Utah Division of Water Quality
Statement of Basis
ADDENDUM
Wasteload Analysis and Antidegradation Level I Review - FINAL

Date: **October 15, 2015**

Facility: **Orem City Water Reclamation Facility**
Orem, UT
UPDES No. UT0020915

Receiving water: **Powell Slough (2B, 3C, 3D)**

This addendum summarizes the wasteload analysis that was performed to determine water quality based effluent limits (WQBEL) for this discharge. Wasteload analyses are performed to determine point source effluent limitations necessary to maintain designated beneficial uses by evaluating projected effects of discharge concentrations on in-stream water quality. The wasteload analysis also takes into account downstream designated uses (UAC R317-2-8). Projected concentrations are compared to numeric water quality standards to determine acceptability. The numeric criteria in this wasteload analysis may be modified by narrative criteria and other conditions determined by staff of the Division of Water Quality.

Discharge
Outfall 001: Powell Slough → Utah Lake

The maximum daily discharge is not projected to exceed 14.0 MGD during this permit cycle and the maximum monthly design discharge for the facility is 14.0 MGD.

Receiving Water
The receiving water for Outfall 001 is Powell Slough Waterfowl Management Area, which is tributary to Utah Lake.

Per UAC R317-2-13.11, the designated beneficial uses for Powell Slough Waterfowl Management Area are 2B, 3C, and 3D.

- *Class 2B - Protected for infrequent primary contact recreation. Also protected for secondary contact recreation where there is a low likelihood of ingestion of water or a low degree of bodily contact with the water. Examples include, but are not limited to, wading, hunting, and fishing.*

- *Class 3C - Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain*

- *Class 3D - Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain.*

Typically, the critical flow for the wasteload analysis is considered the lowest stream flow for seven consecutive days with a ten year return frequency (7Q10). Due to a lack of flow records for Powell Slough, the 20th percentile of flow measurements from sampling station 4995260 Powell Slough above Orem WWTP was calculated to estimate annual critical flow in the receiving water (Table 1).

Table 1: Annual critical low flow

Season	Flow (cfs)
Summer	2.0
Fall	3.0
Winter	5.1
Spring	6.0

TMDL

Powell Slough is not listed as impaired for any parameters according to the 2010 303(d) list. Utah Lake is listed as impaired for Total Phosphorus and Total Dissolved Solids.

Mixing Zone

The maximum allowable mixing zone is 15 minutes of travel time for acute conditions, not to exceed 50% of stream width, and 2,500 feet for chronic conditions, per UAC R317-2-5. Water quality standards must be met at the end of the mixing zone.

The discharge is considered instantaneously fully mixed since the effluent discharge is twice the background receiving water flow; therefore, no mixing zone is allowed per UAC R317-2-5.

Parameters of Concern

The potential parameters of concern identified for the discharge/receiving water were total suspended solids (TSS), dissolved oxygen (DO), BOD_5, total phosphorus (TP), total nitrogen (TN), total ammonia (TAN), E. coli, and pH as determined in consultation with the UPDES Permit Writer.

Water Quality Modeling

A QUAL2Kw model of the receiving water was built and calibrated to synoptic survey data collected in September of 2014 by DWQ staff using standard operating procedures (DWQ 2012). The model of Powell Slough extends 2.1 kilometers downstream from the treatment facility outfall to the outlet at Utah Lake.

Receiving water quality data were obtained from monitoring site 4995260 Powell Slough above Orem WWTP. The average seasonal value was calculated for each constituent with available data in the receiving water. Effluent parameters were characterized using data from monitoring site 4995250 Orem WWTP.

The QUAL2Kw model was used for determining the WQBELs for parameters related to eutrophication and in-stream DO criteria, as well as ammonia toxicity. Effluent concentrations

were adjusted so that water quality standards were not exceeded in the receiving water. Where WQBELs exceeded secondary standards or technology based effluent limits (TBEL), the concentration in the model was set at the secondary standard or TBEL.

The QUAL2Kw model was also used to determine the limits for ammonia. The water quality standard for chronic ammonia toxicity is dependent on temperature and pH, and the water quality standard for acute ammonia toxicity is dependent on pH.

