cubic feet per second (cfs) River flow at Canby, which is equivalent to 224 cfs at the WWTP based on a ratio of 0.64, as was used in the 2008 Molalla-Pudding Subbasin Total Maximum Daily Load[2]).
- Typical winter conditions (used 1,340 cfs River flow at Canby and 858 cfs at the WWTP based on median April flow conditions)
- Maximum month wet weather conditions (used 2,640 cfs River flow at Canby and 1,690 cfs at the WWTP based on 90th percentile River flows)

The results, presented in the next section, indicate that the new WWTP discharge at the 2043 design flow, 30 mg/L effluent BOD, an effluent Ammonia of 6.0 mg/L with the new treatment process, and an effluent DO concentration of 7.0 mg/L will not violate the antidegradation condition for DO.

Results for Low Flow Conditions

- Table 1 presents the values uses for analysis of both current and future conditions at River flows of 350 cfs at Canby.

Table 1. Assumptions and Values used in Dissolved Oxygen Analysis for Low Flow Conditions During November-April.

Assumption/ Parameter	Assumed Value, Current WWTP	Assumed Value, New WWTP	Notes/Reference
WWTP Flow Rate	3.0 MGD	4.24 MGD	Average 2043 wet weather design flow conditions[3]
Ambient DO concentration	10.49	10.49	Saturation value at the point where the WWTP enters the River after mixing
WWTP Effluent DO Concentration	6 mg/L	7 mg/L	The existing Cascade Aeration System has historically provided an

[2] Williams, K.F., and Bloom, J., 2008, Molalla-Pudding Subbasin total maximum daily load (TMDL) and Water Quality Management Plan (WQMP): Oregon Department of Environmental Quality.
[3] This is a conservative analysis since the WWTP will not discharge at average wet weather design flow rates during when River flows are as low as 350 cfs at Canby.

Assumption/ Parameter	Assumed Value, Current WWTP	Assumed Value, New WWTP	Notes/Reference
			effluent DO greater than 7 mg/L.
WWTP Effluent BOD Concentration	10 mg/L	30 mg/L	Increase to basin standard for winter conditions.
WWTP Effluent Ammonia Concentration	16.7 mg/L	6.0 mg/L	The new WWTP has a process guarantee to achieve 5 mg/L ammonia.
Total Kjeldahl Nitrogen	20.9 mg/L	7.5 mg/L	Based on Ammonia being 80% of total Nitrogen
Deoxygenation rate constant at 20°C	Worst Case: 0.14/day	Worst Case: 0.14/day	Maximum of range for Willamette River (McCutchen, 1983, DEQ spreadsheet)
River velocity	2.54 feet/second	2.54 feet/second	Estimated based on USGS (2010)
River depth	1.70 feet	1.70 feet	Estimated based on USGS (2010)
River width	67.3 feet	67.3 feet	Estimated based on USGS (2010)
Sediment Oxygen Demand	0.24 $g/m^2/day$	0.24 $g/m^2/day$	Set so that the River without the WWTP maintains a constant DO.

The results of this analysis are presented in Figure 1. The figure shows that the new WWTP will produce DO conditions very similar to current WWTP conditions. The figure also shows that at RM 18.2 (1.5 miles downstream of the plant), the difference between current and future predicted

DO is 0.003 mg/L, which represents no change at two decimal places. For most of the RM 0 – 18.2 reach, the future conditions model predicts a higher DO than that current conditions model.

