Utah Wasteload Analysis Procedures

Version 1.0

Utah Department of Environmental Quality
Division of Water Quality

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1.0 INTRODUCTION

The purpose of this guidance is to document DWQ's standard practices and procedures for conducting wasteload analyses. A wasteload analysis (WLA) determines water quality based effluent limits (WQBEL) for UPDES permits. A WQBEL is an effluent limitation that has been determined necessary to ensure that water quality standards in a receiving water will not be violated. The WQBEL may be more stringent than a technology based effluent limitation (TBEL), which is a minimum waste treatment requirement based on type of industry and treatment technology (also referred to as "secondary standard" or "categorical limit").

Water quality standards are established to protect and enhance existing and designated beneficial uses of waterbodies, including recreational, aquatic life, drinking water and agricultural uses. To protect the beneficial uses of waterbodies, narrative standards have been adopted per UAC R317-2-7.2. In addition, numeric criteria have been adopted for many priority pollutants per UAC R317-2-14.

> ***UAC R317-2-7.2 Narrative Standards***
> *It shall be unlawful, and a violation of these regulations, for any person to discharge or place any waste or other substance in such a way as will be or may become offensive such as unnatural deposits, floating debris, oil, scum or other nuisances such as color, odor or taste; or cause conditions which produce undesirable aquatic life or which produce objectionable tastes in edible aquatic organisms; or result in concentrations or combinations of substances which produce undesirable physiological responses in desirable resident fish, or other desirable aquatic life, or undesirable human health effects, as determined by bioassay or other tests performed in accordance with standard procedures.*

WQBELs are intended to ensure that water quality standards are not exceeded in order to protect the beneficial uses of the receiving water. WQBELs do not minimize the use of the assimilative capacity in the receiving water, which is handled through other programs, including antidegradation and TBELs. Therefore, the discharger is granted full use of the assimilative capacity in the receiving water when determining WQBELs.

EPA has identified the following steps to assess the need for WQBELs and to then establish the limits as necessary based on the assessment:

Step 1. Identify applicable water quality standards.

Step 2. Characterize the effluent and receiving water.

Step 3. Determine the need for parameter-specific WQBELs.

Step 4. Calculate parameter-specific WQBELs.

2.0 TRAINING RESOURCES AND REFERENCES

EPA Water Quality Standards Academy: NPDES Permit including calculating WQBELs:
http://water.epa.gov/learn/training/standardsacademy/permit_index.cfm

EPA Web-based NPDES Permit Writer's Training including calculating WQBELs:
http://cfpub.epa.gov/npdes/outreach/training/pwtraining.cfm

EPA (2010) *NPDES Permit Writer's Manual*: Chapter 6 Water Quality Based Effluent Limits. EPA 8330-K-10-001.

EPA (1991) *Technical Support Document for Water Quality-Based Toxics Control*. EPA 505/2-90-001.

3.0 BENEFICIAL USE OF RECEIVING WATER

The uses of the receiving water and downstream waters must be established in order to determine the WQBELs. UAC R317-2-13 designates the beneficial uses for waterbodies in Utah. A GIS data layer is also available to assist with the determination of the beneficial use of a particular waterbody.

If a waterbody is not listed by name, the following designations apply:

- All irrigation canals and ditches statewide, except as otherwise designated: 2B, 3E, 4
- All drainage canals and ditches statewide, except as otherwise designated: 2B, 3E
- All lakes and any reservoirs greater than 10 acres not listed in 13.12 are assigned by default to the classification of the stream with which they are associated.
- All waters not specifically classified are presumptively classified: 2B, 3D

Procedures for establishing the beneficial use of a waterbody not listed by name in UAC to be developed.

4.0 POLLUTANTS OF CONCERN

This section provides guidance for determining which pollutants to consider in the WLA. WQBELs shall be established for those pollutants in the discharge that are present in quantities or concentrations which can be reasonably expected to cause or contribute, directly or indirectly, to a violation of any water quality standard.

The Permit Writer should provide an initial list of pollutants of concern based on the permit application, previous permit limits, review of monitoring data and knowledge of the discharger and pretreatment program.

The WLA generally will determine WQBELs for pollutants with numeric criteria in the UAC. The determination of which pollutants may cause or contribute to a water quality violation is made through a reasonable potential analysis (RP). The Permit Writer is responsible for the RP and the procedures are outlined in the guidance document (*Reasonable Potential Analysis Guidance for Use in Determining Permit Parameters in the Utah Pollutant Discharge Elimination System*). The wasteload analyst needs to verify that all pollutants in the discharge that have the reasonable potential to contribute to a water quality violation are considered.