A mass balance mixing analysis was conducted for conservative constituents such as dissolved metals.

QUAL2Kw rates, input and output for DO and eutrophication related constituents are summarized in Appendix A. The WQBELs for conservative constituents are summarized in Appendix B.

The calibration and wasteload models are available for review by request.

Whole Effluent Toxicity (WET) Limits

The percent of effluent in the receiving water in a fully mixed condition, and acute and chronic dilution in a not fully mixed condition are calculated in the WLA in order to generate WET limits. The LC_{50} (lethal concentration, 50%) percent effluent for acute toxicity and the IC_{25} (inhibition concentration, 25%) percent effluent for chronic toxicity, as determined by the WET test, needs to be below the WET limits, as determined by the WLA. The WET limit for LC_{50} is typically 100% effluent and does not need to be determined by the WLA.

Table 2: WET Limits for IC_{25}

Season	Percent Effluent
Summer	92%
Fall	88%
Winter	81%
Spring	78%

Effluent Limits

The effect of the effluent on the DO in the receiving water was evaluated using the QUAL2Kw model. A DO sag downstream resulting from the plant discharge was predicted by the model in Powell Slough. However, the DO remained above the minimum criteria and limits more stringent than secondary standards are not required for BOD_5 (Table 3).

Table 3: Water Quality Based Effluent Limits Summary

Effluent Constituent	Acute			Chronic		
	Standard	Limit	Averaging Period	Standard	Limit	Averaging Period
Flow (MGD)	N/A	14.0	1 day	N/A	14.0	30 days
Ammonia (mg/L)						
Summer (Jul-Sep)		10.0			2.5	
Fall (Oct-Dec)	Varies	14.0	1 hour	Varies	3.5	30 days
Winter (Jan-Mar)		16.0			4.5	
Spring (Apr-Jun)		12.0			3.5	
Min. Dissolved Oxygen (mg/L)	3.0	5.5	Instantaneous	5.0	5.5	30 days
BOD_5 (mg/L)	N/A	35	7 days	N/A	25	30 days

Antidegradation Level I Review

The objective of the Level I ADR is to ensure the protection of existing uses, defined as the beneficial uses attained in the receiving water on or after November 28, 1975. No evidence is known that the existing uses deviate from the designated beneficial uses for the receiving water. Therefore, the beneficial uses will be protected if the discharge remains below the WQBELs presented in this wasteload.

A Level II Antidegradation Review (ADR) is not required for this discharge since the pollutant concentration and load is not increasing under this permit renewal.

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Documents:

WLA Document: *orem_potw_wla_2015_final.docx*
QUAL2Kw Calibration Model: *orem_potw_q2kw_cal_2015.xlsm*
QUAL2Kw Wasteload Model: *orem_potw_q2kw_wla_2015.xlsm*

References:

Utah Wasteload Analysis Procedures Version 1.0. 2012. Utah Division of Water Quality.

Field Data Collection for QUAL2Kw Model Build and Calibration Standard Operating Procedures Version 1.0. 2012. Utah Division of Water Quality.

Using QUAL2K Modeling to Support Nutrient Criteria Development and Wasteload Analyses in Utah. 2012. Neilson, B.T., A.J. Hobson, N. von Stackelberg, M. Shupryt, and J.D. Ostermiller.

WASTELOAD ANALYSIS [WLA] Date: 2/2/2015
Appendix A: QUAL2Kw Analysis for Eutrophication

Discharging Facility:	Orem WRF	
UPDES No:	UT-0020915	
Permit Flow [MGD]:	14.00 Maximum Monthly Flow	
	14.00 Maximum Daily Flow	
Receiving Water:	Powell Slough	
Stream Classification:	2B, 3C, 3D	
Stream Flows [cfs]:	2.0 Summer (July-Sept)	Critical Low Flow
	3.0 Fall (Oct-Dec)	
	5.1 Winter (Jan-Mar)	
	6.0 Spring (Apr-June)	
Fully Mixed:	YES	
Acute River Width:	100%	
Chronic River Width:	100%	

Modeling Information

A QUAL2Kw model was used to determine these effluent limits.