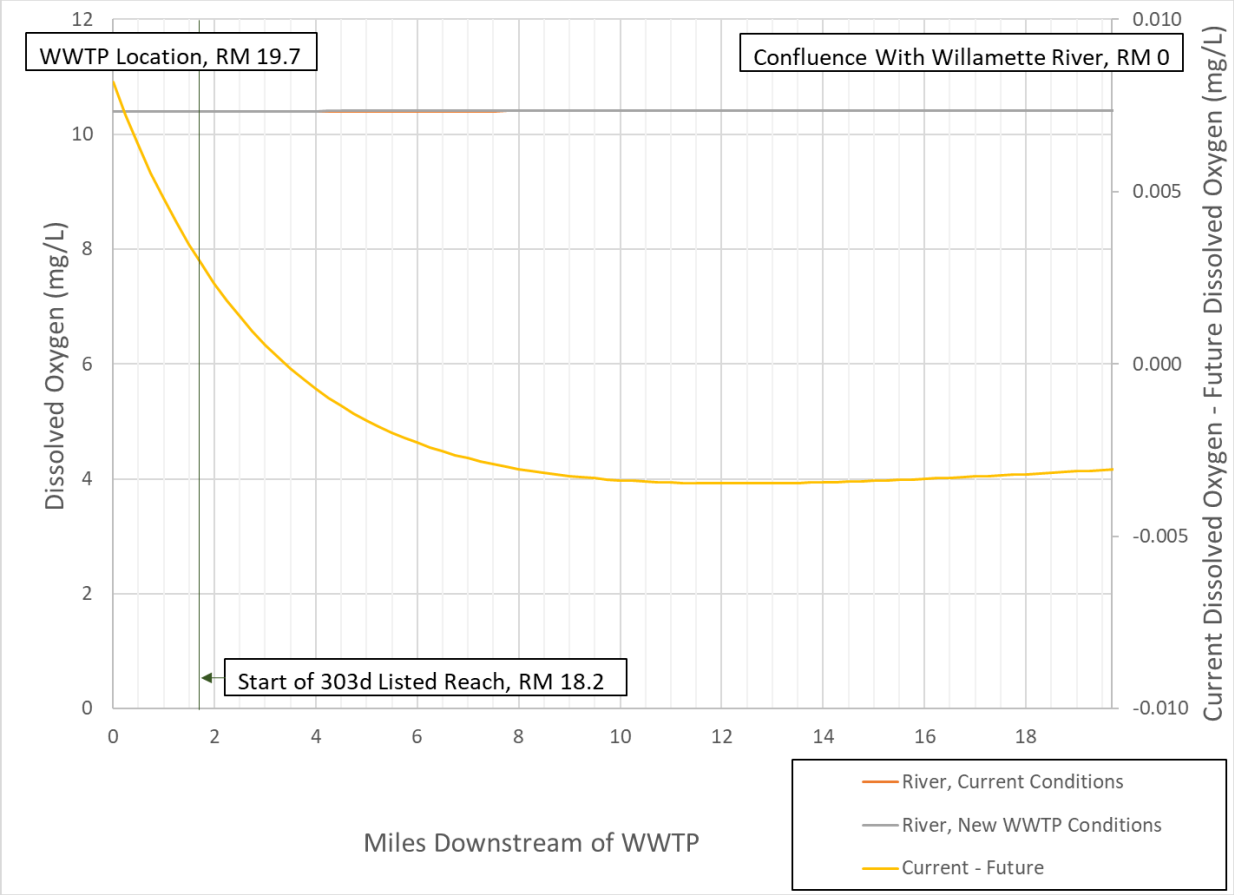

Figure 1. DO sag curve for current and future discharge conditions at River flows of 350 cfs at Canby.

Results for Typical Winter Conditions

- Table 2 presents the values used for analysis of both current and future conditions at River flows of 1,340 cfs at Canby based on median April conditions.

Table 2. Assumptions and Values used in Dissolved Oxygen Analysis for Typical Month Winter Conditions During November-April.

Assumption/ Parameter	Assumed Value, Current WWTP	Assumed Value, New WWTP	Notes/Reference
WWTP Flow Rate	3.0 MGD	4.24 MGD	Average 2043 wet weather design flow conditions
Ambient DO concentration	10.51	10.51	Saturation value at the point where the WWTP enters the River after mixing
WWTP Effluent DO Concentration	6 mg/L	7 mg/L	The existing Cascade Aeration System has historically provided an effluent DO greater than 7 mg/L.
WWTP Effluent BOD Concentration	10 mg/L	30 mg/L	Requesting an increase in permitted BOD to the basin standard of 30 mg/L for winter conditions.
WWTP Effluent Ammonia Concentration	16.7 mg/L	6.0 mg/L	The new WWTP has a process guarantee to achieve 5 mg/L ammonia.
Total Kjeldahl Nitrogen	20.9 mg/L	7.5 mg/L	Based on Ammonia being 80% of total Nitrogen
Deoxygenation rate constant at 20°C	Worst Case: 0.14/day	Worst Case: 0.14/day	Maximum of range for Willamette River (McCutchen, 1983, DEQ spreadsheet)
River velocity	3.74 feet/second	3.74 feet/second	Estimated based on USGS (2010)

Assumption/ Parameter	Assumed Value, Current WWTP	Assumed Value, New WWTP	Notes/Reference
River depth	2.76 feet	2.76 feet	Estimated based on USGS (2010)
River width	85.6 feet	85.6 feet	Estimated based on USGS (2010)
Sediment Oxygen Demand	0.06 $g/m^2/day$	0.06 $g/m^2/day$	Set so that the River without the WWTP maintains a constant DO.

The results of this analysis are presented in Figure 2. The figure shows that the new WWTP will produce DO conditions very similar to current WWTP conditions. The figure also shows that at RM 18.2 (1.5 miles downstream of the plant), the difference between current and future predicted DO is 0.001 mg/L, which represents no change at two decimal places. For most of the RM 0 – 18.2 reach, the future conditions model predicts a higher DO than that current conditions model.