5.0 MIXING ZONES

The following procedures will be used by staff of the Division as guidance in implementation of the mixing zone policy, and specifically in developing effluent limits for UPDES discharge permits for point source discharges into waters of the State. A mixing zone is a limited portion of a body of water, contiguous to a discharge, where dilution is in progress but has not yet resulted in concentrations which will meet certain standards for all pollutants.

5.1 ALLOWANCE FOR MIXING ZONE

A mixing zone may be allowed as limited by rule.

UAC R317-2-5 Mixing Zones

A mixing zone is a limited portion of a body of water, contiguous to a discharge, where dilution is in progress but has not yet resulted in concentrations which will meet certain standards for all pollutants. At no time, however, shall concentrations within the mixing zone be allowed which are acutely lethal as determined by bioassay or other approved procedure. Mixing zones may be delineated for the purpose of guiding sample collection procedures and to determine permitted effluent limits. The size of the chronic mixing zone in rivers and streams shall not exceed 2500 feet and the size of an acute mixing zone shall not exceed 50% of stream width nor have a residency time of greater than 15 minutes. Streams with a flow equal to or less than twice the flow of a point source discharge may be considered to be totally mixed. The size of the chronic mixing zone in lakes and reservoirs shall not exceed 200 feet and the size of an acute mixing zone shall not exceed 35 feet. Domestic wastewater effluents discharged to mixing zones shall meet effluent requirements specified in R317-1-3.

5.1 Individual Mixing Zones. Individual mixing zones may be further limited or disallowed in consideration of the following factors in the area affected by the discharge:

a) Bioaccumulation in fish tissues or wildlife,

b) Biologically important areas such as fish spawning/nursery areas or segments with occurrences of federally listed threatened or endangered species,

c) Potential human exposure to pollutants resulting from drinking water or recreational activities,

d) Attraction of aquatic life to the effluent plume, where toxicity to the aquatic life is occurring.

e) Toxicity of the substance discharged,

f) Zone of passage for migrating fish or other species (including access to tributaries), or *g) Accumulative effects of multiple discharges and mixing zones.*

All mixing zone-dilution assumptions are subject to review and revision as new information on the nature and impacts of the discharge becomes available (e.g., chemical or biological monitoring at the mixing zone boundary). Where justified, such as where there is a downstream drinking water intake, DWQ may require the discharger to conduct in-stream monitoring to verify that mixing zone size restrictions are being achieved. Mixing zone and dilution decisions are subject to review and revision along with all other aspects of the discharge permit upon expiration of the permit.

Applicable Definitions

Zone of Initial Dilution (ZID): that part of a receiving water where it is permissible to exceed the magnitude of an acute numeric criterion.

5.2 BEGINNING OF THE MIXING ZONE

The beginning of the mixing zone is typically at the point of compliance where the discharge meets waters of the state.

> ***UAC R317-1-1.34 Waters of the State***
> *"Waters of the state" means all streams, lakes, ponds, marshes, water-courses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, public or private, which are contained within, flow through, or border upon this state or any portion thereof, except that bodies of water confined to and retained within the limits of private property, and which do not develop into or constitute a nuisance, or a public health hazard, or a menace to fish and wildlife, shall not be considered to be "waters of the state" under this definition (Section 19-5-102).*

5.3 FULLY MIXED DISCHARGES

Fully-mixed discharges will normally receive a dilution allowance equal to the critical low flow where such dilution will protect designated uses. A discharge will be assumed to be totally mixed where an effluent diffuser covers the entire stream/river width (at critical low flow). Further, discharges with a mean daily flow greater than or equal to half the critical low flow of the receiving stream also may be considered to be totally mixed. Where the mean daily flow of the discharge is less than half the low stream flow of the receiving water, the mixing zone and plume width will need to be determined.

5.4 NOT FULLY MIXED DISCHARGES

Where a discharge is not fully mixed, an appropriate mixing zone may be designated for purposes of implementing chronic and acute aquatic life and human health criteria. As described in the policy, for streams, the size of the chronic mixing zone shall not exceed 2,500 feet and the size of an acute mixing zone shall not exceed 50% of stream width nor have a residency time of greater than 15 minutes. For lakes, the size of the chronic mixing zone would normally not exceed 200 feet in radius and the size of the acute mixing zone would normally not exceed 35 feet in radius. Individual mixing zones may be further expanded, limited or disallowed in consideration of the following factors in the area affected by the discharge:

a) bioaccumulation in fish tissues or wildlife,

b) biologically important areas such as fish spawning/nursery areas or segments with occurrences of federally listed threatened or endangered species,

c) potential human exposure to pollutants resulting from drinking water or recreational activities,

d) attraction of aquatic life to the effluent plume, where toxicity to the aquatic life is occurring.

e) toxicity of the substance discharged,

f) zone of passage for migrating fish or other species (including access to tributaries), or

g) cumulative effects of multiple discharges and mixing zones.