Model Inputs

The following is upstream and discharge information that was utilized as inputs for the analysis. Dry washes are considered to have an upstream flow equal to the flow of the discharge.

Headwater/Upstream Information	Summer	Fall	Winter	Spring
Flow (cfs)	2.0	3.0	5.1	6.0
Temperature (deg C)	20.0	8.9	9.0	14.9
Specific Conductance (µmhos)	648	653	701	670
Inorganic Suspended Solids (mg/L)	7.4	4.5	6.3	10.1
Dissolved Oxygen (mg/L)	11.9	11.3	11.3	10.8
$CBOD_5$ (mg/L)	10.0	3.0	3.0	3.0
Organic Nitrogen (mg/L)	0.355	0.363	0.227	0.227
NH4-Nitrogen (mg/L)	0.055	0.058	0.290	0.059
NO3-Nitrogen (mg/L)	0.366	0.950	1.066	0.597
Organic Phosphorus (mg/L)	0.013	-0.044	0.000	0.009
Inorganic Ortho-Phosphorus (mg/L)	0.024	0.196	0.138	0.023
Phytoplankton (µg/L)	0.0	0.0	0.0	0.0
Detritus [POM] (mg/L)	3.2	1.9	2.7	4.3
Alkalinity (mg/L)	227	242	247	234
pH	8.0	8.1	7.8	8.3

Discharge Information

Chronic	Summer	Fall	Winter	Spring
Flow (MGD)	14.0	14.0	14.0	14.0
Temperature (deg C)	22.5	16.5	12.0	17.1
Specific Conductance (µmhos)	1055	1014	1049	951
Inorganic Suspended Solids (mg/L)	4.0	4.3	4.9	5.2
Dissolved Oxygen (mg/L)	5.5	5.5	5.5	5.5
$CBOD_5$ (mg/L)	25.0	25.0	25.0	25.0
Organic Nitrogen (mg/L)	2.198	6.490	4.602	1.255
NH4-Nitrogen (mg/L)	2.500	3.500	4.500	3.500
NO3-Nitrogen (mg/L)	6.242	10.445	5.777	1.754
Organic Phosphorus (mg/L)	2.766	3.442	3.294	2.525
Inorganic Ortho-Phosphorus (mg/L)	0.000	0.000	0.132	0.466
Phytoplankton (µg/L)	0.0	0.0	0.0	0.0
Detritus [POM] (mg/L)	0.0	0.0	0.0	0.0
Alkalinity (mg/L)	186	162	192	203
pH	7.3	7.4	7.3	7.4

Acute	Summer	Fall	Winter	Spring
Flow (MGD)	14.0	14.0	14.0	14.0
Temperature (deg C)	22.5	16.5	12.0	17.1
Specific Conductance (µmhos)	1055	1014	1049	951
Inorganic Suspended Solids (mg/L)	4.0	4.3	4.9	5.2
Dissolved Oxygen (mg/L)	5.5	5.5	5.5	5.5
$CBOD_5$ (mg/L)	35.0	35.0	35.0	35.0
Organic Nitrogen (mg/L)	2.198	6.490	4.602	1.255
NH4-Nitrogen (mg/L)	10.000	14.000	16.000	12.000
NO3-Nitrogen (mg/L)	6.242	10.445	5.777	1.754
Organic Phosphorus (mg/L)	0.000	0.000	0.132	0.466
Inorganic Ortho-Phosphorus (mg/L)	3.287	3.489	3.162	2.058
Phytoplankton (µg/L)	0.0	0.0	0.0	0.0
Detritus [POM] (mg/L)	0.0	0.0	0.0	0.0
Alkalinity (mg/L)	186	162	192	203
pH	7.5	7.5	7.5	7.5

All model numerical inputs, intermediate calculations, outputs and graphs are available for discussion, inspection and copy at the Division of Water Quality.

Effluent Limitations

Current State water quality standards are required to be met under a variety of conditions including in-stream flows targeted to the 7-day, 10-year low flow (R317-2-9).

Other conditions used in the modeling effort reflect the environmental conditions expected at low stream flows.