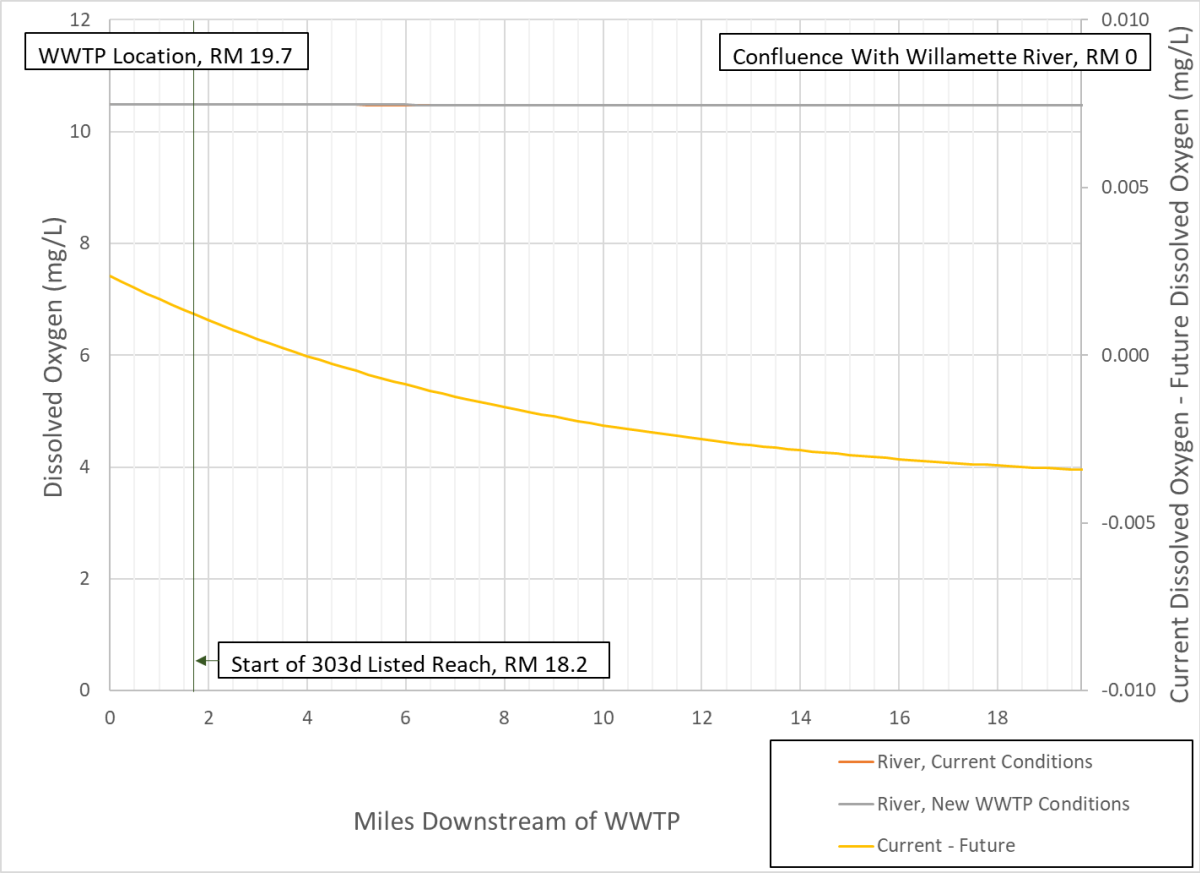

Figure 2. DO sag curve for current and future discharge conditions at River flows of 1,340 cfs at Canby (median April conditions).

Results for Maximum Month Winter Conditions

- Table 3 presents the values used for analysis of both current and future conditions at River flows of 2,640 cfs at Canby based on 90th percentile River flow conditions.

Table 3. Assumptions and Values used in Dissolved Oxygen Analysis for Maximum Month Winter Conditions.