5.5 MIXING ZONE METHODS

The mixing zone policy normally will be implemented by DWQ utilizing a plume jet mixing model developed by EPA Region VIII (refer to Model Selection below). Data obtained from a properly designed field study that quantifies the actual rate and pattern of mixing at or near low flow conditions, may also be used to implement the mixing zone policy. The narrative criteria found at UAC R317-2-7.2 apply within the mixing zone except as indicated below.

5.5.1 DETERMINING ACUTE MIXING ZONE

For application of the acute water quality criteria (higher concentration allowed, but of short duration) for individual substances, a plume model will be used to calculate the length of the plume to reach 50% of the stream width at the critical low flow. A second calculation will be performed to determine the length of the plume corresponding to a 15-minute travel time calculated using the average velocity at the critical low flow. The second calculation is performed to ensure that organisms drifting through the plume will not be in the zone of initial dilution for longer than 15 minutes, which should minimize the potential for drifting organisms to be exposed to a 1-hour average concentration that exceeds the acute criterion. The more stringent of these two methods will be used to establish the acceptable size of the zone of initial dilution. The portion of the low stream flow that mixes with the effluent within the ZID will be utilized in mass balance calculations to determine permit limits applying the various acute criteria. The result will be at least a 50% zone of passage at all times for migrating fish.

5.5.2 DETERMINING CHRONIC MIXING ZONE

The approved procedure for chronic permit limits allows up to 2,500 feet downstream of a discharge for a chronic mixing zone. Chronic water quality criteria must be met at that distance.

5.5.3 MIXING ZONE AND DILUTION FOR WHOLE EFFLUENT TOXICITY

Whole Effluent Toxicity (WET) refers to the aggregate toxic effect to aquatic organisms from all pollutants contained in a facility's effluent. It is one method to implement the Clean Water Act's prohibition of the discharge of toxic pollutants in toxic amounts. WET tests measure wastewater's effects on specific test organisms' ability to survive, grow and reproduce. WET test methods consist of exposing living aquatic organisms (plants, vertebrates and invertebrates) to various concentrations of a sample of wastewater, usually from a facility's effluent stream. WET tests are used by the UPDES to determine whether a facility's permit will need WET requirements.

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. The UPDES Permit Writer will also use the IC_{25} percent effluent in the receiving water to inform the selection of dilution ratios in the required WET testing (i.e. typical dilutions would be 100, 50, 25, 12.5 and 6.25 percent effluent concentrations in the WET test); the selected dilution ratios should bracket the WET limits to maximize effectiveness of the WET test.

6.0 MODEL SELECTION

Model selection will depend on the constituents of concern, the significance of the discharge, and the complexity of the receiving water. Refer to Figure 1 for guidance on model selection for typical wasteload applications.

6.1 RIVERS AND STREAMS

6.1.1 NEAR FIELD MIXING ANALYSIS

Following are models that estimate plume width when full mixing does not occur within the mixing zone, i.e. small discharges into large, low gradient rivers.

- Utah Stream Mix Spreadsheet (Version 1.0): This routine does not consider boundary effects of the streambank. Developed by EPA Region 8.
- WDOE Stream Mix Spreadsheet: This routine does consider boundary effects of the streambank.

- CORMIX: USEPA-supported mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones resulting from continuous point source discharges. Applicable to more complex discharges, including multiple pipes and diffusers, boundary interactions, and buoyant plumes. Appropriate for discharges to the Great Salt Lake. The CORMIX methodology contains systems to model single-port, multiport diffuser discharges and surface discharge sources. Effluents considered may be conservative, non-conservative, heated, brine discharges or contain suspended sediments.

6.1.2 FAR FIELD FATE AND TRANSPORT

- Simple Mix Spreadsheet: Estimates mixed concentration for conservative constituents.

- Simple Decay Spreadsheet: Estimates mixed concentration with decay for chlorine, ammonia and E coli.

- QUAL2Kw: Applicable to discharges that have the potential to alter nutrient dynamics, algal growth and dissolved oxygen in the receiving water, i.e. POTWs. Model assumes fully mixed condition. *Default model for nutrient related discharges to dissolved oxygen sensitive waters.*
  - One dimensional. The channel is well-mixed vertically and laterally.
  - Steady flow. Non-uniform, steady flow is simulated.
  - Diel heat budget. The heat budget and temperature are simulated as a function of meteorology on a diel time scale.
  - Diel water-quality kinetics. All water quality state variables are simulated on a diel time scale for biogeochemical processes.
  - Heat and mass inputs. Point and non-point loads and abstractions are simulated.
  - Phytoplankton and bottom algae in the water column, as well as sediment diagenesis, and heterotrophic metabolism in the hyporheic zone are simulated.
  - Variable stoichiometry. Luxury uptake of nutrients by the bottom algae (periphyton) is simulated with variable stoichiometry of N and P.
  - Automatic calibration. Includes a genetic algorithm to automatically calibrate the kinetic rate parameters.
  - Monte Carlo simulation. Ready to run simulations with either the YASAIw add-in or Crystall Ball, including an example using YASAIw.