Effluent Limitations based upon Water Quality Standards for DO

In-stream criteria of downstream segments for Dissolved Oxygen will be met with an effluent limitation as follows:

Constituent	Standard	Summer	Fall	Winter	Spring
Flow [Maximum Daily] (MGD)	N/A	14.0	14.0	14.0	14.0
Flow [Monthly Average] (MGD)	N/A	14.0	14.0	14.0	14.0
BOD_5 [7-day Average] (mg/L)	N/A	35.0	35.0	35.0	35.0
BOD_5 [30-day Average] (mg/L)	N/A	25.0	25.0	25.0	25.0
Dissolved Oxygen [30-day Average] (mg/L)	5.0	5.5	5.5	5.5	5.5
Dissolved Oxygen [Minimum] (mg/L)	3.0	5.5	5.5	5.5	5.5
NH4-Nitrogen (mg/L)	N/A	2.5	3.5	4.5	3.5

Effluent Limitations based upon Water Quality Standards for Ammonia

In-stream criteria of downstream segments for Ammonia will be met with an effluent limitation as follows:

NH4-Nitrogen (mg/L)	Standard	Summer	Fall	Winter	Spring
Acute [1-hour Average]	Varies	10.0	14.0	16.0	12.0
Chronic [30-day Average]	Varies	2.5	3.5	4.5	3.5

Summary Comments

The mathematical modeling and best professional judgement indicate that violations of receiving water beneficial uses with their associated water quality standards, including important down-stream segments, will not occur for the evaluated parameters of concern as discussed above if the effluent limitations indicated above are met.

Coefficients and Other Model Information

Parameter	*Value*	*Units*
Stoichiometry:		
Carbon	40	gC
Nitrogen	7.2	gN
Phosphorus	1	gP
Dry weight	100	gD
Chlorophyll	1	gA
Inorganic suspended solids:		
Settling velocity	0.001	m/d
Oxygen:		
Reaeration model	Thackston-Dawson	
Temp correction	1.024	
Reaeration wind effect	None	
O2 for carbon oxidation	2.69	gO2/gC
O2 for NH4 nitrification	4.57	gO2/gN
Oxygen inhib model CBOD oxidation	Exponential	
Oxygen inhib parameter CBOD oxidation	0.60	L/mgO2
Oxygen inhib model nitrification	Exponential	
Oxygen inhib parameter nitrification	0.60	L/mgO2
Oxygen enhance model denitrification	Exponential	
Oxygen enhance parameter denitrification	0.60	L/mgO2
Oxygen inhib model phyto resp	Exponential	
Oxygen inhib parameter phyto resp	0.60	L/mgO2
Oxygen enhance model bot alg resp	Exponential	
Oxygen enhance parameter bot alg resp	0.60	L/mgO2
Slow CBOD:		
Hydrolysis rate	0	/d
Temp correction	1.047	
Oxidation rate	0.103	/d
Temp correction	1.047	
Fast CBOD:		
Oxidation rate	10	/d
Temp correction	1.047	
Organic N:		
Hydrolysis	0.84524491	/d
Temp correction	1.07	
Settling velocity	0.056128	m/d
Ammonium:		
Nitrification	0.1761337	/d
Temp correction	1.07	
Nitrate:		
Denitrification	0.66745388	/d
Temp correction	1.07	
Sed denitrification transfer coeff	0.045495	m/d
Temp correction	1.07	
Organic P:		
Hydrolysis	0.32642425	/d
Temp correction	1.07	
Settling velocity	0.086465	m/d
Inorganic P:		
Settling velocity	0.015655	m/d
Sed P oxygen attenuation half sat constant	0.28717	mgO2/L