Assumption/ Parameter	Assumed Value, Current WWTP	Assumed Value, New WWTP	Notes/Reference
WWTP Flow Rate	4.1 MGD	5.3 MGD	Maximum month 2043 design flow conditions
Ambient DO concentration	10.51	10.51	Saturation value at the point where the WWTP enters the River after mixing
WWTP Effluent DO Concentration	6 mg/L	7 mg/L	The existing Cascade Aeration System has historically provided an effluent DO greater than 7 mg/L.
WWTP Effluent BOD Concentration	10 mg/L	30 mg/L	Requesting an increase in permitted BOD to the basin standard of 30 mg/L for winter conditions.
WWTP Effluent Ammonia Concentration	16.7 mg/L	6.0 mg/L	The new WWTP has a process guarantee to achieve 5 mg/L ammonia.
Total Kjeldahl Nitrogen	20.9 mg/L	7.5 mg/L	Based on Ammonia being 80% of total Nitrogen
Deoxygenation rate constant at 20°C	Worst Case: 0.14/day	Worst Case: 0.14/day	Maximum of range for Willamette River (McCutchen, 1983, DEQ spreadsheet)
River velocity	4.25 feet/second	4.25 feet/second	Estimated based on USGS (2010)

Assumption/ Parameter	Assumed Value, Current WWTP	Assumed Value, New WWTP	Notes/Reference
River depth	3.43 feet	3.43 feet	Estimated based on USGS (2010)
River width	95.6 feet	95.6 feet	Estimated based on USGS (2010)
Sediment Oxygen Demand	0.04 $g/m^2/day$	0.04 $g/m^2/day$	Set so that the River without the WWTP maintains a constant DO.

The results of this analysis are presented in Figure 3. The figure shows that the new WWTP will produce DO conditions very similar to current WWTP conditions. The figure also shows that at RM 18.2 (1.5 miles downstream of the plant), the difference between current and future predicted DO is -0.001 mg/L, meaning that the future conditions model predicts slightly higher DO than the current conditions model.

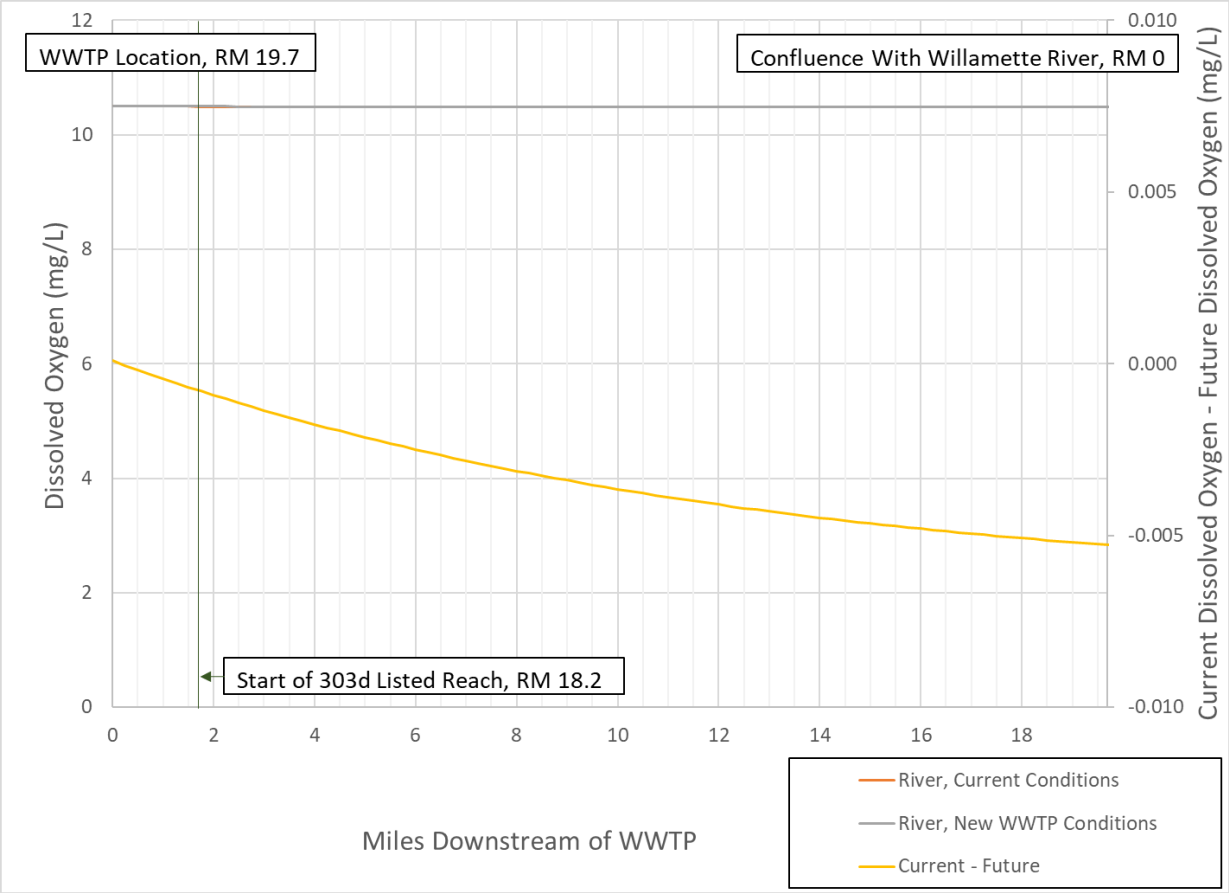

Figure 3. DO sag curve for current and future discharge conditions at River flows of 2,640 cfs at Canby (90th percentile River flows).