- WASP: Applicable to discharges that have the potential to alter nutrient dynamics, algal growth and dissolved oxygen in complex receiving waters with vertical or lateral stratification, dynamic loading and/or long travel times. WASP is a 3-D, dynamic water quality model.

6.2 LAKES AND RESERVOIRS

6.2.1 NEAR FIELD MIXING ANALYSIS

- Utah Jet Spreadsheet: Estimates plume dimensions and mixing for pipe and open channel discharges to lakes. Simplified assumptions - does not account for boundary effects of lake bottom, shoreline and water surface, currents, and density stratification. Developed by EPA Region 8.

- CORMIX: Applicable to more complex discharges, including multiple pipes and diffusers, boundary interactions, and buoyant plumes. Appropriate for discharges to the Great Salt Lake. The CORMIX methodology contains systems to model single-port, multiport diffuser discharges and surface discharge sources. Effluents considered may be conservative, non-conservative, heated, brine discharges or contain suspended sediments.

6.2.2 FAR FIELD FATE AND TRANSPORT

- BATHTUB: Applicable to fully mixed lakes and reservoirs. Applies a series of empirical eutrophication models to morphologically complex lakes and reservoirs. The program performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network which accounts for advective and diffusive transport, and nutrient sedimentation. Eutrophication-related water quality conditions (total phosphorus, total nitrogen, chlorophyll-a, transparency, and hypolimnetic oxygen depletion) are predicted using empirical relationships derived from assessments of reservoir data.

- CE-QUAL-W2: Applicable to vertically stratified lakes and reservoirs. A water quality and hydrodynamic model in 2-D (longitudinal-vertical) for rivers, estuaries, lakes, reservoirs and river basin systems. W2 models basic eutrophication processes such as temperature-nutrient-algae-dissolved oxygen-organic matter and sediment relationships.

- WASP: Applicable to incompletely mixed and vertically stratified lakes and reservoirs. WASP is a 3-D, dynamic water quality model.

- GEMSS (Generalized Environmental Modeling System for Surfacewaters): Applicable to incompletely mixed and vertically stratified lakes and reservoirs. Includes four hydrodynamic modules: the 3-D model GLLVHT (z-grid and sigma-grid), the 2-D longitudinal-vertical model CE-QUAL-W2, the 1-D model GLHT, and the 0-D (fully-mixed) model RTC.
  In addition, GEMSS® includes the following constituent modules:
    - Water Quality Module - WQM

- Sediment Transport Module - STM
- Toxics Module - TOX
- Particle Tracking Module - PTM
- Chemical and Oil Spill Impact Module - COSIM
- Thermal Analysis Module - TAM
- Generalized Bacterial Module - GBM
- Generalized Algal Module - GAM
- Entrainment Module – ENM

6.3 WATERSHED

For WLAs/TMDLs that require estimates of runoff and nonpoint source pollution, a watershed model may be required.

- HSPF: Most well suited for urban watersheds.
- SWAT: Most well suited for agricultural watersheds.

7.0 DATA COLLECTION FOR MODEL BUILD AND CALIBRATION

All data from properly designed and documented studies, as well as routine and intensive monitoring data from DWQ and cooperating agencies will be considered for use in building and calibrating models.

In some cases, DWQ will conduct monitoring specifically for the purpose of model construction and calibration. Early in the permit process, contact the permittee to discuss voluntary support of data collection efforts and to ensure that the data to be collected meets the model requirements.

In other cases, due to limited resources, the model will need to rely upon existing monitoring data from DWQ or other agencies.

7.1 DATA COLLECTION FOR QUAL2KW

Refer to the standard operating procedures (SOP) that were developed for data collection in support of QUAL2Kw model build and calibration (*Field Data Collection for QUAL2Kw Model Build and Calibration Standard Operating Procedures*).

8.0 MODEL BUILD AND CALIBRATION PROCEDURES

The model input should be based on field measurements or estimated from existing data sources. Calibration of the model to observed data is important for building confidence in applying the model to develop effluent limits. Generally accepted and adopted methods will be used to build and calibrate models, as needed. Specific guidance has been developed for applications that involve the use of QUAL2Kw as described in the following section.