Phytoplankton:		
Max Growth rate	2.8944	/d
Temp correction	1.07	
Respiration rate	0.480803	/d
Temp correction	1.07	
Death rate	0.86518	/d
Temp correction	1	
Nitrogen half sat constant	15	ugN/L
Phosphorus half sat constant	2	ugP/L
Inorganic carbon half sat constant	1.30E-05	moles/L
Phytoplankton use HCO3- as substrate	Yes	
Light model	Smith	
Light constant	57.6	langleys/d
Ammonia preference	25.4151	ugN/L
Settling velocity	0.468545	m/d
Bottom Plants:		
Growth model	Zero-order	
Max Growth rate	15.15954	gD/m2/d or /d
Temp correction	1.07	
First-order model carrying capacity	100	gD/m2
Basal respiration rate	0.6500528	/d
Photo-respiration rate parameter	0.01	unitless
Temp correction	1.07	
Excretion rate	0.192404	/d
Temp correction	1.07	
Death rate	0.168976	/d
Temp correction	1.07	
External nitrogen half sat constant	609.3926	ugN/L
External phosphorus half sat constant	166.1311	ugP/L
Inorganic carbon half sat constant	1.00E-04	moles/L
Bottom algae use HCO3- as substrate	Yes	
Light model	Smith	
Light constant	77.733	mgO^2/L
Ammonia preference	17.54875	ugN/L
Subsistence quota for nitrogen	5.1638	mgN/gD
Subsistence quota for phosphorus	3.7292	mgP/gD
Maximum uptake rate for nitrogen	80.134	mgN/gD/d
Maximum uptake rate for phosphorus	72.3308	mgP/gD/d
Internal nitrogen half sat ratio	2.531408	
Internal phosphorus half sat ratio	1.7292025	
Nitrogen uptake water column fraction	1	
Phosphorus uptake water column fraction	1	
Detritus (POM):		
Dissolution rate	2.7941785	/d
Temp correction	1.07	
Settling velocity	0.38251	m/d
pH:		
Partial pressure of carbon dioxide	370	ppm

Atmospheric Inputs:	Summer	Fall	Winter	Spring
Min. Air Temperature, F	61.6	31.4	24.5	48.4
Max. Air Temperature, F	89.5	49.4	42.5	74.1
Dew Point, Temp., F	58.6	35.0	30.3	48.5
Wind, ft./sec. @ 21 ft.	6.6	5.2	6.0	7.4
Cloud Cover, %	10%	10%	10%	10%

Other Inputs:	
Bottom Algae Coverage	100%
Bottom SOD Coverage	100%
Prescribed SOD, $gO_2/m^2/day$	0 to 1.5
Prescribed NH4 Flux, $mgN/m^2/day$	0 to 600
Prescribed PO4 Flux, $mgP/m^2/day$	0 to 300

WASTELOAD ANALYSIS [WLA] Date: 2/2/2015

Appendix B: Mass Balance Mixing Analysis for Conservative Constituents

Discharging Facility:	2B, 3C, 3D		
UPDES No:	UT-0020915		
Permit Flow [MGD]:	14.00	Maximum Daily Flow	
	14.00	Maximum Monthly Flow	
Receiving Water:	Powell Slough		
Stream Classification:	2B, 3C, 3D		
Stream Flows [cfs]:	2.00	Summer (July-Sept)	Critical Low Flow
	3.00	Fall (Oct-Dec)	
	5.10	Winter (Jan-Mar)	
	6.00	Spring (Apr-June)	
Fully Mixed:	YES		
Acute River Width:	100%		
Chronic River Width:	100%		

Modeling Information

A simple mixing analysis was used to determine these effluent limits.

Model Inputs

The following is upstream and discharge information that was utilized as inputs for the analysis.

Headwater/Upstream Information

	Flow cfs
Summer	2.0
Fall	3.0
Winter	5.1
Spring	6.0

Discharge Information

	Flow MGD
Maximum Daily	14.0
Maximum Monthly	14.0

All model numerical inputs, intermediate calculations, outputs and graphs are available for discussion, inspection and copy at the Division of Water Quality.

Effluent Limitations

Current State water quality standards are required to be met under a variety of conditions including in-stream flows targeted to the 7-day, 10-year low flow (R317-2-9).

Other conditions used in the modeling effort reflect the environmental conditions expected at low stream flows.