TIME PERIODS WHERE DISCHARGE IS CURRENTLY NOT PERMITTED

For periods where discharge is not currently permitted, a range of River flows were analyzed to develop a relationship between ambient River flow at Canby and the WWTP effluent flow that would not violate the antidegradation condition (i.e. would not reduce the DO in the River by more than 0.1 mg/L and would not measurably reduce the DO below RM 18.2). This analysis was done for three combinations of WWTP effluent ammonia and effluent DO concentration:

- 3 mg/L ammonia, DO at saturation conditions
- 5 mg/L ammonia, DO at saturation conditions
- 5 mg/L ammonia, DO at 7 mg/L

The new treatment process has a process guarantee to produce effluent ammonia levels less than 5 mg/L or less. To reach DO saturation conditions, additional aeration of the plant effluent will be required.

For all three of the above sets of parameters, the following additional assumptions were used in the analysis (Table 4).

Table 4. Assumptions and Values used in Dissolved Oxygen Analysis for Time Periods Where Discharge is Not Currently Permitted.

Assumption/ Parameter	Assumed Value, New WWTP	Notes/Reference
WWTP Flow Rate	Variable	Varies depending on ambient River flow
WWTP Effluent BOD Concentration	10 mg/L	Basin standard for summer conditions.
Deoxygenation rate constant at 20°C	Worst Case: 0.14/day	Maximum of range for Willamette River (McCutchen, 1983, DEQ spreadsheet)
River velocity	Variable	Estimated based on USGS (2010), varies based on ambient River flow
River depth	Variable	Estimated based on USGS (2010), varies based on ambient River flow
River width	Variable	Estimated based on USGS (2010), varies based on ambient River flow
Sediment Oxygen Demand	Variable	Set so that the River without the WWTP maintains a constant DO.

Results For 3 mg/L Ammonia, DO at Saturation Conditions

Each data point on Figure 4 represents a scenario that was modeled using ODEQ's Streeter-Phelps equation tool and did not violate the antidegradation condition (both upstream and downstream of RM 18.2 as discussed previously). The figure shows the relationship between ambient flow at Canby and the effluent WWTP discharge that will not violate the antidegradation condition given the assumptions in Table 4, an effluent ammonia concentration of 3 mg/L and effluent DO concentration at saturation based on the temperature at the point where the WWTP discharge mixes with the Molalla River.

The figure shows that a 3rd degree polynomial describes the relationship very accurately between ambient River flows of 350 and 5,000 cfs.