8.1 QUAL2KW MODEL BUILD AND CALIBRATION

Section to be completed based on recommendations from Dr. Bethany Neilson, Utah State University.

8.2 MODEL PARAMETERIZATION WITHOUT CALIBRATION

In cases where data is not available for model calibration, rate coefficients used in the modeling process will be taken from EPA recommendations, literature values, and other calibrated models. In some of these cases DWQ may collect additional data to verify key assumptions following model calibration. Permits may need to be reopened if the results of these post hoc models evaluations reveal existing permit limits to be insufficiently protective of the beneficial uses.

9.0 WASTELOAD ANALYSIS

This section describes procedures for deriving water quality based effluent limits (WQBEL) for UPDES permits.

9.1 TMDLS

Whether the receiving water and/or downstream waters are covered under an approved or in-process TMDL will be verified. For approved TMDLs, the load allocation for pollutants included in the TMDL will already be specified. For impaired waters with TMDLs yet to be initiated or under development, the discharge may not cause or contribute to the violation of water quality standards (Friends of Pinto Creek v. EPA).

9.2 ESTIMATING CRITICAL CONDITIONS

The concept behind considering critical conditions in the receiving water is that if an effluent is controlled such that it does not cause water quality criteria to be exceeded in the receiving water at the critical flow condition, then the effluent controls will likely be protective and that water quality criteria will be attained at all flows. The critical condition in the receiving water typically occurs during low flows or volume; however, the critical condition may occur during high flows or volume if wet weather sources predominate.

9.2.1 FLOW FOR RIVERS AND STREAMS

The WQBELs are determined for the critical condition in the receiving water, which for most constituents occurs during low flow conditions in late summer. The low flow statistic used for the WLA is the 7Q10 flow, defined as the 7-day average low flow with a recurrence interval of 10 years. Typically, a summer seasonal 7Q10 will be calculated. However, at the request of the discharger and based on flexibility in the operation of their treatment works, seasonal WQBELs will be determined.

Winter: January 1 – March 31

Spring: April 1 – June 30

Summer: July 1 – September 30

Fall: October 1 – December 31

Proposal under consideration: Use the 1Q10 for acute conditions and 7Q10 for chronic conditions.

For facilities that discharge intermittently and not during low-flow conditions (e.g., lagoons), the stream flow to be used in the mixing zone analysis will be the lowest flow expected to occur during the period of discharge.

The most recent 20 years of daily flow records should be used to calculate the 7Q10. This timeframe balances the data required for a robust 7Q10 statistic with the most recent flow diversion/return flow practices.

Calculation of the 7Q10 flow statistic depends on the availability of flow records:

- USGS Gage: EPA DFLOW software can be used to import USGS flow records and calculate the seasonal 7Q10 flow.
- Other Gage: Data can either be formatted for import into DFLOW or used in an Excel spreadsheet with 7Q10 calculation capability.
- DWQ Flow Data: In the case where no daily flow records are available, calculate the 20th percentile from available discrete (i.e., field measures from a specific day and time) flow measurements. Alternatively, use the low flow condition observed during data collection for model calibration.

Typically, the maximum design discharge of the facility should be used for the wasteload analysis, which coincides with the maximum discharge allowed in the permit. Optional to use 30-day average flow for chronic criteria and maximum daily flow for acute criteria.

9.2.2 WATER SURFACE ELEVATION/VOLUME FOR LAKES AND RESERVOIRS

The WQBELs are determined for the critical condition in the receiving water, which for most constituents occurs during low volume conditions in late summer. The same statistic (7Q10) can be utilized for lakes and reservoirs, except that it applies to volume or water surface level rather than flow.

9.2.3 WATER QUALITY

9.2.3.1 AMBIENT CONDITIONS

Ambient water quality conditions in the receiving water need to be determined for the WLA. Water quality data should be obtained from the sampling station immediately upstream of the discharge. The most recent 5 years of sampling records is typically used to estimate ambient water quality conditions. If insufficient data exists within the prior 5 years, then longer historical data is referenced (i.e. 10 years).

Half of the detection limit is typically assumed for non-detect samples. For constituents lacking sampling data, half of the method detection limit is typically assumed for ambient condition.

Which statistic to calculate for ambient condition depends on the nature of the constituent:

- Bioaccumulative Toxics: Calculate the 80^{th} percentile of water quality samples.
- Conventional Pollutants and Non-Bioaccumulative Toxics: Calculate the arithmetic mean of water quality samples.
- Dissolved Oxygen (DO): Calculate the mean DO and estimate the diel range based on sonde data, if available.

In order to determine water quality standards for dissolved metals and ammonia, the following constituents will need to be characterized in the discharge effluent: total hardness, temperature and pH. These constituents can be calculated from DWQ monitoring data and/or Discharge Monitoring Report (DMR), or estimated based on treatment design performance.