Effluent Limitations for Protection of Recreation (Class 2B Waters)

Physical Parameter	Maximum Concentration
pH Minimum	6.5
pH Maximum	9.0

Bacteriological	
E. coli (30 Day Geometric Mean)	206 (#/100 mL)
E. coli (Maximum)	668 (#/100 mL)

Effluent Limitations for Protection of Aquatic Wildlife (Class 3C Waters)

Physical Parameter	Maximum Concentration
Temperature (deg C)	27
Temperature Change (deg C)	4

Inorganics Parameter	Chronic Standard (4 Day Average) Standard	Acute Standard (1 Hour Average) Standard
Phenol (mg/L)		0.010
Hydrogen Sulfide (Undissociated) [mg/L]		0.002

Dissolved Metals	Chronic Standard (4 Day Average)[1]			Acute Standard (1 Hour Average)[1]		
Parameter	Standard	Background[2]	Limit	Standard	Background[2]	Limit
Aluminum (µg/L)	N/A	20.0	N/A	750.0	20.0	817.4
Arsenic (µg/L)	150.0	3.3	163.5	340.0	3.3	371.1
Cadmium (µg/L)	0.46	0.15	0.49	4.8	0.2	5.2
Chromium VI (µg/L)[3]	11.0	7.4	11.3	16.0	7.4	16.8
Chromium III (µg/L)[3]	153.9	103.1	158.6	1183.0	103.1	1282.7
Copper (µg/L)	19.2	2.5	20.7	31.1	2.5	33.8
Cyanide (µg/L))[3]	5.2	3.5	5.4	22.0	3.5	23.7
Iron (µg/L)				1000.0	17.7	1090.7
Lead (µg/L)	6.5	0.2	7.1	168.0	0.2	183.5
Mercury (µg/L)[3]	0.012	0.008	0.012	2.4	0.0	2.6
Nickel (µg/L)	110.6	6.1	120.3	995.9	6.1	1087.3
Selenium (µg/L)	4.6	1.3	4.9	18.4	1.3	20.0
Silver (µg/L)				14.9	0.6	16.2
Tributylin (µg/L)[3]	0.072	0.048	0.074	0.46	0.05	0.50
Zinc (µg/L)	251.6	16.0	273.3	249.5	16.0	271.1

1: Based upon a Hardness of 244 mg/l as CaCO3

2: Background concentration average of monitoring data

3: Background assumed 67% of chronic standard

Organics [Pesticides]	Chronic Standard (4 Day Average)			Acute Standard (1 Hour Average)		
Parameter	**Standard**	**Background[1]**	**Limit**	**Standard**	**Background[1]**	**Limit**
Aldrin (µg/L)				1.5	1.0	1.5
Chlordane (µg/L)	0.0043	0.0029	0.0044	1.2	0.0	1.3
DDT, DDE (µg/L)	0.001	0.001	0.001	0.55	0.00	0.60
Diazinon (µg/L)	0.17	0.11	0.18	0.17	0.11	0.18
Dieldrin (µg/L)	0.0056	0.0038	0.0058	0.24	0.00	0.26
Endosulfan, a & b (µg/L)	0.056	0.038	0.058	0.11	0.04	0.12
Endrin (µg/L)	0.036	0.024	0.037	0.086	0.024	0.092
Heptachlor & H. epoxide (µg/L)	0.0038	0.0025	0.0039	0.26	0.00	0.28
Lindane (µg/L)	0.08	0.05	0.08	1.0	0.1	1.1
Methoxychlor (µg/L)				0.03	0.02	0.03
Mirex (µg/L)				0.001	0.001	0.001
Nonylphenol (µg/L)	6.6	4.4	6.8	28.0	4.4	30.2
Parathion (µg/L)	0.0130	0.0087	0.0134	0.066	0.009	0.071
PCB's (µg/L)	0.014	0.009	0.014			
Pentachlorophenol (µg/L)	15.0	10.1	15.5	19.0	10.1	19.8
Toxephene (µg/L)	0.0002	0.0001	0.0002	0.73	0.00	0.80

1: Background concentration assumed 67% of chronic standard

Radiological	Maximum Concentration		
Parameter	**Standard**	**Background[1]**	**Limit**
Gross Alpha (pCi/L)	15	10.1	15.5

1: Background concentration assumed 67% of chronic standard; TDS is based on observed ambient data