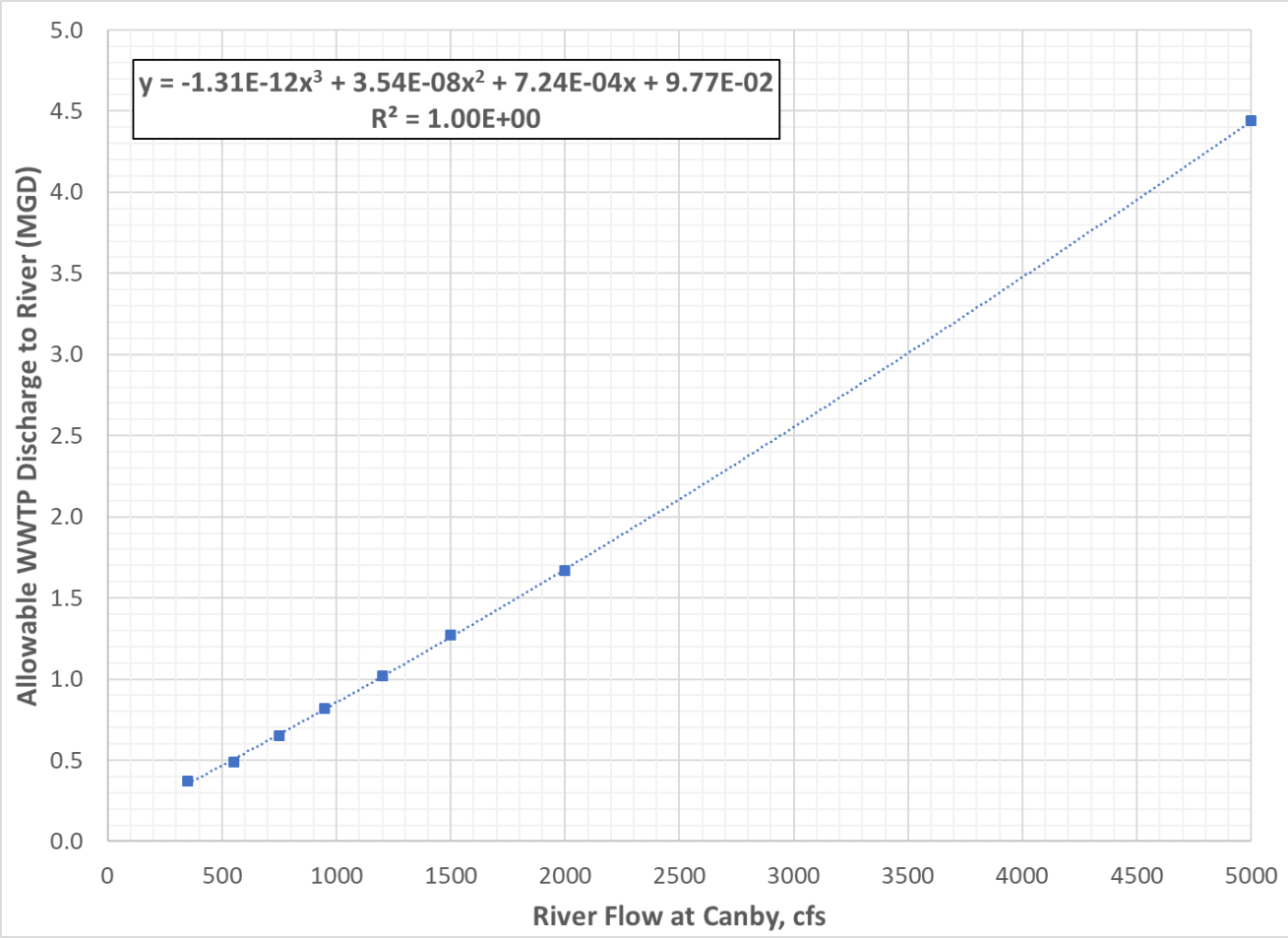

Figure 4. WWTP Discharge that Does Not Violate the Antidegradation Condition as a Function of Ambient River Flow at Canby, for 3 mg/L ammonia and effluent DO at saturation.

Table 5 shows the ambient River flows at which the WWTP can discharge 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.5 and 2.0 MGD without violating the antidegradation condition, based on the equation shown in Figure 4.

Table 5. WWTP Discharge that Does Not Violate the Antidegradation Condition as a Function of Ambient River Flow at Canby, for 3 mg/L ammonia and effluent DO at saturation.

Ambient River Flow at Canby (cfs)	WWTP Discharge (MGD)
542	0.5
673	0.6
802	0.7
930	0.8
1,056	0.9
1,181	1.0
1,791	1.5
2,376	2.0

Results For 5 mg/L Ammonia, DO at Saturation Conditions

Figure 5 shows the relationship between ambient flow at Canby and the effluent WWTP discharge that will not violate the antidegradation condition assuming the WWTP has an effluent ammonia concentration of 5 mg/L and the effluent DO is at saturation based on the temperature at the point where the WWTP discharge mixes with the Molalla River. As with Figure 4, each point on the plot represents a scenario modeled with ODEQ's Streeter-Phelps equation tool.

Additionally, as with Figure 4, the figure shows that a 3rd degree polynomial describes the relationship very accurately between ambient River flows of 350 and 5,000 cfs.