If sufficient data are available ($n > 20$), water quality summary statistics should be calculated on a seasonal basis; otherwise, water quality parameters are summarized on an annual basis.

9.2.3.2 EFFLUENT

Similar statistics are calculated for the discharge based on DWQ monitoring data and/or DMR data. For new or upgraded facilities, effluent concentrations are estimated based on the design Engineer’s projections.

9.2.4 METEOROLOGY

Weather data (air temperature, dew point temperature, wind speed, cloud cover) is required for the QUAL2Kw model. Long term (20 years) monthly and/or seasonal averages for air temperature, dew point, and wind speed for the nearest weather station can be obtained from the Western Regional Climate Center. Typically, 10% cloud cover conditions are assumed for model simulation unless site-specific long term data is available.

9.3 DETERMINING EFFLUENT LIMITS

Water quality based effluent limits (WQBELs) are determined by the flow and concentration of pollutant in the discharge that will result in meeting, but not exceeding, the water quality criteria in the receiving water.

9.3.1 DISSOLVED OXYGEN AND NUTRIENT-RELATED DISCHARGES

Both algae and microbial growth rates increase with increasing nutrient concentrations, which in turn affects the DO dynamic within aquatic ecosystems. However, numerous chemical, physical and biological processes mediate these effects. Hence, if DO concentrations in the receiving water are a concern (i.e., nutrient concentrations are high in the effluent, background DO conditions are near standards), then models that simulate the nutrient cycle and algal growth should be employed, i.e. QUAL2Kw for streams and BATHTUB for reservoirs (see Figure 1).

Several water quality constituents commonly found in discharge effluent can potentially contribute to low dissolved oxygen conditions, including: organic content (CBOD, TOC), nitrogen, phosphorus, dissolved oxygenand temperature. Adjustments to any of these parameters in the model changes DO output. When determining which constituents to limit in order to meet DO criteria, consideration will be given to the past performance of the facility or for new facilities the design engineers projection of which parameters can be most reliably controlled. If model results find that a constituent needs to be limited beyond the capabilities of the facility, the operator/owner will be consulted on which other constituents are most feasible to adjust for the facility to meet DO criteria. The wasteload analyst will work as much as possible within the limits of the existing treatment capabilities of the facility before setting a WQBEL that would require facility modification.

Guidance to be developed for determining presence of early life stages of fish in the receiving water.

9.3.2 AMMONIA

The water quality standard for ammonia in the receiving water depends upon both temperature and pH. As a result, adjustments for temperature and pH need to be made for the mixed discharge. For the both the acute and chronic standard, the monthly average temperature/pH is used.

Rate for nitrification of ammonia to nitrate and uptake of ammonia for plant growth will be based on reasonable conditions derived from the scientific literature, unless empirical data are available for the site. For discharges with organic matter, ammonification rates of organic nitrogen to ammonia will be determined similarly.

Guidance to be developed for determining presence of early life stages of fish in the receiving water.

9.3.3 TOTAL RESIDUAL CHLORINE

Total residual chlorine (TRC) is a non-conservative pollutant that experiences decay during transport to and within the receiving water. Therefore, calculation of the WQBEL requires two steps: 1) calculate the TRC effluent concentration required at the mixing zone boundary using a mass balance equation; 2) calculate the TRC WQBEL at the point of compliance using a decay model.

The following mass balance equation is used to solve for TRC concentration at the mixing zone boundary:

$$C_bQ_b + C_oQ_o = C_s(Q_b + Q_o)$$

where:

C_b = Background TRC concentration, µg/l

Q_b = Background flow in the mixing zone, cfs

Q_o = Effluent flow, cfs

C_s = TRC criteria (acute or chronic, µg/l)

C_o = TRC concentration required at the mixing zone boundary, µg/l

The decay model uses a standard first order expression in which the time of travel in the stream reach is incorporated into the calculations. The model expression noted in the EPA's *Technical Guidance Manual for Performing Wasteload Allocations; Book 2, Chapter 3, Toxic Substances* June 1984, Appendix D, is used for TRC decay. The decay equation projects the amount of TRC loss within the mixing zone and from the point of compliance to the receiving water. The following TRC decay equation is used, solving for Cd.

$$C_o = C_d e^{(-kt)}$$

where:

C_d = WQBEL TRC concentration, µg/l

C_o = TRC concentration required at the mixing zone boundary, µg/l

k = Decay rate constant, /day

t = Time of travel in mixing zone, day

Guidance to be developed for selecting appropriate TRC decay rate (k).