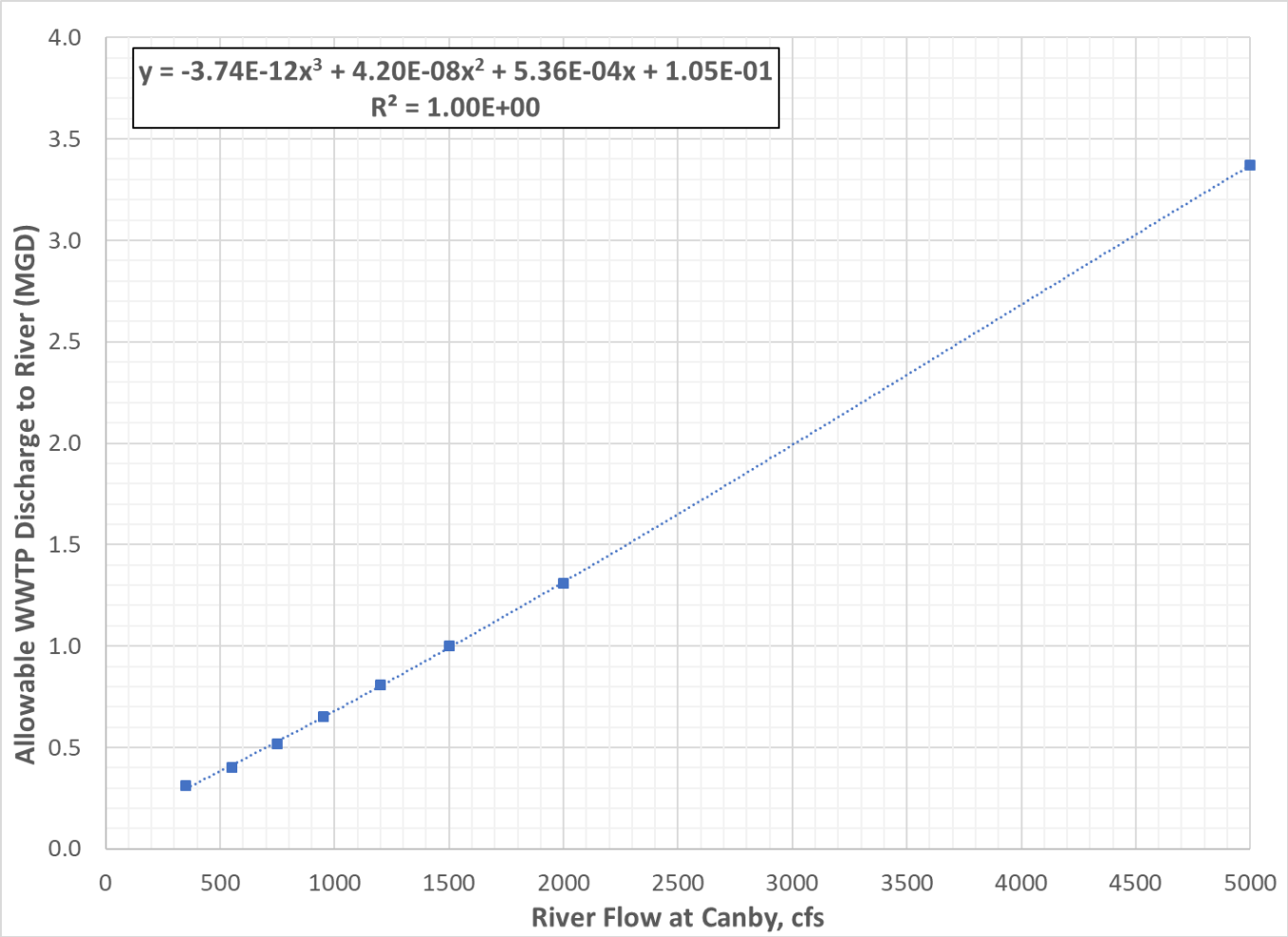

Figure 5. WWTP Discharge that Does Not Violate the Antidegradation Condition as a Function of Ambient River Flow at Canby, for 5 mg/L ammonia and effluent DO at Saturation.

Table 6 shows the ambient River flows at which the WWTP can discharge 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.5 and 2.0 MGD without violating the antidegradation condition, based on the equation shown in Figure 5.

Table 6. WWTP Discharge that Does Not Violate the Antidegradation Condition as a Function of Ambient River Flow at Canby, for 5 mg/L ammonia and effluent DO at Saturation.

Ambient River Flow at Canby (cfs)	WWTP Discharge (MGD)
700	0.5
868	0.6
1,033	0.7
1,196	0.8
1,356	0.9
1,514	1.0
2,277	1.5
3,013	2.0

Results For 5 mg/L Ammonia, 7 mg/L DO

Figure 6 shows the relationship between ambient flow at Canby and the effluent WWTP discharge that will not violate the antidegradation condition assuming 5 mg/L effluent ammonia concentration and 7 mg/L effluent DO concentration. As with Figure 4 and Figure 5, each data point represents a scenario modeled using ODEQ's Streeter-Phelps equation tool and a 3rd degree polynomial can be used to describe the relationship between ambient River flows and allowable WWTP discharge (for River flows at Canby between 350 and 5,000 cfs).