9.3.4 DISSOLVED METALS

The water quality standards for dissolved metals in the receiving water depends upon total hardness. Development of metal effluent limits requires calculation of the total hardness of the mixed discharge per the equations in Table 2.14.3a (chronic) and Table 2.14.3b (acute) in R317-2-14. These equations calculate the water quality standard for total recoverable metals based on hardness dependence and convert the total recoverable metals standard to the dissolved metals standard through the use of a conversion factor. The maximum hardness used in determining the water quality standard for dissolved metals shall be 400 mg/L as $CaCO_3$.

For wasteload purposes, dissolved metals will be considered conservative substances, i.e. adsorption/desorption to sediment will be disregarded.

The following mass balance equation is used to determine WQBELs for dissolved metals:

$$C_bQ_b + C_oQ_o = C_s(Q_b + Q_o)$$

where:

C_b = Background metals concentration, µg/l

Q_b = Background flow in the mixing zone, cfs

Q_o = Effluent flow, cfs

C_s = metals criteria (acute or chronic, µg/l)

C_o = WQBEL metals concentration, µg/l

The effluent limits for metals in the UPDES permit are expressed as total recoverable metals; therefore, a translator must be applied to convert the dissolved metal fraction to a total hardness limit. *Guidance to be developed for selecting a translator value for expressing the dissolved metal WQBEL in terms of total recoverable metal WQBEL for UPDES permit.*

9.3.5 BACTERIA

E. coli is a non-conservative pollutant that experiences decay during transport to and within the receiving water. Therefore, calculation of the WQBEL requires two steps: 1) calculate the *E. coli* effluent concentration required at the mixing zone boundary using a mass balance equation; 2) calculate the *E. coli* WQBEL at the point of compliance using a decay model.

The following mass balance equation is used to solve for TRC concentration at the mixing zone boundary:

$$C_bQ_b + C_oQ_o = C_s(Q_b + Q_o)$$

where:

C_b = Background *E. coli* concentration, # org./100 ml

Q_b = Background flow in the mixing zone, cfs

Q_o = Effluent flow, cfs

C_s = *E. coli* criteria (acute or chronic, µg/l)

C_o = *E. coli* concentration required at the mixing zone boundary, µg/l

The decay model uses a standard first order expression in which the time of travel in the stream reach is incorporated into the calculations. The decay equation projects the amount of *E. coli* loss within the mixing zone and from the point of compliance to the receiving water. The following *E. coli* decay equation is used, solving for C_d—the WQBEL for *E. coli*..

$$C_o = C_d e^{(-kt)}$$

where:

C_d = WQBEL *E. coli* concentration, µg/l

C_o = *E. coli* concentration required at the mixing zone boundary, µg/l

k = Decay rate constant, /day

t = Time of travel in mixing zone, day

Guidance to be developed for selecting appropriate E. coli decay rate (k).

9.3.6 TOTAL DISSOLVED SOLIDS

For the purposes of the wasteload, total dissolved solids (TDS) will be considered conservative substances, i.e. decay does not occur. With the exception of several site-specific standards, the TDS criterion is 1,200 mg/L for all Class 4 waters—waters protected for agricultural beneficial uses (R317-2-13).

The following mass balance equation is used to determine WQBELs for TDS:

$$C_bQ_b + C_oQ_o = C_s(Q_b + Q_o)$$

where:

C_b = Background TDS concentration, µg/l

Q_b = Background flow in the mixing zone, cfs

Q_o = Effluent flow, cfs

C_s = TDS criteria (acute or chronic, µg/l)

C_o = WQBEL TDS concentration, µg/l

9.3.7 TEMPERATURE

Two water quality criteria are applicable for thermal discharges to receiving waters with aquatic life beneficial uses (3A, 3B, and 3C; 3D and 3E do not have numeric criteria for temperature: 1) maximum temperature, and 2) maximum temperature change.

Criteria	**3A**	**3B**	**3C**
Maximum Temperature (deg C)	20	27	27
Maximum Temperature Change (deg C)	2	4	4
The temperature standard shall be at background where it can be shown that natural or un-alterable conditions prevent its attainment. In such cases rulemaking will be undertaken to modify the standard accordingly. Site Specific Standards for Temperature Ken's Lake: From June 1st - September 20th, 27 degrees C.			

For the purposes of the wasteload, temperature is treated as a conservative substance.

The following mass balance equation is used to determine WQBELs for temperature:

$$T_bQ_b + T_oQ_o = T_s(Q_b + Q_o)$$

where:

T_b = Background temperature, deg C – seasonal or annual average

Q_b = Background flow in the mixing zone, cfs

Q_o = Effluent flow, cfs

T_s = Temperature criteria (deg C) – either max. temperature or T_b + max. temperature change, whichever is more restrictive

T_o = WQBEL temperature, deg C

In the case where the influent water is diverted from the receiving stream, the following mass balance equation is used to determine WQBELs for temperature:

$$T_b(Q_b - Q_o) + T_oQ_o = T_sQ_b$$

where:

T_b = Background temperature, deg C – seasonal or annual average

Q_b = Background flow above point of diversion, cfs

Q_o = Effluent flow, cfs

T_s = Temperature criteria (deg C) – either max. temperature or T_b + max. temperature change, whichever is more restrictive

T_o = WQBEL temperature, deg C

10.0 DOWNSTREAM ANALYSIS

Guidance to be developed for performing downstream analysis to ensure water quality standards will be achieved.

11.0 GLOSSARY

IC_{25}: the effluent concentration of a toxin that results in a 25% reduction in a biological measurement of the test organism, including reproduction, growth, fertilization, or mortality. A point estimate that is interpolated from the actual effluent concentrations at which measured effects occurred during a chronic test.

LC_{50}: the median lethal concentration of a toxin that kills half the members of a tested population after a specified duration

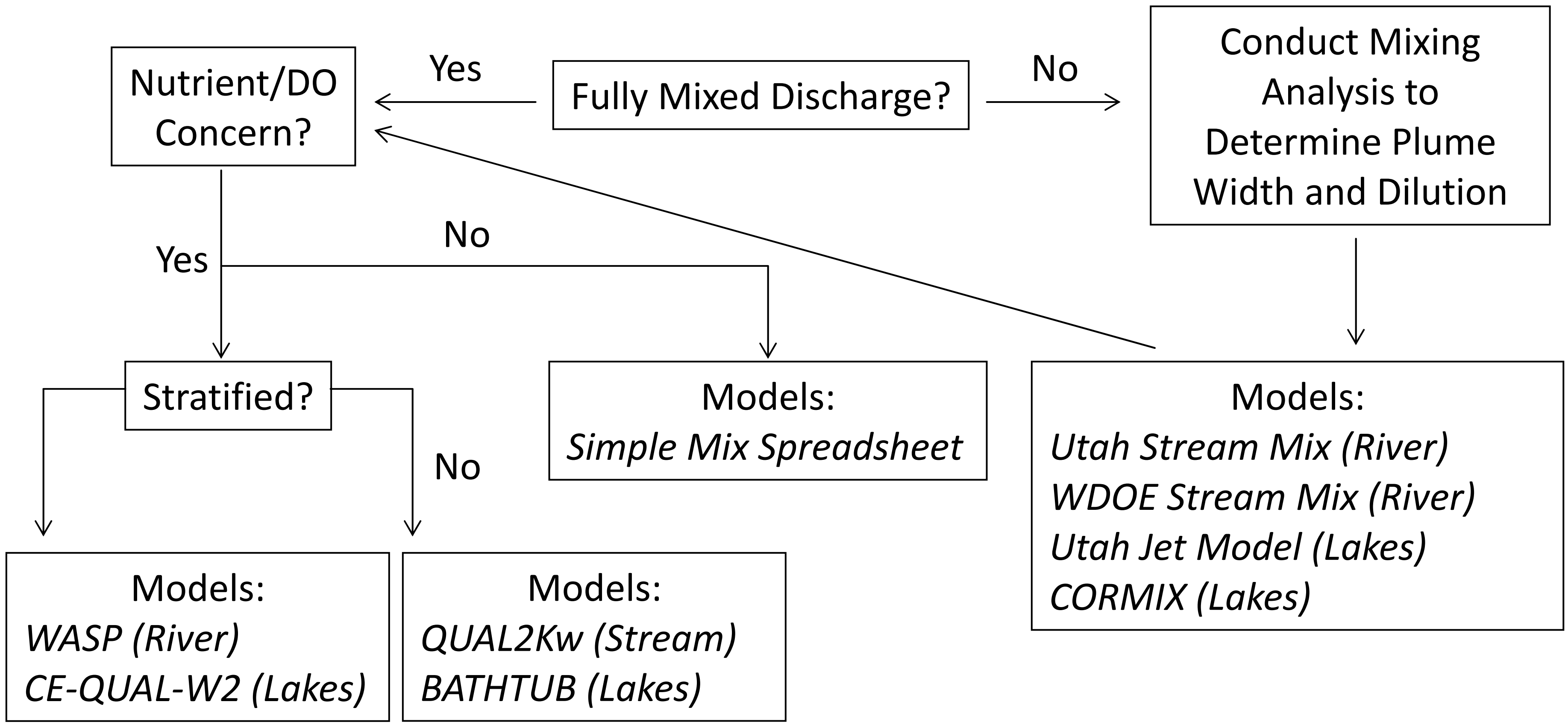

Figure 1: Model selection for typical wasteload analyses