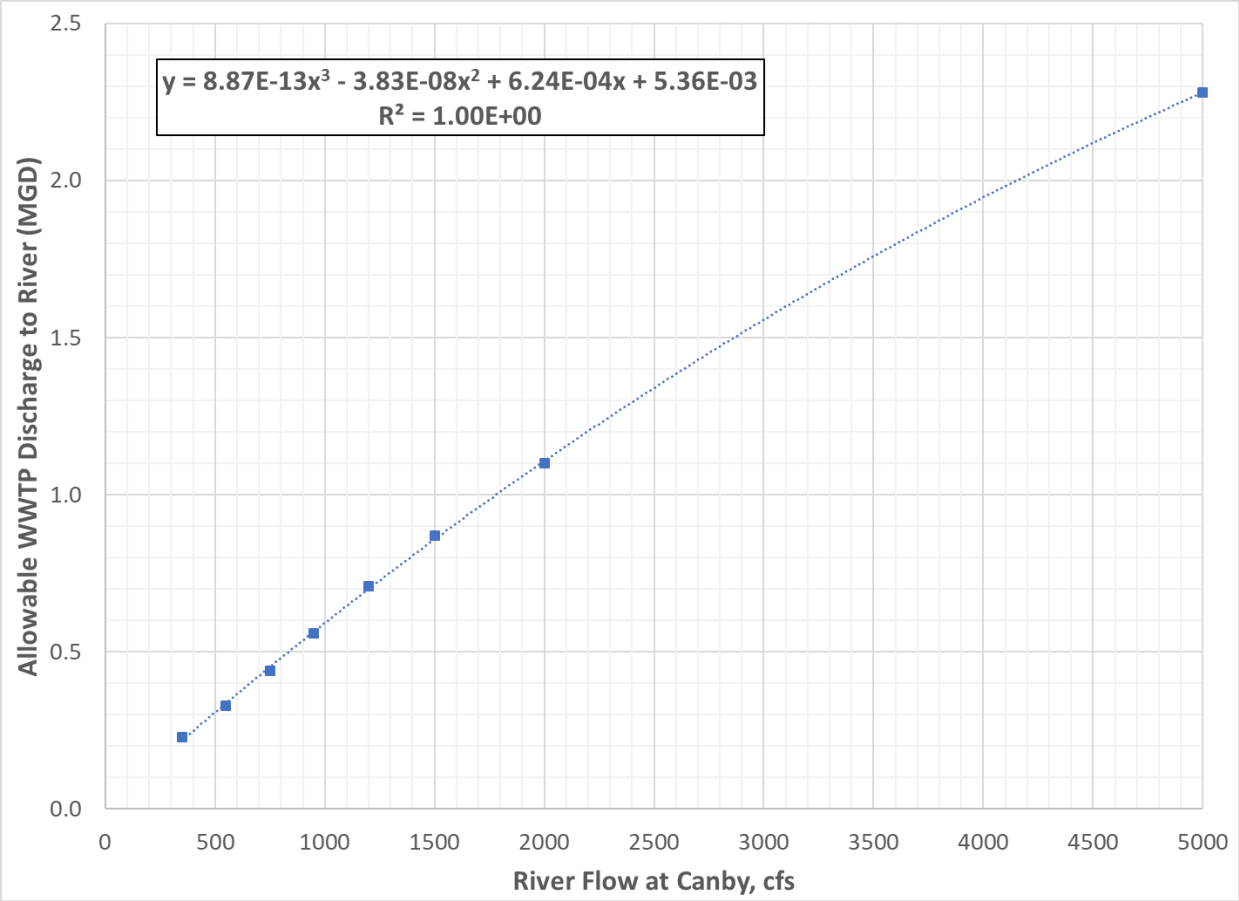

Figure 6. WWTP Discharge that Does Not Violate the Antidegradation Condition as a Function of Ambient River Flow at Canby, for 5 mg/L ammonia and 7 mg/L effluent DO.

Table 7 shows the ambient River flows at which the WWTP can discharge 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.5 and 2.0 MGD without violating the antidegradation condition (based on the equation shown in Figure 6). Higher River flows are required for a given WWTP discharge compared with the previous sections.

Table 7. WWTP Discharge that Does Not Violate the Antidegradation Condition as a Function of Ambient River Flow at Canby, for 3 mg/L ammonia and 7 mg/L effluent DO.

Ambient River Flow at Canby (cfs)	WWTP Discharge (MGD)
834	0.5
1,014	0.6
1,199	0.7
1,387	0.8
1,581	0.9
1,780	1.0
2,865	1.5
4,151	2.0

SUMMARY

This memorandum demonstrates that with an effluent DO concentration of 7 mg/L and effluent ammonia concentration of 6 mg/L, the new WWTP with increased discharge and 30 mg/L effluent BOD will not violate the antidegradation condition during periods where the WWTP is currently permitted to discharge (November-April). This memorandum also provides the allowable WWTP discharges that will not violate the antidegradation condition during May and June (where the current WWTP is not permitted to discharge) for three combinations of WWTP effluent DO and ammonia concentrations.